

Mainstreaming Green Product Innovation: Why and How Companies Integrate Environmental Sustainability

Rosa Maria Dangelico
Devashish Pujari

ABSTRACT. Green product innovation has been recognized as one of the key factors to achieve growth, environmental sustainability, and a better quality of life. Understanding green product innovation as a result of interaction between innovation and sustainability has become a strategic priority for theory and practice. This article investigates green product innovation by means of a multiple case study analysis of 12 small to medium size manufacturing companies based in Italy and Canada. First, we propose a conceptual framework that presents three key environmental dimensions of green product innovation such as energy minimization, materials reduction, and pollution prevention as identified in the life cycle phases of products. Based on insights gained from in-depth interviews, we discuss firms' motivations to develop green products, environmental policies and targets for products, different dimensions of green product innovation, and challenges faced during developing and marketing of green products. Results from the study are then synthesized and integrated in a toolbox that sheds light on various aspects of green product innovation and provides solutions to challenges and risks that are faced by firms. Finally, implications for managers, academia and public policy makers are discussed.

KEY WORDS: environmental sustainability, green product innovation, life cycle analysis, manufacturing firms, Italy, Canada, multiple case studies

Introduction

A large number of trade magazines and numerous media reports in the past few years have shown that companies from disparate industries have launched or are planning to launch new green products. In recent years, academic research on green product innovation has also grown in interest (e.g., Chen,

2001; Chung and Tsai, 2007; Pujari et al., 2003, 2004; Pujari, 2006; Rehfeld et al., 2007). In a recent survey on companies' thinking on climate change, McKinsey and Company (2008) find that the greatest percentage of executives surveyed consider climate change strategically important, and about 60% take it into account in developing and marketing new products. According to Datamonitor, companies have so far launched 458 products that claim to be "sustainable," "environmentally friendly," or "eco-friendly," and this number is likely to touch 1570 new green products launched this year (Greenbiz, 2009). For example, Ford has developed soy-based seat cushion foam, while SC Johnson uses a green list process to weed out restricted ingredients, and Lipton Tea recently announced an expansion of their sustainability program, pledging to source 100% of their tea from estates certified as sustainable. This kind of intent among companies suggests a new shift in the environmental debate indicating that change towards environmental value and social good is fostered by market-driven product innovation and new technologies rather than regulation alone (Berger et al., 2007).

Even though recent trends show that green product innovation is becoming mainstream among the companies, there is still much confusion on what constitutes a green or sustainable product (Baumann et al., 2002; Berchicci and Bodewes, 2005; Ottman, 1997; Peattie, 1995; Roy et al., 1996). In this article, we follow Ottman et al. (2006), who state that "although no consumer product has a zero impact on the environment, in business the terms 'green product' or 'environmental product' are used commonly to describe those that strive to protect or enhance the natural environment by conserving

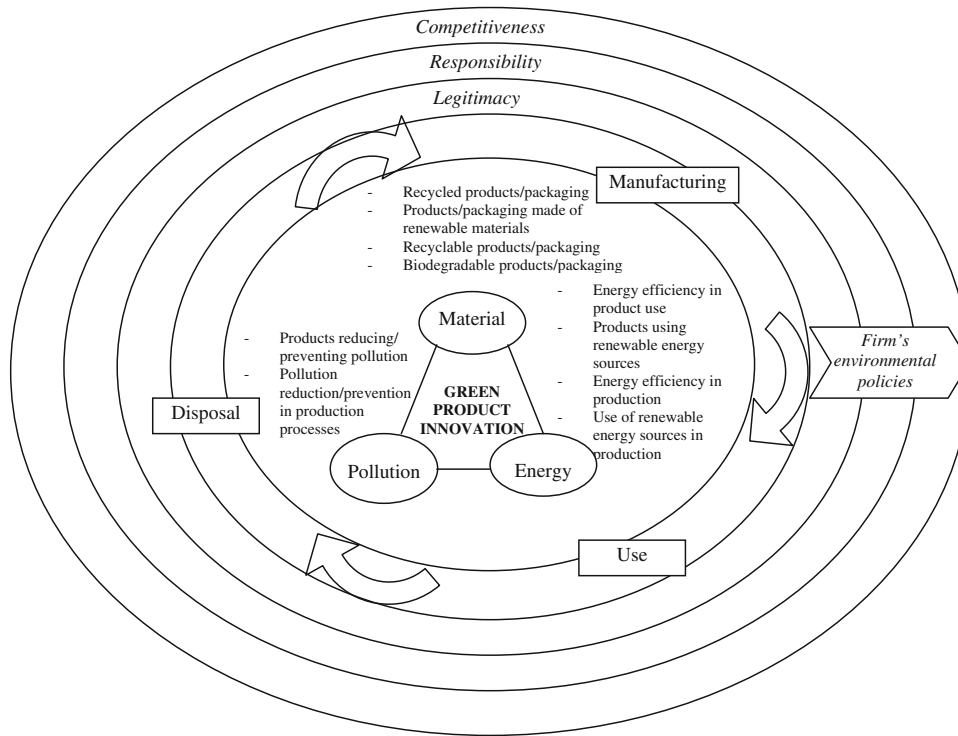


Figure 1. A conceptual framework for green product innovation.

energy and/or resources and reducing or eliminating use of toxic agents, pollution, and waste.” This definition highlights how different types of green products focus on key environmental issues such as energy, materials/resources, and pollution/toxic waste (Roy et al., 1996) as shown in a conceptual framework for green product innovation (see Figure 1).

As shown in Figure 1, green product innovation is a multi-faceted process wherein three key types of environmental focus – material, energy, and pollution – are highlighted based on their major impact on the environment at different stages of the product’s physical life cycle – manufacturing process, product use, and disposal. It is important to note that neither all products have a significant environmental footprint on each stage of physical product life cycle nor does the footprint stem from all aspects (material, energy, and pollution) but almost all products have significant environmental impact in at least one of the stages. For example, a furniture company’s environmental impact may be primarily on the forests (material) whereas washing machine manufacturer’s main environmental impact occurs during

product usage (energy use, water use, and detergent use). There are, of course, other high environmental impact industries such automobile and oil whose environmental footprint may be bigger as it covers all physical life cycle stages (manufacturing, product use, and disposal). Introducing radical green innovation in any stage of product’s physical life cycle or addressing sustainability challenges across different dimensions such as material selection, energy use, or pollution prevention can bring substantial product differentiation and competitiveness for these products at the market place. However, the intent to introduce innovation will require not only an enhanced level of corporate environmental responsibility but also a sustained level of implementation of the firm’s environmental policies to put green product ideas into practice and overcoming of challenges and risks.

A review of literature reveals that there is little knowledge on why and how companies integrate environmental sustainability into new product development. The business climate is undergoing rapid change in terms of societal and environmental expectations from multiple stakeholders. Marketers

are facing increasing challenges to address sustainability issues in order to attract, satisfy, and retain customers. The size of green markets is increasing and is likely to get bigger in future. These changes and expectations make it essential for researchers to investigate green product innovation. New societal expectations also make it imperative for firms to understand how to integrate sustainability issues into their product development so that the firm's social, environmental, and economic goals can be achieved. Our quest for an in-depth insight into the reasons, approaches for and challenges in integrating environmental sustainability issues into product innovation is the key motivation for this study. To this aim, the article investigates in depth, 12 companies to find out why and how these companies in Italy and Canada are responding to environmental sustainability challenges and integrating them into their new product strategy and new product development process. In particular, we analyze: (i) different motivations influencing companies to develop green products; (ii) setting of environmental policies and targets for products; (iii) different dimensions of green product innovation (e.g., radical versus incremental, packaging, product life cycle stage, and environ-

mental performance); and (iv) challenges faced in developing and marketing green products. The following sections provide details on methodology and a discussion of the main results. Finally, besides discussing implications of the study, a toolbox is developed to help understand the challenges and possible solutions for integrating environmental sustainability in green product innovation.

Methodology

A qualitative approach was employed in this study to achieve the research aims of gaining deeper insights on companies' green product innovation through personal interviews, company records, and published data sources (Eisenhardt, 1989; Patton, 1990; Yin, 1981, 1989). Specifically, an inductive multiple case study methodology is employed (Yin, 2003) to cover contextual or complex multivariate dimensions of the phenomenon—greening of new product innovation.

A series of in-depth, intensive interviews with executives and managers in 12 companies was conducted. These companies are based in Italy and Canada and are small to medium size consumer and

TABLE I
Companies in the sample

Company, country	Industrial sector	Size (number of employees)	Market served	Role of the interviewee
Company A, Italy	Detergents	120	B2C ^a , B2B	Director of Quality Control
Company B, Italy	Photovoltaic applications	14	B2C, B2B, B2G	New product development Executive
Company C, Italy	Ink-jet systems and inks	14	B2C, B2B	Project Manager
Company D, Italy	Glass tiles	12	B2B	CEO
Company E, Italy	Wooden pallets	80	B2B, B2G	President & CEO
Company F, Italy	Ecologic products or product coming from fair trade	13	B2C, B2G	Environmental/marketing advisor
Company H, Italy	Recycled rubber products	16	B2C, B2B, B2G	Director
Company I, Italy	Paper carrier bags	30	B2B	CEO
Company L, Canada	Solar integrated roofing system	60	B2B	VP of Sales & Market Development
Company M, Canada	Solar thermal providing hot water/heat not electricity	20	B2C	Product Development Engineer
Company N, Canada	Solar wall	8	B2B, B2G	President
Company O, Canada	Bio-diesel	38	B2B	VP of Business Development & Sales

^aB2C = Business to Consumer; B2B = Business to Business; B2G = Business to Government.

industrial manufacturing companies (see Table I). One of the reasons why we chose Canadian and Italian companies was to have an international perspective and to benefit from our accessibility to companies in these two countries. The choice of companies was also based on their commitment towards sustainability issues as evident from their winning environmental awards or having environmentally-specific patents. To gain greater insights on the phenomenon, the unit of analysis in this study is green product innovation projects (see Table II). We discussed issues relating to innovativeness of green products companies have developed, motivations to engage in green product innovation, firm-level environmental product, tools companies have used to address sustainability issues, measurement of environmental performances, and challenges and risks they face. Even though we investigated sustainability issues at the firm level, this analysis was in the context of product development. Project level analysis in particular provided opportunities to investigate intricacies of the sustainability challenges the product development teams face. Open-ended interviews were conducted by direct visits to companies, and clarifications were sought through e-mails and phone calls. Interviews on an average lasted for more than one hour thus covering the research issues comprehensively. The interviews were then transcribed and content analyzed for within case and cross case analyses. Appropriate procedure was undertaken in translating and back translating interviews in Italian language to ensure the accuracy and consistency of comments. For the purpose of data triangulation, and to strengthen and verify the use of the interview data (Miles and Huberman, 1994; Seale, 2000), other sources of information about the companies and the projects under study were also analyzed, such as companies' website content, company documents, patent office databases, environmental innovation awards listings, internal company reports, as well as media reports on companies' environmental activities.

Analysis and results

Firm's motivation for green product development

Integrating environmental sustainability issues into business strategy and greening the innovation

process are becoming a strategic opportunity for companies (e.g., Porter and Reinhardt, 2007). As a result, the number of companies embracing the concept of environmental sustainability into their business strategy, and developing environmental strategies is growing (Aragon-Correa and Sharma, 2003; Dyllick and Hockerts, 2002; Sharma and Vredenburg, 1998).

However, reasons that push firms to go 'green' can be very different (Bansal and Roth, 2000; González-Benito and González-Benito, 2006). Interviews with executives have allowed us to gain further understanding on the motivations that influence companies to go 'green' and in particular to develop green products. One of the motivations is to have compliance with regulations. During the last two decades, a number of declarations and regulations for environmental protection have followed one another. These included the restriction on chlorofluorocarbon (recommended by the Montreal Protocol of 1987), the restriction on CO₂ (recommended by the Kyoto Protocol of 1997), the European Community directives on the restriction of the use of certain hazardous substances (RoHS) and on waste electronics and electrical equipment (WEEE) effective since 2006. The regulations continue to determine growing impacts on industries, and compel companies to green their processes and products. However, environmental regulations do not represent only constraints for companies, as highlighted by this executive: "Regulations represent for us constraints but also caution for avoiding risks of activity breakdown, money losses or damage to the company image" (Company A).

Discussions with case companies suggest that compliance with environmental regulations is also one of the means for risk minimization, revenue, and image protection. Furthermore, regulations can even become an opportunity for new business creation, as highlighted by this executive: "Some years ago the Italian government was thinking of enacting a law forbidding the use of plastic bags, which are very pollutant. So the idea to create a company producing low environmental impact bags was born" (Company I).

Environmental sustainability imperative also represents an opportunity to improve competitiveness in a win-win logic (Porter and van der Linde, 1995). In particular, the development of green products, by

TABLE II
Description of green product innovations

Company, country	Product description (source: interviews, company material, website, media, etc.)	Main environmental focus
Company A, Italy	It is a laundry detergent with the European flower eco-label. As such, it has a reduced impact on the aquatic environment: it does not contain dangerous substances, it has a limited effect on the growth of algae in water, and it is largely biodegradable. Moreover, it uses less packaging, it contains information on how to wash ecologically and economically, and it is guaranteed to perform at least as effectively as conventional detergents	Pollution
Company B, Italy	It is a luminous square that lights gardens and pathways using solar energy (it is endowed with a photovoltaic unit). The product is made of LED lamps, more energy efficient and lasting than conventional lamps	Energy
Company C, Italy	It is an ecological ink non-toxic, biodegradable, and easily removable from the paper. The product packaging is made of recycled paper and is printed with the product itself	Material
Company D, Italy	It is a decorative glass tile realized with 80% of recycled materials (post-consumer recycled mirrors and pre-consumer recycled glass). Packaging is made of polystyrene and recycled board	Material
Company E, Italy	It is an environmentally sustainable wooden pallet. It is made of FSC or PEFC certified wood. The production processes use energy coming from renewable energy sources. The product is transported by means of an efficient logistics platform. It is designed following eco-design principles and a 'cradle to cradle' logic. In fact, it can be reused (with or without repairing), collected, disassembled and components can be recycled	Material
Company F, Italy	It is a toy made of corn starch and natural colorings, and it is completely biodegradable. In the design phase the environmental impacts during the whole life cycle of the product is assessed in terms of energy, emissions, and materials consumption	Material
Company H, Italy	It is a floor made of rubber recycled from tires and covered with synthetic grass. At the end of life it can be recycled	Material
Company I, Italy	It is a carrier bag made of recycled paper and printed with water-based inks, which are not polluting and allow easier paper recycling. Production processes are clean, and in particular there is a closed loop for water use and production waste paper is collected and recycled	Material
Company L, Canada	It is a solar photovoltaic integrated roofing system	Energy
Company M, Canada	It is a solar thermal product producing hot water or heat. It is generally combined with traditional systems, and provides pre-heating	Energy
Company N, Canada	It is a solar air heating system for commercial and industrial buildings	Energy
Company O, Canada	It is biodiesel from vegetable oils, seed oils, waste animal fats, and recycled cooking oils	Energy

improving firm reputation and image, is seen as a means to enhance competitiveness, as opined by this executive: “The reduction of packaging materials and of environmental risk is quantified and easily recognizable at the eyes of our main market, and so environmental innovation in products and packaging gives added value to our company” (Company A). This position is further strengthened by the environmental/marketing advisor in company F who pointed out that the development of green products represents a means to exploit the opportunities created by the growth of green markets: “The market for green products is rapidly growing and surely represents the most promising trend of the future.”

Beyond compliance with regulations and competitiveness, another important reason for companies to develop green products is ecological responsibility, deriving from the concerns that companies have for social obligations and values. For example, company B and company L aim at increasing social and environmental benefit by making the use of renewable energy more widespread. In fact, the executive of company B stated: “Our mission is to produce solar energy products for a more widespread and daily use,” whereas the executive of company L reported: “Our job is to create renewable energy solutions that make solar power more affordable, more convenient and more available to anybody who wants it... we think solar should be for everybody.” A similar position, even though not related to renewable energy solutions but to material resources, is shown by the executive in company D, who said: “The most important motivation that pushes us to consider the environmental dimension in new product development is to develop and communicate a new concept of recycle and reuse of daily used materials. These materials are transformed and moulded, in order to make waste, ugly and useless, something nice and useful.”

This environmental responsibility in new product development often originates from an internal environmental orientation of the firm combined with potential to market success, as highlighted by the environmental/marketing advisor in company F: “Our company is totally committed towards the respect for the natural environment...The greatest difference from conventional new product development process is that we don’t start from the economic evaluation, but we believe that a product

with the features we give it has great possibilities to succeed in the market.” This position is further strengthened by the executive in Company H, who stated: “The idea for this new product was born from the company’s internal sensitivity to environmental issues, rather than from customers’ requirements.” In other cases, the main driver of green product development is the personal commitment of top management, as pointed out by the President and CEO in company E: “The interest towards environmental sustainability starts from me and involves all the company’s areas.” From the analysis of case studies, it has emerged that the development of green products can be driven by different motivations that sometimes can co-exist within the company. For example, both compliance and competitiveness are the main drivers for green product development in company E, whereas both competitiveness and environmental responsibility are the main drivers for company F. It is important to note that simply having motivations to “go green” is not enough. The firms will have to set policies and targets in place to move forward on green product innovation. Taking these results together suggests that environmental regulations represent opportunities beyond simple compliance. Specifically, they offer opportunities for new business creation, waste reduction, and customer satisfaction.

Firm’s environmental policies for product development

At corporate level, it is important to understand how targets and policies for green product development are set and how they are communicated within the company. As environmental sustainability issues continuously evolve, for example in terms of regulations, new environmental technologies, and low-environmental impact materials, we find that companies see it as important to acquire knowledge from a variety of actors, as opined by this executive: “The environmental targets and policies for products are set following the guidelines of European Union and paying a greater attention to the scientific world, society, companies, universities, and other organizations” (Company E).

To guide the operational definition of environmental targets and policies and to internally communicate them to all employees, companies develop

sustainability plans or ethical codes, as pointed out by these interviewees: “We aim at producing innovative and high quality products, and this means for us developing products with low environmental impact. The guiding document for the environmental targets and policies is the company’s ethical code” (Company C). These documents provide directions for green product development, as highlighted by the executive of company A: “There is a company sustainability plan, which provides general directions for product development and reduction of their environmental impact during the whole life cycle” (Company A). Our further investigations into ethical codes and sustainability plans suggest that these internal company documents include sustainability criteria that were put in place as a result of a study of production and life-cycle analysis of products. In particular, cross-point activities in social/environmental and economic/environmental fields are identified such as selection/warehousing of components, workplace environment/product manufacturing cycle, and product development (risks for the health and safety of the consumer and reduction in packaging materials and/or optimization of packaging to provide logistical advantages). These results show that formalizing environmental policies and targets for products into documents such as ethical codes or sustainability plans is important to guide companies in the development of green products.

TABLE III
Type of innovation in green products

Company	Type of innovation
Company A, Italy	Incremental
Company B, Italy	Incremental
Company C, Italy	Radical
Company D, Italy	Incremental
Company E, Italy	Incremental
Company F, Italy	Incremental
Company H, Italy	Incremental
Company I, Italy	Incremental
Company L, Canada	Radical
Company M, Canada	Incremental
Company N, Canada	Incremental
Company O, Canada	Radical

Radical versus incremental green product innovation

For a deeper understanding on the differences between radical and incremental green product innovations, our case studies included both types of green innovations (see Table III). Literature suggests that radical green product innovations include the use of new technologies (e.g., hybrid or hydrogen vehicles), or the replacement of one critical component with a completely new one that significantly reduces the overall environmental impact of the product (e.g., an insecticide, which is based on a completely new, natural, or eco-friendly ingredient). Incremental green innovations include the increasing use of existing key dimension of green product such as eco-efficiency (e.g., incremental improvement of fuel efficiency in vehicles), the substitution of conventional materials with materials with a lower environmental impact (e.g., replacement of virgin materials with recycled ones), or the design of recyclable products (e.g., designed for disassembly) (e.g., Hellström, 2007).

As described below, green product innovations are characterized as radical if it is new to the market or is based on a radically new technology, and/or has been patented by the firm. As one project manager of a company that developed a non-toxic and biodegradable ink that is easily removable from paper said, “It is a radically new product- it is the first ecologic ink. At the present, nothing similar exists in the market” (Company C). Another interesting case in our study was a company L that has developed a solar roofing membrane that is a unique solution combining power generation with a very lightweight material. Company L executives consider this product’s technology to be extremely innovative and new. Similarly, in the case of company O producing biodiesel, the technology used is radically new and is patented.

On the other hand, our analysis shows that incremental green product innovations are characterized by small or incremental improvements of previous product versions or their reliance on existing technologies with minor changes, not dissimilar to the features of their incremental conventional products (for example in Companies D and N). More specifically, the manager in company H highlights, “Synthetic grass flooring had already existed, but in the considered product there is an

additional layer of rubber with absorbing impacts properties, particularly suitable for sports players.” It was also noticed in our analysis that incremental improvement in green credentials of existing product may come from a single dimension such as recycled content, recyclability ratio or improvement in energy efficiency levels as one product development engineer from company M says, “The product is not radically new because it is based on an existing technology. It is much more efficient than in the past.” In other cases, however, companies have tried to integrate some new features in an existing product probably for product differentiation or repositioning based on green features of the new product, as pointed out by the executive of company F, “Our product is an incremental improvement of an earlier version, but with some radically new elements, such as the communication approach, the green message, and the link between ecological materials and environmental protection”. However, it is important to note that changes solely on marketing communication without any credible and verifiable green credentials may leave a brand open for public or stakeholder backlash.

New product's physical life cycle stages

A new product's physical life cycle perspective is an important aspect of green product innovation (Gauthier, 2005) which allows product managers and environmental specialists to measure and analyze the environmental impact of each stage. The companies we studied seem to be aware of the need to evaluate and judge greenness of the product over the whole life cycle as highlighted by an executive (company F), “Product's ‘environmental friendliness’ for us means an ecological product in the whole life cycle...we evaluate the whole life of the product...we carry out an analysis of energy costs and of environmental impacts such as emissions, transport, and materials consumption.” Another executive emphasizes going beyond the ‘cradle to grave’ approach as he says, “The product development process in our company is strictly focused on eco-design and therefore on life cycle thinking...for the environmentally friendliness of our products, we use the necessary quantity of materials without exceeding in the use, we reduce the environmental

impact of production process through the use of renewable energy and of water and energy efficient machineries...we use only FSC or PEFC certified wood... we try to create a network to obtain a short supply chain... products can be reused (with and without repairing), collected, disassembled and components recycled... Our product is different from a ‘cradle to grave’ path because it follows a ‘cradle to cradle’ logic.” Similar logic is highlighted by another manager (Company D) who says, “At the end of their life cycle, all types of products we produce are reusable in our production processes for future uses: they can be removed from the wall or flooring, cleaned and used again in production processes, giving life to new products.”

However, approaches or philosophies such as ‘cradle to grave’ or ‘cradle to cradle’ are complex and difficult to implement. A useful methodology to evaluate the environmental impact of a product during whole life is Life Cycle Assessment (LCA) which is becoming rather common among firms who are genuinely addressing environmental sustainability challenges. One of the respondents (Company C) in our study provided some insights with regards to the use of LCA to assess the environmental impact of ecological ink, “In order to evaluate the whole life of the product, we do a life cycle assessment study. It has been necessary to define the study boundaries, which include raw materials, the whole production process up to the final destination of washing and production waste, and the end-of-life of the refill.” These results show that a life cycle perspective is essential when developing green products.

Packaging and sustainability

A major frontier in the quest for achieving environmental sustainability is packaging due to its environmental impact during product transportation (in terms of energy consumption and pollution) and at the disposal stage (in terms of waste). Even though environmental laws were enacted several years ago in most of the countries in the Western world and particularly in Europe, companies started to express their commitment to have ever higher goals for recycled content and recyclability in sustainable packaging. For example, Starbucks has recently

announced a new goal to have 100% recyclable or reusable cups,¹ whereas HP has cut packaging on a recent product by 97%.² Even in emerging economies, such as China, where new packaging rules have come into effect, government directions encourage the development of sustainable packaging.³ During our interviews with companies, it emerged that environmental design of packaging is fast becoming an integral part of green product innovation and greater attention is devoted to green packaging when developing green products. For example, one executive (Company D) pointed out the importance of R&D in packaging while another (Company A) stated, “The research for reducing and optimizing packaging for our company is one of the most important areas of incremental and radical innovation development...we have received awards for concept and production of sustainable packaging.” Other initiatives in sustainable packaging include the use of recycled materials (company C), or natural and biodegradable materials, such as biopolymers based on cornstarch (Company F).

Product’s environmental performance

The reduction of environmental impact of products throughout their life cycle is fundamental to green product innovation. However, assessing the environmental impact of a product in a scientific and systemic way is a difficult and complex process. The interviews we did for this study provided interesting insights on how companies measure environmental performance of products. In some cases, the measurement of environmental performance of green products takes the form of a comparison with conventional products. For example, using a life cycle assessment software, company C (that develops inks), measures and compares environmental impact during the whole life cycle of its green product (ecological ink) with conventional products which helps them make a credible claim of lowering environmental impact in green products by 30%. Similarly, the respondent in company O also emphasized the uses and benefits of using life cycle assessment study that compared crude oil and different types of bio-diesel which allowed them to make credible claims of producing bio-diesel of highest environmental performance.

It also emerged in our study that in certain product/service categories such as energy-based products, environmental impact assessment is done in a single stage but has still been very useful for both manufacturers and customers. For energy-based products, the outcome of the assessment generally is expressed in terms of energy saved or pollution avoided during the usage stage. For example, the product development engineer in company M says, “Thanks to the use of software it is very easy to calculate kilowatt-hours or cubic meters or litres of propane and that in turns allows us to do a CO₂ calculation... you can reduce typically for a home between 1 and 1.5 tones of CO₂ per year.” This issue was also highlighted by an executive in company N, who says, “We use computer software that calculates the energy savings using the local weather data... We tell people it will save this amount of energy and you recover your cost over so many years.” Interestingly, for material-driven products too, in some cases, environmental performance can be expressed in one single stage, for example, as percentage of recycled materials used during product development process, as highlighted by the executive in company D: “The percentage of recycled materials inside the resin may vary depending on the material used. For example, using waste glass bottles or mirrors, recycled content ranges between 60% and 80%. If we use recycled electric circuits, recycled contents generally range between 50% and 60%, even though percentage can rise to 80% if we use glass fragments as filler.” Two key insights come to light from these discussions. First, life cycle assessment is not only a useful tool but it is now used more frequently by companies. Secondly, even though life cycle assessment’s purpose is to evaluate environmental impact during each stage of the physical life cycle of the products, in some product categories, the LCA tool is used for only one or two stages, the ones which have the potential of causing greatest environmental impact.

Challenges in green product innovation

Companies that develop and market innovative green products seem to face several challenges but empirical studies that report on these challenges are scant (Berchicci and Bodewes, 2005; Hall and

Vredenburg, 2003; Ottman et al., 2006). To enhance our understanding on the key challenges companies face while developing green products, we gained some interesting insights during our discussions with companies in this study. First of all, it emerged that a key challenge in green product innovation is to integrate environmental and conventional product attributes (e.g., avoiding trade-off between product quality and green attributes). Another challenge is selling at a competitive price, as pointed out by a project manager in company C: “In the sectors such as fuels, automotive, paper, ink, leather, etc. green solutions already exist, but their price exclude them from any possible preference from industrial and final consumers.” One of the reasons why pace of green product introduction is still slow in several industries is not the lack of adequate technologies, but high development and manufacturing costs that make their price non-competitive. In several product categories, without government subsidies to companies or government rebate to customers, companies find it difficult to compete with brands and companies who have not invested in green technologies, as highlighted by several executives in our study. For example, the product development engineer in company M elaborates, “Economics is another challenge... We are at a disadvantage when comparing price to price with electricity and natural gas... We are not given any grants... Our customers have to pay taxes for saving energy, I mean it is just not a level playing field.” Besides price, other important attributes that must be integrated with environmental sustainability are product quality, esthetics, and credibility of claims.

Another key challenge that is faced by companies that develop and market green products is the lack of customers’ awareness of green products’ benefits as pointed out by an executive (company M), who concedes, “Many people aren’t even aware... mass awareness is not present in the market... awareness is one of the key challenges.” Another executive in company E highlights the difficulty of sometimes leveraging product’s green attributes for competitive advantage as he says, “The customers don’t perceive the added value of product sustainability. The market isn’t aware of eco-design advantages, such as waste reduction. The greatest difficulty is to make the environmental variable as a source of competitive advantage.” However, lack of customers’

awareness can be addressed by means of eco-labeling or third party certification which makes green products clearly recognizable and creates credibility of the green claims. However, some product categories still do not have eco-labels as was evident in the frustration of one of the executives (Company M) we had discussion with as he says, “There isn’t an eco-label for this type of product: it doesn’t consume energy, it generates energy.” Another challenge that was unraveled in our discussion related to the organizational issues, notably the management of information flows and coordination of resources within and outside of the product development team particularly when companies seek to get third party certification or eco-label. Eco-labeling process is sometimes tedious and requires managerial skills to deal with multiple stakeholders. This process is likely to be more seamless when the role of environmental specialists in the product design and product development process becomes more prevalent.

Discussion

It is evident from our study that several motivations drive companies to develop green products. Our results also show that environmental regulations don’t just represent constraints or regulatory compliance, but can also offer opportunities for risk minimization, preservation of revenues and reputation, or for new business creation. The literature highlights several benefits that can arise from integrating environmental sustainability issues into product development and business operations: increased efficiency in the use of resources, return on investment, increased sales, development of new markets, improved corporate image, product differentiation, and enhanced competitive advantage (Fraj-Andre’s et al., 2008; Miles and Covin, 2000; Miles and Munilla, 1993; Pujari et al., 2003; Shrivastava, 1995; York, 2009). For example, with a particular focus on green innovation, Chen et al. (2006) found that the performance of both green product and green process innovation is positively correlated to competitive advantage. In our case studies we found that the expectation of green market growth and increasing profits (such as in the case of company F) or the improvement of reputation and corporate image (such as in the case of company A) are important drivers of green product development.

Another motivation, common to several cases (such as in the case of companies B, L, and D), is ecological responsibility, deriving from the concerns that companies have for social obligations and values, and that often originates from an internal environmental orientation of the company or from the personal commitment of the top management. An important result is that different types of motivations often co-exist within the same company.

However, engaging in developing and marketing of green products is not without its challenges and risks in certain situations. One of the key risks of developing and marketing green products is an increased public scrutiny by stakeholders, particularly the environmental groups. Some companies may not find this situation comfortable. Developing customer awareness about green products is not difficult but customer attitude and customer behavior in buying and paying more for green products is not the same. Some product categories are more price sensitive than others when it comes to how much more customers want to pay for the green products. Further, several new green ventures and companies are founded on the expectations of continuing government subsidies which may not last, leaving the companies very vulnerable. Finally, betting on green product technologies that may achieve technical and commercial success is not without significant risks. Only some companies with deep pockets can afford to invest in multiple technologies but it is costly.

With regards to setting environmental policies and targets for the development of new products, companies acquire knowledge from a variety of sources. These environmental policies and targets are then formally defined and communicated by means of sustainability plans or ethical codes, which provide general directions for the reduction of products' environmental impact during the whole life cycle. Having investigated both radically new green products and incremental new green products in this study, we have highlighted how green product innovativeness (new to the world or new features with existing technology) can play an important role in addressing the environmental sustainability challenges. Since radical product innovation brings significant changes such as making old products obsolete, and permitting entire markets to emerge, transform, or disappear (Kaplan, 1999; Van de Ven et al., 1999), radical green products could greatly contribute to the achievement

of the environmental sustainability objectives. This, however, requires a systemic change in both infrastructure and consumers' behavior.

Another important aspect of green product innovation that is emphasized in this study is measuring product's environmental impact or performance which is rather a complex process. However, companies have started to embrace product's physical life cycle perspective in their product management operations. Companies in this study do believe in 'cradle to grave/cradle' philosophy, and use life cycle analysis tool to assess environmental impact of the products at each stage of the product's life cycle or at most impactful stages. One of the areas that have received an increased attention is green packaging (Kassaye and Verma, 1992; Sterling, 2008). Our interviews have shown that material reduction in packaging, packaging minimization and optimization, and the use of recycled or biodegradable materials are the main green initiatives that companies have undertaken to make product packaging sustainable. In future, packaging is likely to face more stringent regulations as well as greater scrutiny from the external stakeholders.

Finally, it is important to identify challenges that companies will have to overcome to achieve commercial success for green products. To achieve environmental sustainability, commercial or market success of green products at a mass scale is vital. Unless an increasing number of green products provide viable choices for customers and wrestle away market share from conventional products, developing green products will not have much impact. It is important to note that green products are unlikely to be able to sustain long-term success in the market unless they can demonstrate credible environmental performance without compromising functional benefits of the product. However, sometimes environmental attributes are often seen by companies as distinct from more traditional ones (Berchicci and Bodewes, 2005). Lack of capability in some companies to recognize that environmental attributes should be integrated with desired consumer value may lead to product failures (Ottman et al., 2006). From our interviews, it emerged that companies were more aware of the importance of integrating environmental and conventional product attributes, particularly quality and pricing which is an encouraging sign. Another challenge the companies face is a lack of

TABLE IV
A toolbox for green product innovation

Strategy	Dimensions	Challenges	Useful actions/activities	Useful tools	
Environmental policies	Environmental policies	Setting attainable environmental targets	Gathering information and knowledge from policy makers, the scientific world, society, universities, other companies creating a sustainability culture within the organization	Ethical code/sustainability plan specifying firm's environmental targets and policies	
		Avoiding trade-off between product quality and environmental benefits			Mission statement
		Employee engagement			
Process/design	Energy-based products	Alternative energy platform development	Build incentives/awards for employee engagement	Eco-design guidelines	
		Cost of development	Energy efficiency of the product in use		Extranets for green suppliers networks
Material-driven products	Material-driven products	Global sources	Products using renewable energy sources	Eco-design guidelines	
		Tracking of environmental credentials of suppliers	Reduction of size and weight		Extranets for green suppliers networks
		Availability of sustainable materials	Use of biodegradable materials	Supplier environmental audit	
		Technology development	Use of recycled materials	Eco-design guidelines	
Pollution-prevention products	Pollution-prevention products	Pollution reduction	Pollution prevention	Eco-design guidelines	
		Packaging	Reduction of size and weight		Eco-design guidelines
		Availability of sustainable material	Biodegradable		
Infrastructure/network for recycling	Infrastructure/network for recycling	Recycled	Recyclable		

TABLE IV
continued

Performance	Dimensions	Challenges	Useful actions/activities	Useful tools
	Environmental performance of products	Focusing on single life cycle phases Not many firms in a same industry display environmental performance of their products	Adoption of a life cycle perspective	LCA software suites Regulations making it mandatory to display environmental performance of products Ecolabels Ecolabels
	Market success of green products	Lack of customers' awareness	Highlighting the benefits of green products to the environment (associating a green message to the product) Establishing credibility through third party certification Absence of eco-labels for certain categories of green products (e.g. products related to renewable energy sources) Highlighting the benefits of green products to customers' wallet in the whole life cycle	Credible green marketing Extension of ecolabels to product categories
		Price not competitive with conventional offerings Perceived or real long pay-back Lack of integration of product environmental features with its functional attributes	More cross-functional collaboration in product development	Software showing energy savings in the lifecycle (for energy-based products) Government incentives Environmental intranet

awareness by customers, who are often not willing to pay a premium price for green product attributes. Sometimes, customers' awareness can be stimulated by means of eco-labels, which make green products clearly recognizable for customers, but creating credibility through eco-labels or third party certification will require stringent, scientific, and systematic internal processes to integrate and measure product's environmental impact at each life cycle stage. In this article, we have created a toolbox (see Table IV) which identifies key elements that are integral part of green product innovation—green product strategy, design/process, and performance. Several dimensions and useful activities for each of these elements are highlighted. This toolbox also identifies risks and challenges associated with developing green products as well as useful tools and solutions that will be helpful for managers to mitigate these risks.

Conclusions and implications

This article investigated green product innovation projects in companies that have pursued the path towards environmental sustainability. By using a qualitative methodology, the article provides insights on multi-faceted nature of green product innovation process involving both micro and macro environmental issues. This study advances our understanding on the green product development process, innovativeness of green products (radical versus incremental), and life cycle analysis as a tool for measuring environmental impact at each of stage of green products.

There are several implications that can be drawn from this study. This knowledge can help develop a theoretical framework to engage in future studies. First, this article enhances our knowledge on why and how companies integrate environmental sustainability into product development, explaining different types and dimensions of green products. This study provides preliminary evidence that different types of green products could require different approaches for integrating environmental sustainability. Future researchers can focus on investigating distinctive approaches and practices of green product innovation, by analysing innovativeness of green products, such as radical or incremental, and different types of green products such as material-driven, energy-based, or green products based on pollution-prevention.

Managers will be able to appreciate benefits as well as challenges and risks of engaging in green product innovation. Secondly, the study also provides possible solutions to mitigate these challenges and risks as shown in the toolbox. Thirdly, the study emphasizes the role of public policy that can play an active role in stimulating the demand for green products through subsidies and consumer rebate for the new emerging green markets, especially alternative energy markets. Finally, the article provides useful knowledge with regards to the use of life cycle assessment and environmental performance measurement which should spur more detailed studies in future.

Future studies may also look at green product programs in companies rather than focusing on individual green projects. A deeper understanding of green product portfolio management will further enhance our understanding of how companies are investing in green product technologies platforms to bring new green products to markets. Future studies should also investigate the impact of the size and scope of investments in green product technologies and the breadth of green product portfolio on firm's overall environmental impact, providing a more integrative approach towards environmental sustainability.

Notes

¹ <http://www.starbucks.com/SHAREDPLANET/environmentalInternal.aspx?story=greenerCups> (last accessed on October 2009).

² <http://h71036.www7.hp.com/hho/cache/605859-0-0-225-121.html> (last accessed on October 2009).

³ http://sustainablebrandsinternational.com/content/column/design/new_packaging_rules_in_china (last accessed on October 2009).

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Rosa Maria Dangelico

Department of Mechanical and Management Engineering,
Politecnico di Bari,
Bari, Italy
E-mail: r.dangelico@poliba.it

Devashish Pujari

DeGroote School of Business,
McMaster University,
1280 Main Street West, Hamilton,
ON L8S 4M4, Canada
E-mail: pujarid@mcmaster.ca