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CICLO XXIV

# **ENVIRONMENTAL MANAGEMENT IN OPERATIONS: ANTECEDENTS, STRATEGIES, PERFORMANCES**

**Direttore della Scuola:** Ch.mo Prof. Guglielmo Weber

**Supervisore:** Ch.mo Prof. Andrea Furlan

**Dottoranda:** Ambra Galeazzo

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# Introduction

In the last few decades, the natural environment has increasingly received attention among policy makers, media and the international community. In such a context, firms have approached the environmental issue by developing different strategies and adopting practices that contribute to pollution reduction, resources savings and, more generally, to green efficiency.

The present Ph.D. dissertation blends together the natural environment and operations management. As plants are the major responsible of pollution in the industry, this thesis aims at investigating their environmental choices and actions within the framework of manufacturing strategy. The thesis consists of three papers, each corresponding to a chapter. The first one addresses the environmental issue from a general perspective and defines the role of environmental strategy as long as the drivers underlying higher proactiveness; the second one deals with the environment as a competitive priority to understand which firm-related characteristics affect environmentally oriented manufacturing strategies; and the final one analyses the implementation of green and lean practices and the effects on plant performance.

More precisely, the first chapter investigates the concept of proactive environmental strategy (PES). The literature has defined this strategy as a set of voluntary practices that go beyond mere compliance with regulations. In order to examine this concept and provide a narrower definition of PES, I first propose that PES is composed of two dimensions: the technical/organizational dimension and the embeddedness dimension. Second, I propose a theoretical framework that allows identification of different typologies in a firm's environmental strategy. I finally outline the dynamics that drive shifts among PES typologies. In such a way, my final intention is to show that proactive environmental strategy is multidimensional and that there is not a unique definition of it, thus recommending an in-depth investigation of its position within the firm's strategy.

The second chapter allows understanding the role of the natural environment within the manufacturing strategy. Particularly, I analyse the effects of the organizational context on the emphasis that plant managers place on the environmental priority compared to the competitive priorities of cost, quality, delivery, flexibility and innovation. A multinomial logit model is used to explore whether and to what extent the organizational context, proxied by plant- and supply chain-related characteristics, influences three clusters of different manufacturing strategic patterns: environmental-oriented group, balanced set group, and cost-oriented group. Data is collected from a survey of manufacturing plants from Canada in the fabricated metal products, machinery, electronics, and electrical appliances industries. The results highlight that the organizational context affects the emphasis managers put on the environmental issue. In particular, they show that an international supply chain leads the plant to adopt an environmental oriented strategy. This might be explained by arguing that plants are more exposed to environmental risks caused by their international stakeholders, thus threatening their image or raising the chances to monetary fines.

The final chapter analyses environmental management from a more operational perspective. Specifically, it contributes to the exploration of how lean and green practices might fit together to improve competitiveness. The relationship of lean manufacturing and environmental performance on the one side, and environmental management and operational performance on the other side, has widely been investigated but final benefits are still uncertain. Anyway, several researches have shown that some lean and green practices actually synergistically interact to improve plant performance. Using a case study methodology, the present paper aims to understand how the two sets of practices interact together and how they affect operational and environmental performance. Based on the analysis of three successful projects of two Italian plants, I find that the timing of implementation, i.e. sequential *vs* simultaneous, defines modes of managing lean and green practices, i.e. planning *vs* mutual adjustment, that ultimately affect plant performance. Finally, the findings identify what drivers foster lean practices and green practices to be synergic and jointly produce a positive impact on both environmental and operational performance.

# Introduzione

Negli ultimi decenni, l'ambiente è stato al centro di un crescente interesse tra regolamentatori, media e comunità internazionali. In tale contesto, le aziende si sono ritrovate ad affrontare la questione ambientale attraverso lo sviluppo di strategie e l'implementazione di pratiche atte a ridurre l'impatto inquinante, l'uso di risorse e, in generale, ad accrescere la propria efficienza in ottica *green*.

La presente tesi di dottorato ha lo scopo di analizzare congiuntamente la questione ambientale e le *operations*. Questo tema è particolarmente interessante perché prende in considerazione le fabbriche, ovvero le principali responsabili di inquinamento, allo scopo di investigarne le scelte e le azioni ambientali nell'ambito della strategia manifatturiera. La tesi è formata da tre articoli, ognuno dei quali corrisponde ad un capitolo. Il primo tratta della questione ambientale partendo da una prospettiva generale e definendo qual è il ruolo della strategia ambientale e quali sono i fattori determinanti per accrescerne la proattività; il secondo considera l'aspetto ambientale come una possibile priorità competitiva e cerca di individuare i fattori legati alle caratteristiche dell'azienda che incidono su una strategia manifatturiera orientata alla protezione dell'ambiente; infine, l'ultimo capitolo esplora il processo di implementazione di pratiche *lean* e *green* nelle fabbriche e l'effetto che questo produce sulle *performance*.

In particolare, il primo capitolo analizza il concetto di strategia ambientale proattiva (SAP). La letteratura ha definito questa strategia come un insieme di pratiche volontarie che non si limitano ad applicare le norme in materia ambientale. Allo scopo di formulare una puntuale definizione, dapprima identifico le dimensioni di SAP: una dimensione tecnica e organizzativa e una dimensione di intensità relazionale. Secondo, propongo una struttura teorica che permetta di individuare differenti tipologie di strategia ambientale. Infine, provo a delineare le spinte dinamiche che sono alla base dei cambiamenti tra una tipologia di SAP e l'altra. In questo modo, metto in evidenza che la

strategia ambientale proattiva è multidimensionale e che non può essere definita univocamente, rendendo pertanto opportuno capirne il ruolo all'interno della strategia aziendale.

Il secondo capitolo affronta il tema dell'ambiente naturale nell'ambito della strategia manifatturiera delle aziende. In particolare, lo scopo è analizzare gli effetti del contesto organizzativo sull'enfasi che i *managers* pongono sulla priorità ambientale con rispetto alle tradizionali priorità competitive di costo, qualità, consegna, flessibilità e innovazione. Grazie a una regressione logistica multinomiale, indago la relazione tra il contesto organizzativo, espresso in termini di caratteristiche dell'azienda e della catena di fornitura, e tre diverse possibili strategie manifatturiere: strategia orientata al sostegno ambientale; strategia orientata alla riduzione dei costi; e strategia con simile enfasi su tutte le priorità competitive. L'analisi empirica si basa su un campione di aziende manifatturiere canadesi operanti nei settori dei metalli, dei macchinari, dell'elettronica e delle apparecchiature elettroniche. I risultati dell'analisi evidenziano che il contesto organizzativo influisce sull'enfasi che i *managers* decidono di dare alla sostenibilità ambientale. Infatti, essi mostrano che quanto più la catena di fornitura si estende internazionalmente, ovvero i clienti e i fornitori sono dispersi in diverse aree geografiche, tanto più l'azienda adotta una strategia manifatturiera che pone enfasi sulla protezione dell'ambiente naturale. Questo è probabilmente motivato dal fatto che un'azienda ha maggiore difficoltà a controllare i potenziali rischi ambientali causati dai propri *stakeholders* operanti in diverse aree geografiche, dai quali possono derivare sanzioni pecunarie su pezzi importati non conformi alle norme e/o un danno alla propria visibilità a livello globale.

L'ultimo capitolo affronta il tema della gestione ambientale da una prospettiva esclusivamente operativa. Nello specifico, questo articolo contribuisce a esplorare come le pratiche di *lean management* e le pratiche di *green management* possono essere implementate insieme per migliorare la competitività. La relazione tra *lean manufacturing* e *performance* ambientale da un lato, e tra gestione ambientale e *performance* operativa dall'altro, è stata ampiamente studiata ma senza arrivare a una visione univoca dei benefici che ne derivano. Tuttavia, un certo numero di ricerche hanno mostrato che alcune pratiche di *lean* e *green* sono complementari. Basandosi sulla metodologia dello studio di caso, il presente articolo ha lo scopo di capire come i

due insiemi di pratiche interagiscono tra di loro e producono effetti sulle *performance* operative e ambientali. Attraverso l'analisi di tre progetti di successo di due aziende italiane, identifico che il *timing* di implementazione, sequenziale vs simultaneo, definisce le modalità di gestione delle pratiche da adottare – pianificazione vs mutuo aggiustamento. Questo aspetto ha un effetto significativo sulle *performance* dell'azienda in quanto l'approccio simultaneo porta a risultati maggiori rispetto all'approccio sequenziale. Infine, l'analisi dei casi mi permette di individuare i *drivers* che influenzano la relazione tra pratiche *green* e *lean* nell'implementazione di progetti ambientali.





# **Chapter 1**

## **UNPACKING THE BLACK BOX OF PROACTIVE ENVIRONMENTAL MANAGEMENT: A CONCEPTUAL MODEL**

### **1.1 Introduction**

Firms have increasingly paid attention to a particular typology of environmental strategy—the proactive environmental strategy (PES). Since the works of Porter and van der Linde (1995), Shrivastava (1995), and Klassen and McLaughlin (1996), PES has been related to positive benefits for the firm, such as upgraded international reputation, increased efficiency, and higher competitive advantages (Florida, 1996; Russo and Fouts, 1997; Klassen and Whybark, 1999a). Thus, to understand this relationship, researchers have focused their investigation on mainly the underlying reasons and the extent to which PES benefits the firm and its corporate strategy (King and Lenox, 2001; Melnyk et al., 2003; Zeng et al., 2010).

The extant literature shows that PES differs from a reactive environmental strategy in that it entails practices that a firm voluntarily adopts in order to protect the natural environment (Aragon-Correa, 1998; Sharma, 2000; Buysse and Verbeke, 2003). Compared with reactive strategies, environmental proactiveness is conducive to higher economic and environmental outcomes (Klassen and Whybark, 1999a; Gonzalez-Benito and Gonzalez-Benito, 2005). Specifically, PES fosters the development of rare, unique resources and capabilities that enable more flexibility, continuous improvement, and innovation (Hart, 1995; Sharma and Vrandenburg, 1998; Sharma and Henriques, 2005). Moreover, PES allows firms to respond better to

stakeholders' interests, which leads to higher levels of risk taking and improved ability to deal with international businesses, thanks to the multiple relationships that proactive environmental firms foster. The result is a better reputation in the market (Cespedes-Lorente et al., 2003; Martin-Tapia et al., 2010). Therefore, PES is strongly related to positive outcomes, and its implementation has been shown to improve overall firm performance ( e.g. Klassen and Whybark, 1999a).

Although the research on environmental management has made significant progress in investigating PES, some key questions about the conceptualization of this strategy remain unanswered. Specifically, while past research has made a strong case for the importance of assessing the relationship between proactive environmental strategies and performances, researchers have generally paid less attention to the definition of PES. Generally, it encompasses a set of voluntary practices that go beyond mere compliance with environmental regulations (Aragon-Correa and Rubio-Lopez, 2007). These practices include a wide range of actions and decisions, but it is unclear whether they should be considered the same or differently. More precisely, researchers have highlighted only aspects of proactive environmental strategies that are relevant to their study, thus eluding a more comprehensive and categorical definition.

However, this approach has two potential problems. First, a common feature of the treatment of PES in the literature has been the lack of a unique definition to characterize it. For example, Aragon-Correa (1998) proposed that “firms with the most proactive business strategies employed both traditional corrective and modern preventive natural environmental approaches,” thus associating PES with technological portfolios. Klassen and Whybark (1999a) stated that “continuous improvement and stakeholder integration might enable proactive environmental policies,” by recognizing the central role of innovative capabilities and relationship management skills. Other studies, instead, have defined proactive environmental strategies as the capability of coordinating and integrating heterogeneous resources that both reduce pollution and improve firm performance (e.g., Christmann, 2000; Hart, 1995; Sharma and Vredenburg, 1998). Although there is a common thread, we suggest that a systematic revision of the definition of PES might provide a better identification of its dimensions.

Second, several researchers have assumed that environmental strategies develop progressively along a linear path ranging from reactivity to proactivity (Hunt and Auster, 1990; Roome, 1992). For example, Murillo-Luna et al. (2008) asserted that “patterns of environmental response differ in their degree of proactivity, that is, in their tendency to anticipate needs (related to environmental protection),” thus assuming that firms move gradually from reaction to proactive environmental regulations for higher commitment to the adoption of advanced environmental initiatives. This suggests that PES has been identified mostly as a unidimensional concept that aggregates different voluntary practices. According to this concept, the frequent implementation of one practice is a sufficient condition to demonstrate the frequent implementation of the whole set of practices. We therefore intend to investigate this condition and show that PES entails multiple dimensions that do not move along a linear horizon.

This study aims to advance the conceptualization of environmental proactiveness in two ways: by developing a theoretical framework that articulates its multidimensionality; and by exploring the implications of this framework for understanding the dynamics among the different typologies of environmental proactiveness. The first part of the model highlights the two dimensions underlying PES, i.e., the organizational/technological dimension and the embeddedness dimension. The second part of the model provides a definition of PES based on the role it assumes with respect to the overall business strategy, following the framework of Hayes and Wheelwright (1984). Next, we analyze the driving factors that motivate the dynamics of the different typologies of PES by advancing three propositions. Finally, we conclude with the discussion and the implications of our framework for managerial practice.

## **1.2 Proactive Environmental Strategy in Management Research**

In the last few decades, the management literature has proposed different definitions of environmental strategy. Carroll (1979) and Wartick and Cochrane (1985) defined corporate social responsibility as reactive, defensive, accommodative, and proactive. Subsequent researchers analyzed various typologies of environmental strategy. Hunt and Auster (1990) categorized environmental program development in five steps: beginner, firefighter, concerned citizen, pragmatist, and proactivist. In addition,

Roome (1992) proposed identifying firms according to their environmental stance. First, he outlined the noncompliance category, which encompasses firms with no environmental protection policy. Second, his compliance category referred to firms that undertake environmental actions to abide by regulations. Third is the compliance-plus category, which comprises firms with a slightly higher commitment to the environmental cause. Fourth, the commercial and natural environmental excellence category concerns firms that adopt a set of pollution prevention practices and managerial systems that increase the environmental commitment of the organization. Fifth, the leading edge category comprises firms whose environmental position is outstanding with respect to others.

It is interesting to notice how the literature has identified PES. Table 1 lists some examples. Klassen and Whybark (1999a) showed that proactive environmental strategies are linked to a greater use of pollution prevention technologies and thus form a set of practices that aim to re-engineer and re-design existing processes and products. Other researchers have instead drawn on resource based view (RBV) to provide a definition, thus identifying PES as a firm capability (e.g., Hart, 1995; Judge and Douglas, 1998; Christmann, 2000). Some studies proposed that proactive environmental strategies encompass a set of resources and capabilities that range from creative problem solving to the introduction of innovative technologies (Russo and Fouts, 1997) and the adoption of collaborative interactions with stakeholders (Sharma and Vredenburg, 1998). For example, Verbeke and Buysse (2003) advanced a definition of PES that is based on distinctions among reactive strategy, pollution prevention, and environmental leadership. Specifically, they found that reactive strategies show lower levels of particular resources and capabilities compared with the other two strategies. All these examples provide evidence that the extant literature has therefore identified PES by considering only some of its characteristics without providing a systematic synthesis of them.

Table 1 Definitions of Proactive Environmental Strategy in Literature

<b>Example Studies</b>	<b>Research Topic</b>	<b>PES Definition</b>
Hunt and Auster (1990)	Taxonomy	Classification of environmental strategies into five categories: beginner, firefighter, concerned citizen, pragmatist, and proactivist
Hart (1995)	The role of resources in environmental strategy	Three environmental strategies: 1) pollution prevention, relative to process; 2) product stewardship; 3) sustainable development.
Porter and van der Linde (1995)	The relationship between environmental goals and firm competitiveness	"Proactive environmental strategies are more innovative, entrepreneurially oriented, technologically sophisticated, and socially conscious, which makes such organizations distinct in the eyes of customers"
Russo and Fouts (1997)	Typology	"Proactive policies translate into internal competitive advantages"
Aragon-Correa (1998)	Taxonomy	"The firms with the most proactive business strategies ("prospectors") employed both traditional corrective and modern preventive natural environmental approaches"
Sharma and Vredenburg (1998)	The competitive benefits associated with environmental proactive strategies	"The proactive firms exhibit a consistent pattern of voluntary actions over time". Dimensions considered: material use reduction and conservation, use of alternative fuels, energy conservation, less environmentally damaging products, stakeholder partnerships for environmental preservation, public disclosure, and commitment to research and employee training programs for environmental preservation.
Klassen and Whybark (1999a)	The relationship between proactive environmental strategies and operations technology portfolio	"Proactive environmental orientation is operationalized by environmental technologies, defined as those that limit or reduce the negative impacts of a product or service on the natural environment" (..) There are three general categories of environmental technologies: pollution control technologies, pollution prevention technologies, and management systems".
Klassen and Whybark (1999b)	The relationship between environmental proactiveness and manufacturing performance	"Proactive pollution prevention relies on strategic resources and thereby can deliver sustainable competitive advantage, is the opposite of reactive pollution control, which cannot impart competitive advantage".

Table 1: continued

Example Studies	Research Topic	PES Definition
Sharma (2000)	The relationship between the managerial perception of environmental strategy and the implementation of proactive environmental strategies.	"A voluntary environmental strategy represents a consistent pattern of company actions taken to reduce the environmental impact of operations. Such actions would be the product of a wide range of organizational and managerial choice. They range from pollution prevention to habitat preservation, voluntary restoration, reduction in the use of unsustainable materials and fossil fuels, and increased use of environmentally friendly technologies."
Aragon-Correa and Sharma (2003)	The relationship between business environment and proactive environmental strategy	They characterize a proactive environmental strategy as a dynamic capability. "Proactive strategies such as pollution- prevention approaches need to be integrated into the administrative, entrepreneurial, and engineering dimensions of a firm".
Buysse and Verbeke (2003)	The role of stakeholders in the impact on environmental strategy	Three clusters of environmental strategies: reactive - pollution prevention - environmental leadership.
Sharma and Henriques (2004)	The relationship between different types of stakeholders and different types of sustainable practices	"Proactive strategies include eco-efficient strategies for reducing wastes, materials and energy use and preventing pollution at sources via the redesign of processes and products"
Gonzalez-Benito and Gonzalez-Benito (2005)	The relationship between environmental proactivity and business performance	"Environmental proactivity, typical of companies that voluntarily take measures to reduce their impact on the natural environment.(...) A multi-dimensional view of environmental proactivity made of 1) planning and organization practices, 2)logistics processes, 3)product design attributes and 4) internal production processes".
Clemens and Douglas (2006)	The relationship between superior firm resources and voluntary green initiatives	"PES is defined as voluntary green initiatives. These are not required by the government and arise from the belief that the initiatives can be good for firms and the environment."
Sharma et al. (2007)	The influence of externally-focused capabilities and the managerial perception of uncertainty on environmental proactivity	"Proactive environmental strategy include capabilities such as organizational teaming, shared vision, cross-functional integration, stakeholder engagement, strategic proactivity, and continuous innovation"

Table 1: continued

Example Studies	Research Topic	PES Definition
Murillo-Luna et al. (2008)	The relationship between stakeholders and resources underlying PES	PES is defined as drawing from stakeholder pressures. Four types of environmental response pattern: passive response, attention to legislation response, attention to stakeholders' response, and total environmental quality response. Each of these patterns represents a specific and internally consistent configuration of both the scope of environmental objectives and the allocation of internal resources to achieve them.
Darnall et al. (2010)	The perception of environmental stakeholder groups by firms	"Proactive environmental practices are intangible managerial innovations and routines that require organizational commitments towards improving the natural environment and which are not required by law"
Lopez-Gamero et al. (2010)	Relationship between voluntary norms/ command-and-control norms and manager perceptions	Two groups of items to measure the pro-activeness of the environmental management. The first category was related to organizational aspects of environmental management, and the second group was related to technical aspects.
Menguc et al. (2010)	Beneficial effects of proactive environmental strategies on performance	"PES as a top management-supported, environmentally oriented strategy that focuses on the prevention (versus control or the reactive using of an end-of-pipe approach) of wastes, emissions, and pollution through continuous learning, total quality environmental management, risk taking, and planning"
Martin-Tapia (2010)	The relationship between PES and export in SMEs	"Proactive environmental strategies are designed to voluntarily avoid environmental impacts by dealing with their sources"
Ramanathan et al. (2010)	The relationship among regulations, innovation and performance	"The environmentally proactive firms have met the demands of environmental regulation generally by introducing innovations in their products, production and managerial processes"
Sharma and Sharma (2011)	The relationship between family and family firms environmental attitude	"Proactive environmental strategies (PES) focus on environmental preservation practices for reducing waste, energy, and material use at source, which are also known as pollution prevention"



In general, PES has been identified as the top extreme of a continuum ranging from reactive practices to higher levels of voluntary practices. Despite several attempts to provide a taxonomy of environmental strategy (e.g., Dillon and Fisher, 1992; Roome, 1992; Hart, 1995; Aragon-Correa, 1998), the final result has been that a proactive environmental strategy can assume any characterization as long as it includes a pattern of actions that a firm voluntarily undertakes to reduce its environmental impact. It seems that any accumulation of these practices determines a proactive posture in an environmental strategy. Thus, it can be helpful to advance a different perspective in the investigation of proactive environmental strategies while reducing the number of definitions that the extant literature has created.

### **1.3 Proactive Environmental Strategy as a Multidimensional Concept**

Aragon-Correa (1998) criticizes the idea that PES is unidimensional and moves from reactivity to higher levels of proactivity. He advances an alternative definition of PES based on three strategic dimensions—entrepreneurial, engineering, and administrative. The entrepreneurial dimension encompasses choices about products, markets, and ways of competing. The engineering dimension refers to process technologies in the production function. The administrative dimension comprises choices about structures and organizational processes for fostering environmental innovation.

Bansal and Roth (2000) also suggested that environmental strategies can be outlined by drawing on different dimensions, such as the degree of competitiveness a firm wants to attain, which is assessed by the degree of implementation of practices such as ecolabeling, green marketing, ecoproducts and environmental management systems; the search for legitimization, which includes the adoption of voluntary regulation programs and other socially legitimated practices; and, finally, the level of social responsibility, which encompasses practices with a social objective, such as donations to environmental interest groups and other local community groups.

This multidimensional view of PES has been further proposed by other researchers. Table 2 lists some of these works. Most previous studies have used a resource-based view to identify the dimensions characterizing PES.

Table 2. Some Examples of the Multiple Dimensions in Proactive Environmental Strategies

Example Studies	Dimensions	Categories
Aragon-Corea (1998)	Information and education; traditional/regulated correction; modern/voluntary prevention	Environmental Excellence Category; Leading Edge Category; Compliance Category; Compliance Plus Category; Noncompliance Category.
Klassen and Whybark (1999b)	Environmental management orientation and environmental technology investments	Leadership, Compliance, Opportunistic
Dillon and Fischer (1992)	1) systems analysis and planning, 2) organizational responsibility, and 3) management controls	Reactive vs. Proactive Environmental Orientation
Hunt and Austen (1990)	Commitment of organization; program design; integration with companies; reporting to top management; reporting structures Involvement with legal counsel/public relations/manufacturing and production/product design	Beginner, firefighter, concerned citizen, pragmatist, and proactivist
Hart (1995)	1) Competences related to green products and manufacturing processes; 2) employee involvement; 3) stakeholder integration; 4) fostering a shared vision	1) End-of-pipe approach; 2) pollution prevention or total quality management (TQM); 3) product stewardship; 4) sustainable development.
Nehrt (1996)	Timing of investment and intensity of investment	1) asset mass efficient and first mover; 2) early mover but lacks asset mass efficient; 3) asset mass efficient but time compression diseconomies; 4) follower
Buyse and Verbeke (2003)	1) Investments in conventional green competencies; 2) investments in employee skills; 3) investments in organizational competencies; 4) investments in formal (routine-based) management systems and procedures; 5) strategic planning process.	Reactive strategy, pollution prevention, environmental leadership

Since the work of Hart (1995), in which RBV was integrated with the natural environment, resources and competences have helped identify the underlying dimensions of PES. Hart distinguished four types of resource-based environmental approaches: the end-of-pipe approach, the pollution prevention or total quality management (TQM) approach, the product stewardship approach, and the sustainable development approach. According to Hart, resources and capabilities that enable differentiating among these approaches are the following: competences related to green products and manufacturing processes; ability to involve employees in the development of environmental strategies; competences in integrating both internal and external stakeholders; and, finally, the ability to foster a shared vision supporting green practices.

As briefly outlined, RBV offers an in-depth approach to investigating the internal key sources of a sustainable competitive advantage (Barney, 1991; Barney and Hansen, 1994). Indeed, it helps identify firm-specific organizational resources and capabilities that are valuable, costly-to-copy, and rare, thus providing a tool for understanding a firm's strategy. Drawing from the literature on the natural resource-based view (Hart, 1995; Judge and Douglas, 1998; Sharma, 2000; Carmona-Moreno et al., 2004; Sharma and Henriques, 2004; Murillo-Luna et al., 2008), we propose to group the several dimensions highlighted in the previous literature to only two dimensions by gathering common characteristics. Therefore, the next sections will present the dimension related to the technical and organizational capabilities of environmental management, and the dimension related to the degree of embeddedness of environmental management in the firm's overall business practices.

### *1.3.1 Technical and organizational environmental capabilities*

Klassen and Whybark (1999a) showed that a proactive environmental orientation drives the adoption of pollution prevention technologies. In his study, Aragon-Correa (1998) argued that prospectors, i.e., firms with the highest degree of PES, adopt both pollution prevention technologies and pollution control technologies. The natural resource based view (NRBV) approach also emphasized that proactive firms need technical competences if they want to undertake voluntary environmental practices. Indeed, waste minimization programs, design of green products, reduction in the use of unsustainable materials, and other proactive practices all require a certain technical knowledge (e.g.,

Hart, 1995; Darnall and Edwards, 2006). It is thus necessary to have access to technical resources and competences in order to adopt and develop proactive environmental practices.

Sharma et al. (2007) showed that the literature on organizations and the natural environment identified several capabilities that accompany a proactive environmental strategy. These include organizational teams, implementation of environmental policies, utilization of internal assessment tools (e.g., benchmarking and accounting procedures) shared vision, cross-functional integration, stakeholder engagement, strategic proactivity, and continuous innovation (e.g., Russo and Fouts, 1997; Aragon-Correa, 1998; Marcus and Geffen, 1998; Henriques and Sadorsky, 1996). Proactive environmental practices thus encompass an organizational aspect that enables the firm to make environmental strategic decisions that are not technically focused.

The degree of technical and organizational capabilities a firm possesses allows for understanding the scope, depth, and complexity of the implementation of proactive environmental practices within the organization. These capabilities indicate the actual and potential development a proactive environmental strategy may realize. Indeed, both technical and organizational aspects are important in the characterization of a firm's environmental posture. We thus propose that the intensity of their combined presence explains the degree of environmental proactiveness within a firm.

### *1.3.2 The level of embeddedness in business strategies*

The ultimate goal of firms is to improve their overall corporate performance continuously. According to the RBV literature, achievement of this goal is possible when resources are able to create competitive advantages by leveraging isolating mechanisms (Rumelt, 1984), such as time-compression diseconomies, historical uniqueness, embeddedness, and causal ambiguity (Barney, 1991; Dierickx and Cool, 1989; Peteraf, 1993). In his study, Hart (1995) identified how embeddedness works in the relationship between existing firm competences and different environmental strategic approaches. For example, he suggested that firms that have already developed capabilities in TQM are more likely able to deploy resources related to pollution prevention than firms without such prior capabilities. Similarly, researchers in lean and green management have proposed that lean organizations are more likely to undertake

environmental practices because of their possible complementary effects (Florida, 1996; Rothenberg et al., 2001). Because a firm's first objective is to realize better performances, proactive environmental strategies can thus provide some contribution by integration with the firm's existing strategies.

Clemens and Douglas (2006) found a significant and positive relationship between superior firm resources and voluntary green initiatives by predicting that firms with proactive environmental strategies may have developed capabilities that successfully interrelate with other resources and competences. In addition, Christmann (2000) stressed that the joint presence of environmental and organizational competences can positively affect overall performance. In particular, she found that proactive environmental strategies should be implemented together with complementary assets that enable the firm to gain a competitive advantage. Therefore, the more that environmental practices and other strategic practices are implemented jointly, the greater the benefits for which a firm can strive.

Aragon-Correa and Rubio-Lopez (2007, p. 358) stated, "the degree of a firm's environmental strategic proactivity is correlated with its general level of strategic proactivity." In the same vein, Porter and van der Linde (1995) emphasized that firms deploying their capabilities of strategic proactivity and continuous innovation tend to undertake proactive environmental practices. Thus, the more that firms accumulated competences relate to environmental management find possible interrelationships with resources they already possess, the more they will be prone to broader the applicability of environmental practices within the firm. This direct relationship also implies that the greater the interconnection between environmental practices and the overall business strategy, the more likely it is that managers will be able to justify a proactive environmental posture and therefore implement innovative environmental strategies more easily.

Therefore, we maintain that one dimension of environmental proactivity can be measured by the degree of embeddedness of environmental practices with other strategic practices. Indeed, embeddedness refers to the degree of interrelations between resources and capabilities that a firm is able to develop in order to increase its competitive advantage. We thus propose that higher levels of embeddedness provide an explanation of the integration of resources and capabilities underlying environmental

proactive strategies with those of other firm strategies in marketing, operations, and other functional areas.

#### 1.4 A New Definition of PES Based on its Role in Strategic Management

To provide a definition, we borrow Hayes and Wheelwright's (1984) model in operations management because it offers an important theoretical perspective on the categorization of PES. Indeed, its main contribution has been to identify the pattern of choices related to operations management by highlighting its role in the overall business strategy (Skinner, 1969). Following the same reasoning, we intend to provide a definition of PES that enables the understanding of its role within the whole business strategy. Drawing on the two dimensions of proactive environmental management—the technical/organizational aspect and the embeddedness aspect—we propose a precise and consistent configuration of the different degrees of proactivity based on the relative role of PES in the firm's overall strategy. This taxonomy is thus appropriate to mark the systematic differences within PES as it does not define the level of proactiveness in the gradually higher accumulation of resources, competences, and/or increased investments (Buysse and Verbeke, 2003; Lopez-Gamero et al., 2010). Instead, it facilitates a more general definition of PES that compares advanced environmental postures within the firm's business strategy.

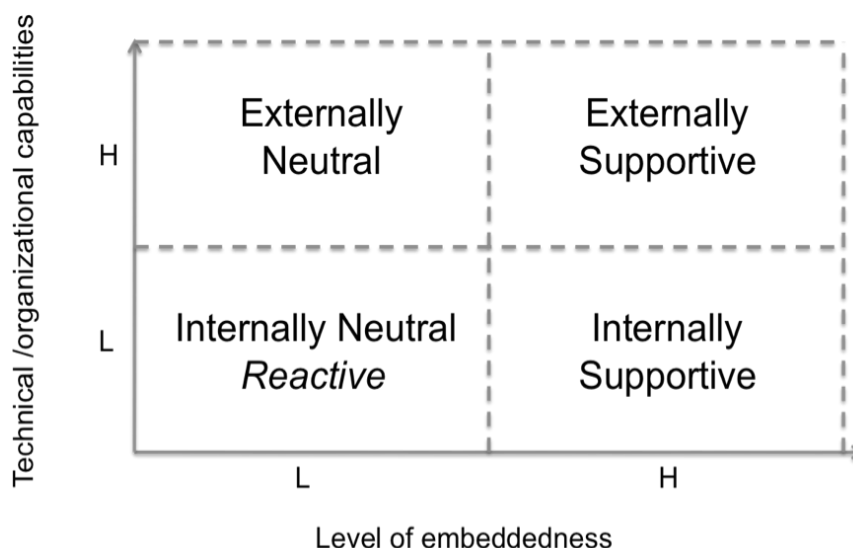


Figure 1. Model of a Proactive Environmental Strategy

### *Internally neutral category*

The internally neutral category includes firms with a low implementation of environmental practices within the organization. These firms do not show any involvement in environmental issues, and environmental protection is not an objective of the organization's functions. Technical practices of pollution control and remediation are adopted (Hart, 1995; Klassen and Whybark, 1999b; Menguc et al., 2010) so that minimal structural changes affect the product and manufacturing processes (Angell and Klassen 1999; Klassen and Whybark, 1999a). They are traditionally implemented in response to the pressures of environmental regulations (Hunt and Auster, 1990; Buysse and Verbeke, 2003). From an organizational perspective, the scarcity or lack of involvement of people and/or managerial routines precipitates environmental measures to avoid pollution abatements.

### *Externally neutral category*

The externally neutral category includes firms with environmental strategies that are voluntarily undertaken to replicate competitors' best practices. More precisely, these firms follow environmental standards that are broadly adopted in their industry and are therefore socially accepted as a minimum prerequisite (Di Maggio and Powell, 1991; Vastag and Melnyk, 2002; Bansal and Hunter, 2003). Among such standards, there might be environmental certifications such as EMS and ISO 14001, which easily allow public recognition and legitimization (Sastry et al., 2002). Technical and organizational capabilities are both well developed as these standards are "a formal system of articulating goals, making choices, gathering information, measuring progress, and improving performance" (Florida and Davison, 2001, p. 64) that require both ability and effort to be implemented within the organization (Gonzalez-Benito and Gonzalez-Benito, 2008). Although resources might be embedded, they are normally narrowed to one or few functions, such as the joint implementation of ISO 9000 and ISO14001 (King and Lenox, 2001; Vastag, 2004). In such instances, there is no search for developing and implementing the resources and capabilities necessary to meet the firm's environmental, operational, and economic issues. Instead, the emphasis is on avoiding potential environmental threads that might undermine external legitimacy (Darnall et al., 2008).

### *Internally supportive category*

The internally supportive category refers to firms that aspire to capturing new ideas to develop resources and capabilities in order to support their corporate strategy. These firms show strategic proactivity that is embedded in routines and processes to identify opportunities for improvement (Barney, 1991; Teece et al., 1997). In particular, they leverage their own routines and processes to undertake new initiatives, such as those involving environmental protection. Thus, the environmental issue is seen as a potential dimension to the improvement of corporate performance.

Rothenberg et al. (2001) found that firms adopting advanced manufacturing techniques are more likely to implement environmental practices because of complementary opportunities, such as the case of TQM and pollution prevention technologies (Hart, 1995). Furthermore, Christmann (2000) showed that capabilities in the areas of process innovation and implementation are necessary for the successful adoption of environmental practices, which ultimately affect cost advantages positively. Therefore, firms in this category acknowledge that pollution reductions lead to higher efficiency and waste abatements, but they do not possess enough technical and organizational capabilities to develop the environmental practices that would reap these benefits. Thus, they commonly proactively embed green issues into their corporate strategies (Aragon-Correa, 1998; Sharma et al. 2007) in order to generate a proactive environmental attitude.

### *Externally supportive category*

The externally supportive category includes firms that include environmental protection as a prominent objective in their business strategy. In this category, an environmental strategy is a priority. All functions are involved in developing environmental and complementary assets with the ultimate goal of reducing the impact of pollution by the firm (Hunt and Auster, 1990). It is more likely that primary and secondary stakeholders play an important role in generating and developing knowledge and learning related to the environment. Thus, they create and diffuse a shared vision about green products and processes (Hart, 1995). These firms capitalize on well-developed technical and organizational environmental capabilities, such as process and manufacturing environmental competencies, management systems, and planning (Aragon-Correa,



1998; Buysse and Verbeke, 2003) in order to foster the embeddedness of environmental strategies both inside and outside the organization.

### **1.5 Dynamics of Proactive Environmental Strategies: the Driving Factors**

An important aspect arising from the multidimensional definition of environmental proactive strategies is the possibility of understanding what motivates firms to move to a different typology of PES.

The theoretical framework we present here opens a debate on the investigation of whether PES moves along a unidimensional horizon, or, on the contrary, develops a non-linear path ranging from reactivity to proactivity. Indeed, previous research identified several potential drivers that explain the shift from a reactive approach toward a proactive environmental strategy (e.g., Bansal and Roth, 2000; Bansal and Hunter, 2003; Buysse and Verbeke, 2003). For example, Buysse and Verbeke (2003) maintained that firms adopt environmental strategies in response to the type of pressures they perceive. In particular, they found that the reactive environmental approach is implemented to gain external legitimization. However, it remains unclear whether the move from reactivity to proactivity is solely linear. Furthermore, the driving factors that motivate firms to shift to higher degrees of proactivity also need clarification.

The extant literature has relied on both institutional theory and the resource based-view to explain what motivates the implementation of environmental strategies. Specifically, the former proposes that firms that are willing to gain legitimacy among stakeholders are more interested in adopting voluntary environmental practices that are externally visible, such as eco-labeling and international certifications (Delmas and Toffel, 2004; Bansal and Clelland, 2004). The latter suggests that firms willing to leverage their complementary assets and/or to improve their internal efficiency are more likely to adopt environmental practices involving creative problem solving, continuous innovation, higher collaborative capabilities, and rapid learning processes, among others (e.g. Shivastrava, 1995; Russo and Fouts, 1997; Sharma and Vredenburg, 1998; Lopez-Gamero et al., 2008). By identifying the driving factors that guide the adoption of strategies, we might be able to highlight the role of PES in the firm's overall business, therefore providing an opportunity to understand the dynamics of different PES typologies.

### *1.5.1 From reactive to externally neutral environmental strategy*

Institutional theory suggests that firms tend to adopt a mimicry approach by replicating the best practices of competitors and avoiding the risk of potentially damaging exposure to the public (Di Maggio and Powell, 1983). In the case of an environmental strategy, this situation leads firms to undertake symbolic actions that are necessary, rather than voluntary, for gaining external legitimacy (Bansal and Hunter, 2003).

The decision by pollutant firms to adopt environmental practices to improve their image requires them to move from a stance that is environmentally reactive toward a more proactive position. They need to acquire or develop environmental, technical, and/or organizational capabilities for implementing proactive practices within one or more functions. Indeed, environmental certifications comprise general guidelines, rather than specific recommendations, for reducing environmental waste and pollution emissions in the manufacturing process and the managerial system. Certification requires firms to set up environmental goals and targets, introduce control, monitoring and measurement tools, and implement continuous innovation procedures, among others (Vastag and Melnyk, 2002; Jiang and Bansal, 2003).

Nonetheless, firms moving to the externally neutral category do not perceive that the adoption of an environmental strategy is important to the overall business. Thus, they are not interested in utilizing their environmental technical and organizational capabilities throughout the entire organization. For example, Darnall et al. (2008) showed that firms implementing EMS do not necessarily understand the potential synergies that environmental capabilities can create by jointly utilizing them with existing strategic resources. Thus, they do not appear to grasp the benefits for business. In addition, Boiral (2011) found that the implementation of ISO14001 certification might be associated with several potential drawbacks if there is no intent to implement it properly, such as when managers do not perceive opportunities of improvement throughout the entire organization.

Therefore, we propose the following:

*Proposition 1: Ceteris paribus, a shift from a reactive to an externally neutral environmental strategy, draws on the improvement of technical and organizational environmental capabilities that enable external legitimization.*

### *1.5.2 From a reactive to an internally supportive environmental strategy*

The previous literature has indicated that a firm's complementary assets are conducive to the successful adoption of environmental practices (Christmann, 2000; Lopez-Gamero et al., 2008; Sharma et al., 2007). In particular, Aragon-Correa (1998) highlighted that firms with proactive strategies are more likely to implement an environmental technology portfolio to a higher degree. It follows that firms recognize the benefits related to incremental improvements in pollution abatement and waste reduction and therefore embed green opportunities into their own set of strategic capabilities (Darnall and Edwards, 2006; Sharma et al., 2007). Therefore, firms that do not already possess environmental technical and organizational capabilities explore their existing resources in new ways to achieve increased economic, social, and environmental performances.

Applying environmental criteria to the strategic business process may be facilitated when a firm's existing assets are potentially able to reduce the cost of adoption and exploit synergies. For example, Gonzalez-Benito and Gonzalez-Benito (2008) found that advanced manufacturing practices, such as employee training, continuous innovation, and pioneering product design, allow easier deployment of environmental policies and techniques, and thus facilitate more immediate positive outcomes (Christmann, 2000; Lopez-Gamero et al., 2009). Hence, it is possible that these firms are more interested in the associated cost advantages and increased efficiencies resulting from proactive environmental strategies. They thus explore the combination of new strategic assets across the whole organization to attain such improvements.

The above reasoning is summarized in the following proposition:

*Proposition 2: Ceteris paribus, a shift from a reactive to an internally supportive environmental strategy, draws on the use of complementary strategic capabilities that enable internal efficiency.*

### *1.5.3 From an externally neutral/internally supportive to an externally supportive environmental strategy*

Externally supportive environmental strategies entail the adoption of both pioneering strategies and the ability to leverage accumulated experience. They also leverage the path dependence of environmental technical and organizational capabilities to develop innovations and managerial systems that lead to an environmentally competitive advantage (Hart, 1995; Shrivastava, 1995; Russo and Fouts, 1997; Aragon-Correa, 1998).

On the one hand, firms adopting externally neutral environmental strategies decide to take a step further into environmental proactivity because they realize the potential benefits of embedding their environmental capabilities into their overall business strategy. As Lopez-Gamero et al. (2011) suggested, the greater the access to environmental resources and capabilities, the more positively managers perceive the environment in terms of the competitive opportunities it can provide. Sharma (2000) found that managers' perceptions of environmental issues as opportunities leads to higher investments in proactive environmental practices. In particular, she argued that access to a discretionary amount of resources and time allows managers to respond to changes more flexibly and adopt creative problem-solving behavior that moves away from negative attitudes towards environmental issues. Therefore, firms extend their accumulated environmental capabilities to planning, processes, operations, and other activities because managers recognize that the pursuit of an environmental objective also improves business performance.

On the other hand, firms decide to shift from an internally supportive to an externally supportive environmental strategy as soon as they recognize their environmental drawbacks. They then accumulate technical and organizational environmental capabilities. In this case, firms want to reap the benefits of being an early mover in their industry and adopting a leadership position in environmental awareness. It follows that managers should look for green opportunities and learn how to exploit environmental capabilities in order to trigger a continuous improvement process (Sharma et al., 2000; Sharma and Vredenburg, 1998).

Because this typology of PES draws on the highest level of embeddedness in the business strategy and the highest accumulation of environmental capabilities, it requires

a high commitment of the firm to the pollution abatement issue. Therefore, the managers' environmental perceptions are the most important resource taken into consideration when it is time to decide the role of PES within the organization (Henriques and Sadorsky, 1999; Klassen, 2001; Aragon-Correa and Sharma, 2003).

Finally, we advance the following proposition:

*Proposition 3: Ceteris paribus, a shift from an externally neutral (internally supportive) to an externally supportive environmental strategy, draws on managerial discretion that enables early adoption of environmental practices.*

## **1.6 Discussion**

The aim of this paper is twofold. First, the PES model has provided insights into the clear definition of a proactive environmental strategy. Although the extant literature tried to identify typologies or taxonomies of a proactive environmental strategy (e.g. Hunt and Auster, 1990; Aragon-Correa, 1998; Klassen and Whybark, 1999b), most studies recognized that proactivity can be measured as the level of pollution abatement in products, manufacturing processes, and the managerial systems of a firm (Sharma and Henriques, 2004; Martin-Tapia, 2010; Ramanathan et al., 2010; Sharma and Sharma, 2011). However, this definition of PES is still too broad for a clear understanding of its impact on a firm's organization and technological portfolio. .

We argue that the definition of PES should encompass notions that consider how we need to think about the relationship between the dimensions of the environmental strategy and its overall business strategy. Our multi-dimensional conceptualization of PES suggests that the implementation level of proactive environmental practices, i.e., the degree of organizational and technical capabilities, is not the only dimension that is critically important. In addition, the level of embeddedness may lead to significant environmental improvement if the firm is able to leverage existing strategic capabilities, such as the complementarities of lean management and green management (e.g., King and Lenox, 2001; Rothenberg et al., 2001).

Second, previous research has tended to treat PES as a relatively stable and homogeneous concept that entails rare and unique resources and capabilities, such as those that increase flexibility, innovation, and the management of stakeholder relationships (Hart, 1995; Sharma and Vrandenburg, 1998; Sharma and Henriques,

2005). Based on the general definition of PES, this view implies that whenever a firm possesses or develops one of these resources and capabilities, it is likely that it will adopt a proactive environmental strategy. In contrast, we argue that proactivity is a complex and multifaceted concept that encompasses different environmental strategies. A shift from one typology to another therefore does not draw on a simple accumulation of environmental capabilities or a higher adoption of proactive environmental practices. Instead, proactivity is related to the influence that environmental concerns should have on the corporate strategy.

However, this is only a first attempt to investigate proactive environmental strategies by highlighting its internal characteristics. Future research should focus on providing empirical supporting for our model and propositions. Nonetheless, the present study raises some implications for managers. First, managers should understand the intended role of PES in the corporate strategy and determine how they can exploit the strategic capabilities of the firm. In this way, managers may more easily zero in on time and other resources to reach the expected outcomes. Second, the different typologies of PES are associated with different levels of managerial commitment. This implies that, for example, firms in the externally neutral category do not raise environmental issues that encompass the entire organization. Instead, they are able to handle these issues with one or a few functions. On the other hand, firms in the internally supportive category need the strong involvement of different managerial levels to channel environmental issues into strategic plans and actions. Finally, our model allows managers to understand the potential implications on both environmental and economic performances. Indeed, some scholars have advised that firms need complementary assets (e.g., Christmann, 2000) to reap economic benefits. Others have cautioned that proactive environmental practices may lead to negative effects on performances (e.g., Gonzalez-Benito and Gonzalez-Benito, 2005). Therefore, a clear definition of the role of PES allows a better identification of the actions required to gain the expected outcomes.

## 1.7 Conclusion

In the introduction, we argue that proactive environmental strategies (PES) have gained increasing attention in the literature, but a thorough and unique definition is still lacking. We suggest that two important areas are worth investigating.

First, we analyze the extant literature on PES and conclude that researchers have drawn on the general definition—a set of voluntary practices that go beyond mere compliance with environmental regulations—to provide their own descriptions of its policies, practices, and actions. Having searched for previous studies on taxonomies or typologies of PES, we summarize their findings and propose to define environmental strategies according to two dimensions: technical/organizational capabilities and embeddedness. We thus corroborate the hypothesis that PES is composed of multiple dimensions and does not move along a continuum from reactivity to proactivity.

Second, we argue that PES may be analyzed by taking into consideration its relative role in the overall business strategy. In order to avoid a proliferation of definitions, we aim at distinguishing among different typologies of proactivity by identifying their function and the extent to which they participate in the overall business strategy. In this way, we suppose that firms can better understand the environmental practices that are more suitable for implementation and in the dimension in which they should invest more time and economic effort. Hence, we categorize PES as externally neutral, internally supportive, or externally supportive.

Finally, we suggest that firms do not necessarily follow a continuum from reactivity to proactivity when they develop environmental strategies. Our study does not argue that the greater implementation of one environmental practice is a sufficient condition to demonstrate higher levels of implementation across a whole set of business practices. Instead, the dynamics among the different typologies of PES are related to the objective firms ultimately intend to pursue. For example, whenever firms are worried about their external legitimization and therefore about pressure from their stakeholders, they are more likely to introduce a set of environmental practices that increases their public image. Therefore, the degree of implementation of environmental practices does not lead to the level of environmental proactivity. Instead, the underlying reasons that foster proactivity explain the shifts to different typologies of environmental strategies.

## **Chapter 2**

# **DRIVERS AND COMPETITIVE PRIORITIES: IMPLICATIONS FOR ENVIRONMENTAL STRATEGIES**

### **2.1 Introduction**

Extant literature has highlighted how firms adopt environmental management strategies in response to several contingent factors (Aragon-Correa, 1998; Aragon-Correa and Sharma, 2003; Murillo-Luna et al., 2008; Darnall et al., 2010). In particular, high attention has been focused on the identification of the environmental pressures exerted by different stakeholders groups (Henriques and Sadorsky, 1999; Buysse and Verbeke, 2003; Sharma and Henriques, 2004; Sharma and Sharma, 2011). Another important concern has been to investigate whether the context can impact the implementation of an environmental strategy (Aragon-Correa and Sharma, 2003; Clemens and Douglas, 2006). There are also some researches that analyze how stakeholders groups and the environmental competitive context are perceived by managers and the related effects on green strategies (Sharma, 2000; Delmas and Toffel, 2008; Lopez-Gamero et al. 2010). Anyway, only few studies aim to understand whether and to what extent other contingent drivers, such as those related to the organizational context, affect a firm's environmental stance.

Taking the impacts of contingent drivers on environmental management strategies at firm level as a starting point, this study intends to investigate whether such impact is relevant also at plant level. In particular, we intend to understand what motivates operations managers to place a higher emphasis on the environment with



respect to the other competitive priorities of the manufacturing strategy. Therefore, our study focuses on the investigation of the influences of different contingent factors on manufacturing strategy, including the environmental priority.

For this purpose, we investigate the environmental priority together with traditional manufacturing choices, such as cost, quality, delivery, flexibility and innovation. Moreover, we draw on both stakeholder theory and contingency theory to analyze the underlying factors that motivate the strategic orientation of manufacturing strategies. On the one hand, stakeholder theory allows investigating how pressures from different stakeholders groups foster firms to be more environmental friendly (Bansal, 1995; Henriques and Sardorsky, 1999; Christmann, 2004; Kassinis and Vafeas, 2006). On the other hand, contingency theory allows understanding whether and to what extent contingent factors contribute to take a proactive environmental stance (Klassen, 2001; Aragon-Correa and Sharma, 2003). Therefore, these two streams of literature are used as our theoretical framework in order to develop our hypotheses.

The results of our paper contribute to bridge together literatures on manufacturing strategy and environmental management. Introducing the environmental issue within the manufacturing strategy allows us to move a step further in the understanding of environmental strategies and, more generally, in the content of manufacturing strategies. Also, our findings contribute to provide some insights in the manufacturing strategy literature of contingency theory. We find that supply-chain related characteristics, a proxy for the organizational context, influence manufacturing strategies. In particular, our analysis shows that higher dispersion of international suppliers is more likely associated with the environmental-oriented manufacturing strategy compared to the traditional competitive priorities of the manufacturing strategy.

## **2.2 Background Literature and the Theoretical Model**

Based on our research question, we develop a model linking contingent factors and competitive priorities. Figure 1 shows how the organizational context, proxied by two sets of contingent factors, is linked to the competitive priorities of manufacturing strategy. The theoretical fundamental of our model is presented in the following paragraphs. First, we explain our choice to include the environmental priority with the other traditional competitive priorities. Then, we define our contingent factors, i.e.

plant-related and supply chain-related characteristics, and advance hypotheses to assess their relationships with the manufacturing strategy.

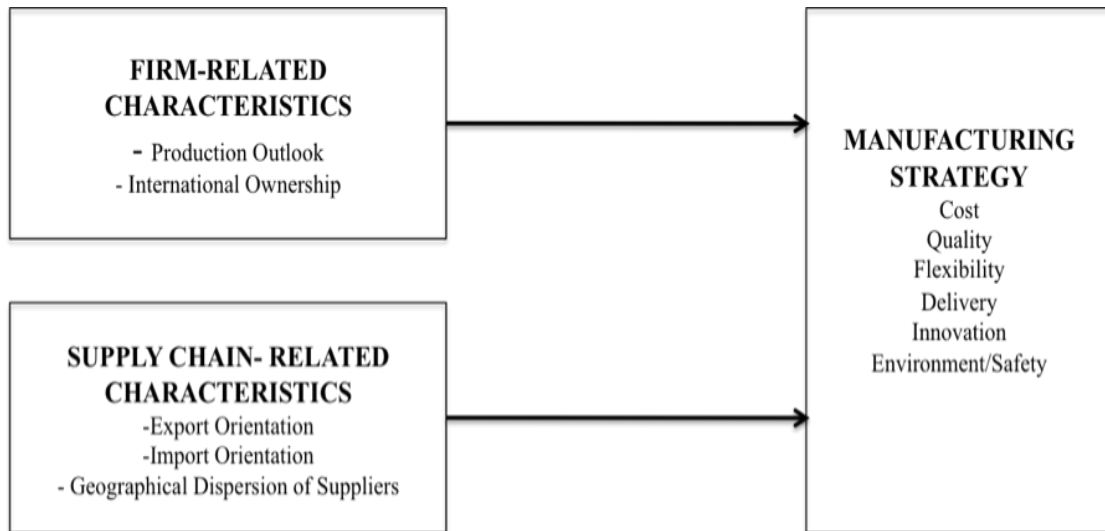


Figure 2. Manufacturing Strategy Model

### 2.2.1 Manufacturing strategy: definition of competitive priorities

Manufacturing strategy translates business strategy's guidelines and targets, defined at corporate level, into strategic decisions and objectives to be adopted at functional levels. In plants, such decisions are traditionally referred to as competitive priorities (Skinner, 1969; Hayes and Wheelwright, 1984; Ward et al., 1995). Though scholars use to operationalize manufacturing strategy in terms of the competitive priorities of cost, quality, flexibility and delivery (Hayes and Wheelwright, 1984; Kathuria and Partovi, 2000), an increasing number of researches suggests that traditional priorities do not cover alone the investing opportunities that plant managers need to think about (Miller and Roth, 1994; Hayes et al., 1998). Therefore, to understand the plethora of decisions that plant manager make, new dimensions of competitive priorities should be taken into consideration.

The natural environment might be a good candidate for being included together with traditional competitive priorities (De Burgo Jimenez and Cespedes Lorente, 2001; Martin-Peña and Díaz-Garrido, 2009; Avella and Vazques-Bustelo, 2010). This holds true for at least two reasons. First, literature on environmental management highlights

that green initiatives are positively related to both financial (Klassen and McLaughlin, 1996) and operational performance (Klassen and Whybark, 1999; Rusinko, 2007). Indeed, environmental management can increase cost savings and production efficiency, as long as innovation capabilities and human resource management skills (Hart, 1995; Porter and Van der Linde, 1995; Florida, 1996; Russo and Fouts, 1997; Sharma and Vredenburg, 1998; Reinhardt, 1999). Second, environmental initiatives are more likely to be undertaken inside plants, “the site of social organization where pollutants are concentrated and usually emitted” (Grant et al., 2002: 390). Indeed, plants produce significant quantities of pollution and are the main responsible for the implementation of process standards (e.g. ISO 14001), and new environmentally friendly techniques (e.g. design for manufacturability, TQEM). Therefore, environmental strategy is a good choice to understand the new opportunities that plant managers face and how these new dimensions of competitive priorities interplay with the traditional ones.

In our study, we thus define manufacturing strategy in terms of the six competitive priorities of cost, quality, delivery, flexibility, innovation and environment/safety and we cluster our sample to identify whether there are similar patterns among plants.

### *2.2.2 Organizational context: definition of plant- and supply chain-related characteristics*

Extant literature on manufacturing strategy has broadly investigated how contingent factors are able to affect the emphasis given to different competitive priorities (Badri et al., 2000; Kathuria and Partovi, 2000). Anyway, most research has focused on the competitive environmental context whereas organizational context has received scarce attention (Klassen, 2001; Lefebvre et al., 2003; Delmas and Toffel, 2004; Sousa and Voss, 2008). Therefore, we intend to study the organizational context, that is defined as the set of characteristics and forces that may be influenced and manipulated on the long term but they are not subjected to the authority of plant managers in the short-medium term (Voss and Sousa, 2008).

In line with manufacturing strategy literature, environmental management researches have not diverted much interest on the relationship between the organizational context and environmental strategies (Klassen, 2001; Delmas and Toffel,

2008). In the present study, we narrow our attention to organizational contextual factors that have already been analyzed in the environmental management literature. The underlying rationale is that the use of such contingent factors allows us to better understand the content of manufacturing strategy when environment is a concern. Moreover, such investigation enables us to show whether the influence of these contextual factors might be somehow undermined by the interplay of the environmental priority with other dimensions of competitive priorities.

Therefore, combining literature on stakeholder theory and contingency theory, we create two sets of contingent factors, i.e. plant-related and supply chain-related characteristics, used as proxy for organizational context, and we develop hypotheses between each contingent factor and the emphasis on the environmental-oriented manufacturing strategy.

## **2.3 Hypotheses**

### *2.3.1 The effects of plant-related characteristics on competitive priorities*

We consider two plant-related characteristics, i.e. production outlook and international ownership, to assess whether and to what extent these contingent factors affect the environmental-oriented competitive priority with respect to the traditional ones.

Klassen (2001) argues that as managers' confidence about the production outlook for a plant improves (i.e., more optimistic), the plant adopts a more proactive environmental management orientation. Instead, a pessimistic perception of the production outlook in the short- to medium-term might be related to uncertainty in the task environment. In this case, it is more likely that plants emphasize traditional competitive priorities (Badri et al. 2000; Pagell et al., 2004). Carried one step further, we thus propose that the more optimistic the production outlook operations managers envisage, the more likely they are to emphasize the competitive priority of the natural environment. On the contrary, managers who negatively perceive their plant's economic viability might be more focused on the traditional competitive priorities of cost, quality, flexibility, delivery and innovation.

Therefore, we hypothesize that:

*H1: As the production outlook improves (i.e., reflecting management optimism), the emphasis on an environmental-oriented competitive priority in the plant-level manufacturing strategy increases.*

Some researchers consider public vs. private owned firms as a proxy for the level of exposure to institutional pressures (Darnell and Edwards, 2006; Shah, 2010). As public firms are more visible and subject to higher need for transparency and scrutiny, they receive more attention from regulators and other stakeholders. In order to be legitimated, firms might decide to adopt more proactive environmental attitudes (Darnell and Edwards, 2006). Generalized one level further, we argue that such rationale might also be valid for internationally owned plants, relative to local (i.e., national) plants. Indeed, the more international the plant ownership is the higher the exposure to stakeholders' pressures in different countries that affects strategic decisions by particularly fostering the emphasis on the environmental priority.

In addition, literature on internationalization suggests that multi-country experience with different environmental regulatory regimes and with multiple stakeholder pressures positively influences environmental strategies (Bansal, 2004; Christmann, 2004; Gonzalez-Benito and Gonzalez-Benito, 2010; Meyer, Mudambi, and Narula, 2010). This is because multinational companies tend to adopt the environmental regulation of the most stringent country in where they operate to reduce strategic complexity (Rugman and Verbeke, 1998; Christmann and Taylor, 2001). Generalized one step further, we argue that international ownership may be subjected to the same stakeholders' pressures that a firm operating in multiple countries experiences.

Combined, the above discussion suggests that international ownership might be a proxy for pressures exerted by stakeholders groups in multiple international countries. Because of the need for legitimation and the complexity related to the management of multiple environmental regulations, operations managers may be willing to emphasize the environmental priority in the manufacturing strategy.

Therefore, we hypothesize that:

*H2: As international ownership increases, the emphasis on an environmental-oriented competitive priority increases.*

### *2.3.2 The effects of supply chain-related characteristics on competitive priorities*

We consider three supply chain -related characteristics, i.e. export orientation, import orientation and geographical dispersion of suppliers, to assess whether and to what extent contingent factors are related to environmental-oriented competitive priority.

First, we argue that the characteristics of a plant's supply chain are the result of a range of choices that include local vs. global suppliers, the degree of exports till the location of the targeted countries to do business with. Of course, these choices are made at corporate level. So, operations managers are asked to define their manufacturing strategy in accordance with corporate managers' expectations and organizational objectives, which, in turn, affect the overall firm performance (e.g. Papke-Shields and Malhotra, 2001). It follows that supply chain-related characteristics are exogenous to manufacturing strategic decisions.

Moreover, we hypothesize that the characteristics of a plant's supply chain may potentially represent a proxy for investigating the extent to which pressures of suppliers, customers and other stakeholders groups exerted along the supply chains are able to influence manufacturing strategy. Of course, because operations managers are responsible for the supply chain management, they are more likely exposed to stakeholders' direct and indirect pressures along the supply chains than other company's functional units are (Delmas and Toffel, 2004, 2008; Shah, 2010). Based on stakeholders groups classification by Buysse and Verbeke (2003), we argue that such groups can have direct or indirect effects for the adoption of an environmental-oriented competitive priority. A common example of indirect stakeholders pressures occurs when plants are pushed to greening their practices and, in order to accomplish them, they foster other players along the supply chains to make environmental decisions alike. It follows that supply chain management characteristics are a good proxy for capturing pressures exerted by stakeholders groups at different levels of the supply chain.

A plant's environmental strategy is subjected to stakeholders pressures in different ways. For example, foreign customers can spur their suppliers to comply with environmental regulations as long as to take a step further and adopt voluntary environmental standards such as ISO 14001 and EMS (Christmann and Taylor, 2001; Bansal and Hunter, 2003; Nishitani, 2010). In addition, regulatory stakeholders play an important role in the development of environmental policies, and they may exert

pressures at both national and supranational level that encourage plants to adopt supply chain-oriented environmental policies (Christmann, 2004; Madsen, 2007). Therefore, stakeholders pressures do not narrow their influence to the single plant but rather they transcend boundaries and are likely to directly and indirectly affect plants' actions and strategies in multiple institutional environments (Kostova and Zaheer, 1999; Bansal and Roth, 2000).

Moreover, another argument supporting our hypotheses draws on risk management literature. International supply chains have greater visibility and higher reputational risk, which in turn might lead to potential liabilities that are more difficult and complicated to deal with. Thus, operations managers tend to protect their supply chain from environmental problems that may hamper the firm legitimacy and conformity to social norms (DiMaggio and Powell, 1983). Indeed, the actions committed by suppliers and customers are able to affect firm public image and overall business (Min and Galle, 1997; Kopling et al. 2007). Therefore, the characteristics of international supply chains may affect the competitive priority setting and lean on diverting more resources to the environmental priority.

To our knowledge, studies that use supply-chain characteristics as proxies for contingent factors in the investigation of manufacturing strategies are rare. Our suggestion is to use export orientation, import orientation and geographical dispersion of suppliers as our variables to assess the degree of internationalization of supply chains and, thus, their exposure to stakeholder pressures. In this way, we hypothesize that as much the supply chain is internationalized, i.e. high export orientation and/or import orientation, and/or geographically dispersed, as much the higher visibility and greater pressures exerted by domestic as long as foreign stakeholder groups lead to the adoption of environmental-oriented manufacturing strategies. It follows that:

*H3a: As export orientation of the plant (i.e., international customers) increases, the emphasis on an environmental-oriented competitive priority increases.*

*H3b: As import orientation of the plant (i.e., international suppliers) increases, the emphasis on an environmental-oriented competitive priority increases.*

*H3c: As geographical dispersion of suppliers increases, the emphasis on an environmental-oriented competitive priority increases.*

## **2.4 Research Methodology**

### *2.4.1 Data Collection and Sample*

Using a large-scale survey, data was collected in 2007 from Canadian manufacturing plants in four industries: fabricated metal products (SIC code 332), machinery (SIC code 333), electronics (SIC code 334), and electrical appliances (SIC code 335). Following preliminary interviews with operations managers from a wide variety of plants, we targeted these industries because of their similarity in terms of products, production processes and environmental regulations.

Using previously validated scales, a survey instrument was designed to collect plant-level information on environmental, social and manufacturing practices, and competitive priorities. Details about the relevant questions used for our research purpose are summarized in Appendix A. The key informant was identified as the plant manager, the operations manager, or the most expert manager in the firm's production processes and environmental and supply chain practices.

We then sampled 503 randomly selected manufacturing plants from the National Pollutant Release Inventory (NPRI) and the Canadian Scott's Directory. We contacted each of them by phone to verify the address and the key informant names. Though the multiple respondents' method allows reducing response bias, the single informant is equally appropriate in relation to the type of knowledge that our questionnaire requires.

Finally, the questionnaires were mailed to the targeted firms from September to December 2007, according to the technique described by Dillman (2000). A total of 94 unique and usable questionnaires were returned, corresponding to 18.5% response rate that is close to the recommended level of 20% for surveys of this type (Malhotra and Grovener 1998). Based on a preliminary statistical analysis, we had to drop two of the 94 observations: one of them had the percentage of missing data over the recommended level (Hair et al. 2006) whereas the second was an outlier based on Mahalanobis difference test (Cohen et al., 2003; Stevens, 1984).



#### *2.4.2 Competitive Priorities Measures*

Our dependent variable is based on the management's weighting of six competitive priorities. Each manager was asked to provide the importance of six priorities for their plant, namely cost, quality, speed, flexibility, innovativeness and environment/safety. Extant literature on competitive priorities has broadly used cluster analysis for creating taxonomies and investigating the alignment paradigm (Miller, 1992; Miller and Roth, 1994). In our study, cluster analysis is appropriate because we study the relationship of competitive priorities with different set of contingent factors.

Though cluster analysis lacks of an unquestionable measurement method and it is mostly considered as an arbitrary process, many devices are suggested for correcting the potential bias. In particular, an initial problem occurs in the decision about the number of clusters. The use of multiple techniques can thus help overcoming such a caveat and provide support for a correct structural characterization of the sample (Ketchen and Shook, 1996).

We follow a two-step process. Firstly, we limit our number of solutions to two or three clusters, in accordance to the rule of Lehmann (1979) that recommends clusters to be between  $n/30$  and  $n/60$ , given  $n$  equal to the sample size (92 observations). Secondly, we combine both hierarchical and non-hierarchical techniques in order to identify the most appropriate number of clusters (Hair et al. 2006). Ward's hierarchical clustering procedure, supported by the visual technique of the dendrogram and the Calinski-Harabasz method, points out clustering-solutions at both two and three clusters, though their agglomeration distances are so similar that prevents us to identifying the best solution. We thus run a non-hierarchical clustering method that, compared to the hierarchical method, allows to reassign cases at later stages and, thus, to avoid potentially misleading solutions (Hair et al. 2006). We employ a k-means clustering algorithm that identifies three clusters as the best data representation.

Before making the final decision, we also look at the interpretability of all the clusters proposed by both the hierarchical and non-hierarchical methods. As the main objective of the cluster analysis is to group together observations that are similar in terms of characteristics and are able to simplify data interpretation, our qualitative interpretation intends to match both a need for clustering parsimony and accuracy of the solution (Boyer et al., 1996). Though the hierarchical and non-hierarchical solutions give

the same cluster profiles, the three k-means clusters guarantee the even distribution of observations among the three clusters, thus providing a more appropriate estimation of the logistic analysis (Hair et al. 2006) for linking drivers and competitive priorities. In this way, we further confirm that the three k-means clustering solution is the more adequate for our analysis.

To evaluate the significant differences in the three clusters, we perform the one-way analysis of variances ANOVA and the Scheffé pairwise comparison tests of mean. The three clusters differ in the environment/safety priority at 0.05 level, whereas cost is significantly different for cluster 3 vs clusters 2 and 3 at  $p < 0.01$ . Table 3 reports information on the cluster means, the standard deviations, the F-statistics and the results of the Scheffé test for group means significantly different ( $p < 0.05$ ).

Table 3. Competitive Priorities: Cluster Characteristics

	<b>Environmental oriented Group n=35</b>	<b>Balanced Set Group n=37</b>	<b>Cost oriented Group n=20</b>	<b>Total</b>	<b>ANOVA - F Statistics</b>
Cost	18.9 (3) s.d. 6.579	20.7 (3) s.d. 7.18	46.2 (1,2) s.d. 10.8	25.6 s.d. 13.44	88.5 ( $p < 0.0001$ )
Quality	19.6 (2) s.d. 6.508	27.1 (1) s.d. 10.63	21.76 s.d. 10.813	23.1 s.d. 9.822	6.05 ( $p < 0.0034$ )
Delivery	17.9 (3) s.d. 5.214	18 (3) s.d. 10.619	12.2 (1,2) s.d. 7.048	16.7 s.d. 8.405	3.76 ( $p < 0.027$ )
Flexibility	12.5 (2,3) s.d. 6.626	8.9 (1) s.d. 3.777	7.7 (1) s.d. 5.461	10 s.d. 5.688	6.42 ( $p < 0.0025$ )
Innovation	8.3 (2) s.d. 6.595	16.6 (1,3) s.d. 10.499	7.6 (2) s.d. 8.001	11.5 s.d. 9.547	10.87 ( $p < 0.0001$ )
Environment/Safety	22.8 (2,3) s.d. 7.436	8.7 (1,3) s.d. 4.391	4.4 (1,2) s.d. 4.391	13.1 s.d. 9.55	85.88 ( $p < 0.0001$ )

The three clusters are labelled environmental-oriented, balanced set, and cost-oriented competitive priority. The first cluster (35 observations) places the strongest

emphasis on the environmental/safety competitive dimension (weighting of 23%), whereas it only slightly exceeds the emphasis on quality, cost and delivery (all slightly less than 20%), thus explaining why we name it “environmental-orientated”. The second cluster (37 observations) is called “balanced set” because it shows scores around the total sample mean for all the variables, though the slightly higher values for innovation and quality. The third cluster (20 observations), labelled “cost-oriented”, is characterised by firms with a very heavy emphasis on cost (46%), followed by quality (22%) while all the other variables are rated under the total sample mean.

#### *2.4.3 Plant- related and supply chain-related characteristics measures*

The measurement of the production outlook variable is based on managers’ assessment of the probability that the plant’s production level would be operating at the same (or higher) level within 1 year and 5 years in the future. We measure the average value of the two items in order to assess to what extent the manager’s positive/negative perception of the production volume in the short-medium term can affect manufacturing strategy at the present. We see that most of the managers estimate slightly positively (65%) the probability that their plant's production volume will be at the same or higher level within 5 years.

For international ownership, export orientation and import orientation, we use questions about the percentage associated with the plant’s international ownership, plant’s sales generated from export, and the costs of materials, parts, and components purchased from international sources, respectively. In case of import orientation, we measure the mean value of the responses for the last two years at the time of the questionnaire. From our database, we see that most of the firms are owned either nationally or internationally while few have both local and foreign owners. The mean value of exports (48%) and international purchases (38%) suggests that most of the plants operate within Canada.

For the geographical dispersion of suppliers, we use a question asking managers where the plant’s suppliers of materials, parts, and components are located on a seven-point Likert scale across six possible regions (Canada, U.S., Europe, Latin America, Asia, Africa). Most of the suppliers are based in North America and Europe while Africa and Latin America have mean score of 1, indicating that our manufacturing firms

do not purchase from these regions. As firms usually count on several suppliers from different geographical areas, a better representation of the geographical dispersion of suppliers should draw on cluster analysis. Following the same methodological process as with the competitive priorities, we identify two clusters labelled “national dispersion of the supply chain” and “international dispersion of the supply chain”. The first cluster (n=33) primarily scouts the local (i.e. national) environment to create its supply chain (mean value of 4.6) whereas international suppliers are scored under the total sample mean value, thus showing they are not relevant for plants within this group. The other cluster (n=59) has a very low score for national suppliers and high scores for all the other suppliers, except African ones. Table 4 reports information on the cluster means, the standard deviations, the F-statistics and the results of the Scheffé test for group means significantly different ( $p < 0.05$ ).

Table 4. Geographical Dispersion of Suppliers: Cluster Characteristics

<b>Suppliers</b>	<b>National dispersion of suppliers n=33</b>	<b>International dispersion of suppliers n=59</b>	<b>Total</b>	<b>ANOVA F-Statistics</b>
Canada	4,6 s.d.(0,862)	2,6 s.d. (0,73)	3,3 s.d. (1,214)	130,65 ( $p < 0,000$ )
US	2,69 s.d. (0,948)	2,9 s.d. (0,84)	2,8 s.d. (0,883)	1,38 ( $p < 0,244$ )
Latin America	1,1 s.d.(0,648)	1,4 s.d.(0,634)	1,3 s.d. (0,651)	4,46 ( $p < 0,038$ )
Europe	1,5 s.d.(0,701)	1,8 s.d. (0,813)	1,7 s.d. (0,783)	2,81 ( $p < 0,097$ )
Asia	1,3 s.d. (0,514)	2,6 s.d. (0,95)	2,2 s.d. (1,057)	60,46 ( $p < 0,000$ )
Africa	0,8 s.d. (0,131)	0,6 s.d. (0,386)	0,7 s.d. (0,34)	13,27 ( $p < 0,000$ )

#### *2.4.4 Control variables measures*

As most empirical studies on environmental management suggest, we include several control variables. First, Size is used to control for bigger plants, that usually have access to higher investments (Aragon-Correa, 1998; King and Lenox, 2000; Sharma, 2000; Bansal, 2003) and deal with broader visibility and a wider range of pressures from stakeholders groups (Bowen, 2002; Jiang and Bansal, 2003). We measure plant size as the logarithm of total number of employees. A second control variable is the Industry. We use four dummy variables for the fabricated metal products, machinery, electronics, and electrical appliances industries. In this way, we account for the stringency effects environmental regulations have on more pollutant industries (e.g. Bansal and Roth, 2000). Third, we control for Environmental Investments. Managers were asked to indicate what percentage of the capital budget has been allocated to environmental projects in the last two years. To control for this variable allows us to rule out that resource slack is an explanation for the relationship between contingency factors and competitive priorities. Finally, we control for Outsourcing. This allows us to account for those suppliers that manufacture a part of the plant production and, thus, have different types of collaboration with the plant. We measure outsourcing referring to a question asking managers to indicate the percentage of the cost of the materials, parts and components that are fabricated inside the plant in the last two years. Then, we calculate the percentage of the mean values of the costs for materials, parts and components borne outside the plant.

### **2.5 Analysis and Results**

Table 5 contains descriptive statistics and correlations among variables in order to provide a broad outlook of our sample. As it can be seen, there are significant correlations among the six variables of competitive priorities, and also among the six geographical regions. These values are not surprising as to the way the underlying questions were formulated. Therefore, correlations among the competitive priorities and the six geographical regions are not a problem considering how we constructed our dependent variable, i.e. clustering method.

Table 5.- Descriptive Statistics and Correlations,

	Mean	s.d.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Cost	25.6	13.4	1																	
2. Quality	23.01	9.8	-.12	1																
3. Delivery	16.7	8.4	-.38*	-.22*	1															
4. Flexibility	10	5.7	-.28*	-.41*	.03	1														
5. Innovation	11.5	9.5	-.27*	-.26*	-.15	0	1													
6. Environment	13.2	9.6	-.52*	-.17	0	.19	-.22*	1												
7. International Ownership	44.1	48.9	-.09	.05	.03	-.11	-.15	.23*	1											
8. Production Outlook	64.8	25.8	-.02	-.22*	.06	.12	.09	.08	0	1										
9. International customers (export)	47.1	35.4	.05	-.02	-.2	-.07	.4*	-.24*	.11	.18	1									
10. International Purchases (import)	37.4	28.5	.01	.01	-.16	-.05	.28*	-.14	.14	.22*	.43*	1								
11. Canada	3.3	1.2	.03	-.11	.15	.18	-.09	-.08	-.3*	-.16	-.31*	-.64*	1							
12. US	2.8	.9	.03	.01	-.12	-.1	.11	.01	-.06	-.15	.03	.25*	-.22*	1						
13. Europe	1.7	.8	-.1	.03	-.01	-.06	.09	.06	.19	-.31*	.13	.24*	-.35*	-.28*	1					
14. Asia	2.2	1.1	.11	-.01	-.04	-.2	.09	-.08	.08	.1	.3*	.39*	-.56*	-.2	-.11	1				
15. Latin America	1.3	.65	-.24*	.14	-.01	.17	-.17	.27*	-.3*	-.08	-.1	-.03	-.31*	-.24*	.02	-.03	1			
16. Africa	.7	.34	.17	.04	-.07	.04	-.09	-.16	-.3	.08	-.05	-.02	.14	-.1	-.02	-.3*	-.15	1		
17. Size (log)	5	.9	-.14	-.02	.01	-.09	.11	.16	.16	.08	.3*	.17	-.33*	-.06	.11	.33*	.1	-.12	1	
18. Environmental Investments	3.8	3.4	-.06	.12	.02	.08	-.22*	.15	.16	.05	-.02	.05	-.11	-.07	.15	-.05	.14	.13	.09	1

\* p<0.05

Table 6 presents the results of our multinomial logit regression model, which allows us to simultaneously test whether our three clusters are significantly different among multiple variables. Also, the multinomial logit is preferred when the discrete choices associated with the dependent variable are not independent from each other, thus accounting for correlations among the error terms. Doing so allows us to identify the contingent factors that are significantly different across our three clusters, particularly the drivers that distinguish the environmental-oriented group from the other two, i.e. cost oriented-group and balanced set group, as described in the hypotheses. We take interchangeably the cost oriented cluster and the balanced set cluster as the baseline of our multinomial logit regression in order to estimate the probability that our independent variables are more likely associated with environmental-oriented cluster rather than our reference categories. Comparisons of the balanced set group vs cost-oriented group are presented for completeness.

In general, two models are estimated. In Model 1, only control variables are included to establish a baseline. In Model 2, we add our contingent factors: two variables for the plant-level characteristics and three variables for the supply-chain related characteristics. Model 2 provides additional significantly better explanatory power than Model 1, as shown in its pseudo R-squared of 0.21 vs 0.12, respectively.

Hypothesis 1 and Hypothesis 2 make predictions about the effects of plant-related characteristics on the emphasis of the environmental-oriented priority. We reject that when plant managers perceive a positive future production volume, the plant is more likely to emphasize an environmental oriented group (H1). Also, we do not support the hypothesis that plants with international ownership will probably be more exposed to stakeholder pressures and, thus, are more likely to pursue environmental objectives rather than focus on a broader range of competitive priorities (H2).

The data do not support the hypothesis that export orientation (H3a) is significantly related to a greater emphasis on the environmental priority. On the other hand, import orientation (H3b) and the geographical dispersion of suppliers (H3c) show to be significant. Indeed, the model highlights that the higher international imports are the lower the

emphasis on the environmental oriented group and the higher the emphasis on the cost priority, thus significantly rejecting H3b ( $p < .05$ ). Also, the model shows that the higher the international dispersion of suppliers, the more likely plants emphasize environmental oriented group vs cost oriented or balanced set groups ( $p < .05$  and  $p < .01$ ).

With respect to our control variables, there is evidence that environmental investments significantly affect the emphasis on the environmental-oriented priority in Model 1. Also outsourcing appears to be significant in Model 1, suggesting that higher degrees of outsourcing emphasize cost-oriented manufacturing strategies, in line with extant literature (Jones and Hill, 1998). Anyway, both environmental investments and outsourcing become insignificant when new variables were included in Model 2, thus indicating that they are not relevant when contingent factors are considered.

The findings relative to the industry dummies suggest that competitive priorities might depend to a limited degree on the type of industrial sector. However, post hoc analysis revealed no significant differences among industrial sectors and, thus, we cannot conclude that higher emphasis on the environmental priority relies on industry effects. This is because three-digit SIC-code level data might be too fine-grained to distinguish among cost-oriented, balanced set and environmental-oriented competitive priority. As we mentioned earlier, fabricated metal products, machinery, electronics, and electrical appliances industries are similar in terms of products, production processes and environmental regulation, thus explaining why these sectors are not significantly different in our study.



Table 6. Results of the Multinomial Logit Regression

VARIABLES	Model 1			Model 2		
	Env'l Oriented vs Balanced Set (a)	Env'l Oriented vs Cost Oriented	Balanced set vs Cost Oriented	Env'l Oriented vs Balanced Set	Env'l Oriented vs Cost Oriented	Balanced set vs Cost Oriented
<i>PLANT-RELATED CHARACTERISTICS</i>						
Int'l Ownership				0.008 (0.006)	0.002 (0.008)	-0.006 (0.008)
Production Outlook				0.012 (0.011)	-0.006 (0.014)	-0.018 (0.013)
<i>SC-RELATED CHARACTERISTICS</i>						
Export Orientation				-0.008 (0.012)	-0.0003 (0.013)	0.007 (0.011)
Import Orientation				-0.03** (0.013)	-0.038** (0.018)	-0.008 (0.017)
Int'l Dispersion of the SC (b)				1.479** (0.685)	2.583*** (0.966)	1.104 (0.922)
<i>CONTROL VARIABLES</i>						
Env'l Investments	0.139* (0.075)	0.123 (0.096)	-0.016 (0.097)	0.135 (0.101)	-0.004 (0.086)	0.002 (0.011)
Outsourcing	-0.016* (0.009)	-0.016 (0.01)	-0.001 (0.01)	-0.019 (0.013)	-0.002 (0.011)	0.006 (0.007)
Size	-0.0425 (0.411)	0.509 (0.490)	0.551* (0.319)	0.126 (0.479)	0.311 (0.347)	0.311 (0.347)
<i>INDUSTRY DUMMIES (c)</i>						
Fabricated Metal	-0.133 (0.652)	-2.195* (1.129)	-2.062* (1.166)	-2.213** (1.088)	-2.188* (1.183)	-2.188* (1.183)
Machinery	-1.062 (0.693)	-2.325* (1.208)	-1.262 (1.232)	-2.964** (1.173)	-1.386 (1.201)	-1.386 (1.201)
Electronics Products	-1.852** (0.908)	-3.136** (1.362)	-1.284 (1.206)	-2.783* (1.556)	-1.416 (1.161)	-1.416 (1.161)
Constant	-0.567 (2.461)	-1.273 (3.026)	-0.706 (1.971)	-0.560 (2.422)	0.648 (3.007)	1.208 (2.062)
Observations	92	92	92	92	92	92
R-squared	0,12 (p<0.018)			0.21 (p<0.008)		

Robust standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

(a) A positive coefficient indicates that the first choice is more likely than the second.

(b) National Orientation of the supply chain dummy is omitted.

(c) Industry dummy omitted is Electrical Appliances.

In sum, our findings do not support H1, H2 and H3a and H3b (significantly) but they significantly support H3c. Considered together, these findings suggest that plant-related characteristics do not seem to drive a higher emphasis on an environmental-oriented manufacturing strategy. In contrast, supply chain-related characteristics affect competitive priority, particularly a higher dispersion of suppliers around the world is more complex to monitor in order to always guarantee a plant's legitimacy along the supply chain and thus are more likely related to the environmental oriented competitive priority. Instead, supplier orientation is more likely related to cost oriented competitive priority.

Before discussing these results further, we present additional analyses to verify the robustness of the above results.

Table 7. Results of the Multinomial Logistic Model (only independent variables)

VARIABLES	Env'l Oriented vs Balanced Set	Env'l Oriented vs Cost Oriented	Balanced set vs Cost Oriented
<i>PLANT-RELATED CHARACTERISTICS</i>			
Int'l Ownership	0.01*	0,007	-0,003
	-0,006	-0,007	-0,006
Production Outlook	0,0104	-0,009	-0,02
	-0,011	-0,013	-0,012
<i>SC-RELATED HARACTERISTICS</i>			
Export Orientation	-0.017**	-0,004	0,012
	-0,008	-0,01	-0,009
Import Orientation	-0.025**	-0.032**	-0,008
	-0,012	-0,015	-0,014
Int'l Dispersion of the SC (b)	0,8	2.1**	1,3
	-0,669	-0,832	-0,799
Constant	-0,021	0,928	0,949
	-0,779	-0,977	-0,924
Observations	92	92	92
R-squared			

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

### *2.5.1 Multinomial logistic model without control variables*

As Hair et al. (2006) suggest that the minimum number of observations per independent variables is 10 in multinomial logistic regressions, we run our model without including control variables. Table 7 confirms our previous findings. Moreover, additional variables result significant in this model. Particularly, export orientation shows to be significantly related to cost-oriented and balanced-set oriented groups with respect to the environmental-oriented group, thus assuming that customers pressures do not significantly affect the plant's environmental stance.

Also, international ownership is significant, thus showing that it is more likely related to the environmental oriented group with respect to the other two groups.

### *2.5.1 Regression analysis*

A regression analysis allows us to investigate the effects of our contingent factors on a continuous variable, i.e. the environment. Though this analysis does not allow to understand the interplay among the different competitive priorities, we can infer that our dependent variable measures the relative importance of the environmental competitive priority with respect to all the others (see scales in Appendix A). Table 8 shows that all the results from the multinomial logistic model are completely confirmed, excepting for outsourcing. Finally, we run also a regression without control variables by finding the same results as in the corresponding multinomial logistic regression.

Table 8. Results of the Regression Analysis

VARIABLES	Environment	Environment	Environment
<i>PLANT-RELATED CHARACTERISTICS</i>			
Int'l Ownership		0,02	0.036**
		-0,017	-0,018
Production Outlook		0,062	0,047
		-0,039	-0,042
<i>SC-RELATED CHARACTERISTICS</i>			
Export Orientation		-0,055	-0.068**
		-0,037	-0,031
Import Orientation		-0.096***	-0.093**
		-0,033	-0,036
Int'l Dispersion of the SC (a)		7.691***	7.473***
		-2,044	-2,081
<i>CONTROL VARIABLES</i>			
Size	1,109	0,49	
	-1,12	-0,908	
Environmental Investments	0.434*	0,356	
	-0,253	-0,268	
Outsourcing	-0,011	-0,0131	
	-0,028	-0,027	
Size	1,109	0,49	
	-1,12	-0,908	
<i>INDUSTRY DUMMIES (b)</i>			
Fabricated Metal	-4,614	-3,654	
	-2,908	-2,553	
Machinery	-8.286***	-9.126***	
	-3,061	-2,569	
Electronics Products	-10.97***	-7.374***	
	-2,627	-2,386	
Constant	12.26*	11.15*	10.53***
	-6,533	-6,085	-2,884
Observations	92	92	92
R-squared	0,226	0,403	0,244

(a) National Orientation of the supply chain dummy is omitted.

(b) Industry dummy omitted is Electrical Appliances.

## 2.6 Discussion

Some researchers point out that the analysis of the organizational context is still scarce (Klassen, 2001; Sousa and Voss, 2008). According to Sousa and Voss' (2008) review on the contingency theory, few papers rely on contingent factors other than the task environment (Badri et al., 2000; Amoako-Gyampah and Boye, 2001) and business strategy (e.g. Gupta and Lonial, 1998; Rhee and Mehra, 2006). Some papers have investigated factors such as location (Voss and Blackmon 1996, 1998), international competition (Das et al. 2000), and scope of operations (Sila, 2007). Our study thus provides some interesting insights in this stream of literature, thus showing the relevance that the organizational context has on competitive priorities.

In particular, our research question aimed to understand what contingent factors motivate operations managers to place higher emphasis on the environmental competitive priority. First, our findings show that plant-related characteristics do not encourage plants to boost environmental priority among all the competitive priorities. However, Klassen (2001) demonstrated that a positive perception of future production volumes increases the likelihood that plants adopt a proactive environmental strategy. This is thus contradicted by our result that does not support the hypothesis. This difference might depend on the fact that the environmental priority has not been investigated alone but together with other competitive priorities. Therefore, our finding suggests that the interplay of the environmental priority with more traditional competitive priorities has somehow interfered on the significant effect that a positive perception of future production volumes has on the environmental strategy when it is considered alone.

Second, our findings show that dispersed international supply chains encourage plants to boost environmental-oriented priority with respect to the more traditional competitive priorities of cost, quality, delivery, flexibility and innovation. As Vachon and Klassen (2008) point out, environmental strategies should be implemented along the whole supply chain. It implies that plants with internationally dispersed supply chains are more exposed to environmental pressures from stakeholders groups (Bansal and Roth, 2000; Buyse and Verbeke, 2003). Moreover, they are more likely subjected to environmental

issues hampering the plant's social legitimacy (Darnall et al., 2010). Therefore, a higher emphasis on the environmental priority allows a plant to divert more financial and managerial resources on either monitoring environmental technologies, such as audits and ISO14001, or improving collaboration with suppliers on environmental technologies (Vachon and Klassen, 2007), thus avoiding potential environmental drawbacks.

Lastly, the finding on the geographical dispersion of suppliers seems to contradict the results for supplier orientation. As both contingent factors are a proxy for pressures directly or indirectly exerted by suppliers, it is interesting to investigate why higher supplier orientation influences positively the cost-oriented competitive priority whereas higher geographical dispersion of suppliers positively influences the environmental competitive priority. On the one hand, it might be argued that the measure of import orientation is too simplistic to capture the important nuances that influence the dimensions of competitive priorities. On the other hand, supplier orientation refers to the degree of plant internationalization at the supply-side whereas the geographical dispersion of suppliers refers to the degree of complexity of the plant's supply chain. In this way, a high number of suppliers might respond to a need for efficiency at corporate level, thus emphasising the cost-oriented competitive priority at plant level (Kathuria, Porth and Joshi, 1999).

In conclusion, the findings described in this study support the importance that organizational context, proxied by two sets of contingent factors, has on the environmental priority and, more generally, on manufacturing strategy.

## **2.7 Conclusion, Limitations and Suggestions for Future Research**

This study examines what motivates operations managers to place higher emphasis on the environmental priority with respect to other competitive priorities of cost, quality, delivery, flexibility and innovation. In particular, it analyzes the extent to which plant-related and supply chain-related characteristics are able to encourage environmental-oriented strategies. We find that a higher dispersion of international suppliers emphasizes the environmental priority whereas the supplier orientation diverts the emphasis towards cost-oriented strategies. In general, this study provides some initial new insights into how an

environmental competitive priority interplays with other traditional competitive priorities, and under what conditions it is perceived as an important dimension of manufacturing strategy.

There are several limitations of this study that can be reported. Particularly, the most relevant are sample size and scales measurement. The first refers to issues arising from small sample size. Our sample with 92 observations might have affected the statistical power of our findings. Also, a larger sample size might have been helpful to better identify the differences among our clusters. For example, the fact that international ownership and export orientation significantly affect the dependent variable in our additional analyses suggest that lack of significance might be due to the low ratio of independent variables and the sample size in our multinomial logit regression. The latter refers to the use of one-item measure for most of the scales. More precisely, different scales should have been used to measure the impact of direct and indirect stakeholder pressures. This is one of the main limitations of this study because the measurement is difficult to validate and potential respondent bias might be a concern.

Future research can expand the set of supply chain-related to include additional downstream (i.e., customer-related) characteristics. For example, customers may serve as a better proxy for stakeholders pressures. Moreover, future analysis should expand our model to include environmental and operational performances. An investigation of the direct and mediated effects of contingent factors on plant performance might provide interesting insights in the stream of literature dealing with the alignment between competitive priorities and current performances. Finally, a broader set of contingent factors might more clearly illustrate how and to what extent the organizational context affects manufacturing strategies, particularly the environmental competitive priority

## **Chapter 3**

# **LEAN AND GREEN IN ACTION: DRIVERS, INTERDEPENDENCIES AND PERFORMANCE OF ENVIRONMENTAL PROJECTS**

### **3.1 Introduction**

As the environmental perspective has been gaining an important role in firms' corporate strategies and consumers' preferences, companies have no choice but to include environmental management in their business agenda (Marcus and Fremeth, 2009). The environmental implications on management have been studied in a stream of literature at the crossroads of different disciplines such as marketing, R&D and corporate strategy (Marcus, 2005; Lefebvre, Lefebvre and Talbot, 2003; Madsen, 2009). In particular, literature on environmental management has mainly studied the somehow controversial effect of green (we use interchangeably the term green and environmental) practices on performance.

On the one hand, several contributions provide empirical evidence of the "green pays" debate and the related opportunities of enhancing resource exploitation, creating new market niches, speeding up innovation, having more productive workforce and a better



reputation (Porter and Van der Linde, 1995a, 1995b; Shrivastava, 1995; Hart and Ahuja, 1996; Klassen and McLaughlin, 1996).

On the other hand, some scholars maintain that environmental practices bear considerable costs related to the compliance with environmental goals that often more than offset the associated benefits (Clark, 1994; Walley and Whitehead, 1994; Filbeck and Gorman, 2004; Kassinis and Vafeas, 2009; Molina-Azorin et al., 2009; Yu et al., 2009).

The resource based view may help to unveil the controversial relationship between environmental practices and performance (Barney, 1991; Hart, 1995; Russo and Fouts, 1997). Indeed, some scholars argue that distinctive operational competencies and capabilities reduce costs and time of the introduction of environmental practices, thus allowing a plant to reap more benefits from the implementation of environmental practices (Christmann, 2000; Aragon-Correa and Sharma, 2003; Russo and Harrison, 2005; Pagell and Gobeli, 2009; Huang and Wu, 2010).

In the present study, the characteristics of distinctive operational competences and capabilities as described by RBV literature (e.g. Barney, 1991) may be identified in lean management. Indeed, literature on world class manufacturing demonstrates that high-performing plants vigorously implement lean practices to sustain and boost competitive advantage (Schroeder and Flynn, 2001; Furlan, Vinelli and Dal Pont, 2011). Bundles of lean practices involve the creation and development of unique operational competencies and capabilities that foster continuous improvement in the search for perfection (MacDuffie, 1995; Peng et al., 2008). Therefore, the implementation of lean practices such as JIT, TQM, TPM can be used as proxy for distinctive operational competencies and capabilities of the plant (Tan et al., 2007; Furlan et al., 2010).

We aim at investigating how the implementation of green practices is affected by the implementation of lean practices, used as proxies for the plant operational competencies and capabilities. More specifically, we study how lean practices interact with green practices to affect both environmental and operational plant performance. We study three successful projects of lean and green practices implementation of two Italian plants of two multinational firms operating in the refrigeration and cooling industry and the water pump industry respectively. We adopt the case study methodology to disentangle the relationships

among lean practices and green practices. Our findings highlight that the interplay of the two bundles of practices is affected by the timing of implementation, i.e. sequential *vs* simultaneous, that turns out to define different modes of management, i.e. planning *vs* mutual adjustment. As a result, we highlight that a simultaneous approach to the implementation of lean and green practices determine better environmental and operational performance. Besides, our case studies provide some insights into the investigation of the underlying drivers of environmental projects. So, we do find that environmental pressures are important but, generally, they are more than offset by operational drivers, thus implying that environmental projects should always guarantee operational improvements.

The paper is organized as follows. In the second section we introduce the theoretical background while, in the third section, we describe the research methodology and data collection process. The fourth section contains the within- and cross-case analysis and advances a set of testable propositions. Fifth section concludes the paper with the discussion of theoretical results and managerial implications.

## **3.2 Theoretical Background**

In this section, we first provide a precise definition of lean practices and green practices. We then review the literature on the relationship between such practices and operational and environmental performance.

### *3.2.1 Lean practices and green practices*

We define green practices as a set of techniques that limit or reduce the possible negative impacts of the production and consumption of products and services on the natural environment, thus improving the firm's environmental footprint (Shrivastava, 1995; Rao, 2004). We focus on two types of environmental practices: pollution prevention technologies and pollution control technologies. The former entails all the activities that change the structure of the manufacturing process and adopt more environmental-friendly resources (Hart, 1995; Klassen and Whybark, 1999a). The latter entails all the end-of-pipe equipments that serve to recognize, capture and dispose of emissions caused by the

production process, without any structural intervention (Hart, 1995; Klassen and Whybark, 1999a).

We define lean practices as a set of techniques aim at eliminating each form of waste along the value chain. These techniques are clustered into bundles of practices such as JIT, TQM and TPM (Furlan et al. 2010) that, on the whole, implement the lean philosophy of scientific search and continuous improvement. Lean management literature has widely demonstrated the positive effects of lean practices on operational performance (Flynn, Schroeder, Flynn, Sakakibara and Bates, 1997; Schroeder and Flynn, 2001; Shah and Ward, 2003). For example, Dal Pont et al. (2008) show that JIT and TQM bundles have a positive impact on operational performance and that human resource management practices act as an antecedent of the implementation of JIT and TQM .

### *3.2.2 Green practices and plant performance*

Many scholars agree on the positive impact of green practices on environmental performance and operational performance. For example, pollution prevention technologies are normally associated with a better environmental performance than pollution control technologies since they remove or curb the root causes of pollution (Porter and Van der Linde, 1995b; Klassen and Whybark, 1999a). Indeed, King and Lenox (2002) demonstrate that pollution prevention improves product quality and could be positively correlated with the innovation process while pollution control might generate unexpected costs.

According to the natural resource based view, environmental practices are conducive to higher competitive advantage in terms of enhanced employee skills, reputation and, more generally, organizational capabilities (Hart, 1995; Russo and Fouts, 1997). As Sharma and Vredenburg (1998) demonstrate, proactive environmental management attitude is a likely antecedent of capabilities that facilitate stakeholder integration, that enhance higher- order learning, and boost continuous innovation. Moreover, the managerial perception of the importance of the environment allows the firm to deploy green values into the firm's strategic planning process and its technology portfolio (Sharma et al. 2007). The contribution of proactive environmental management to

competitive advantage is in terms of reduced costs and increased differentiation (Bansal and Roth, 2000; Rusinko, 2007). For example, as Lopez-Gamero et al. (2010) maintain, a new green technology or the eco-design of products and processes may allow firms to reduce costs. More generally, environmental management buttresses competitive advantage supporting efficiency and response to strategic issues and allowing the identification of new opportunities and more systematic attitude to external uncertainty.

A stream of literature has highlighted some possible negative relationships between environmental management practices and operational performance. A debate about the relationship of eco-efficiency vs eco-effectiveness pinpoints the trade-offs between the environmental and economic dimensions of sustainable performance by arguing that the efficient use of natural capital does not necessarily result in the most favorable solution for the environment and that the effective reduction of pollution determines a laxer pursuit of economic benefits (Dyllick and Hockerts, 2002; Young and Tilley, 2006; Wu and Pagell, 2010). Moreover, it is argued that costs of compliance with environmental regulations and the drawing of resources and management efforts away from more strategic activities may negatively affect operational performance (Clark, 1994; Walley and Whitehead, 1994; Klassen and Whybark, 1999b).

### *3.2.3 Lean practices and plant performance*

While it is widely accepted that the implementation of lean management leads to higher operational performance (Schroeder and Flynn, 2001; Furlan et al. 2011), a common understanding does not exist on the impact of lean practices on environmental performance.

Some scholars argue that lean practices actually reduce environmental performance (Cusumano, 1994; Rothenberg, Pil and Maxwell, 2001; Zhu and Sarkis, 2004). Cusumano (1994) shows that since JIT adoption increases the frequency of deliveries, it also worsens pollution emissions.

Rothenberg et al. (2001) survey 31 automobile assembly plants in North America and Japan but they do not find any empirical relation between buffer minimization, work

practices and human resource management (proxies for lean production practices) and environmental performance.

On the other hand, some authors strongly support the positive impact of lean practices on environmental performance (Shrivastava, 1995; Florida, 1996; Hart, 1997; Rothenberg et al., 2001). For example, King and Lenox (2001) find that lean production, in terms of quality improvement and lower inventory, is associated with lower pollutant emissions. Indeed, drawing from the investigation of 17,499 U.S. plants, they show that the adoption of the standard ISO 14001 is more likely to occur when the ISO 9000 quality management standard has been already implemented.

#### *3.2.4 Synergies and interactions between lean and green practices*

Few studies in the environmental management literature investigate the performance implication of the joint adoption of lean and green practices. In general, scholars agree that green practices can reinforce and been reinforced by lean practices, i.e. the two sets of practices can be synergic.

Within the framework of the resource based view, world-class lean practices allow a plant to spawn distinctive competencies and capabilities that encourage the implementation of green practices (Florida, 1996). Gonzalez-Benito (2008) suggests that a plant that is culturally driven by continuous improvement and counts on flexible and skilled workforce shows a higher endowment of environmental competences and capabilities. In particular, there is a high correlation between a plant's soft lean practices, such as employees training and close collaboration with suppliers, and its environmental proactive stance towards production processes and external logistics. Also, some authors highlight that environmental practices have a mediating role on the relationship between lean practices and environmental performance. Yang et al. (2011), for example, suggest that lean practices, a proxy for operational competences and capabilities are an antecedent of green practices, i.e. a plant that has a high implementation of JIT is more likely to adopt a proactive environmental mindset. Moreover, the continuous improvement of the production processes and supply chain practices are conducive to better distinctive competencies and

capabilities, such as outstanding quality standards and collaborative hand-in-glove supplier partnerships, that facilitate the implementation of green practices, such as the adoption of demanding environmental standards by the suppliers (Yang et al. 2010; Hajmohammad et al., 2011).

Another stream of literature prefers a narrower investigation of the relationship between single lean practices, rather than considering the lean production system as a whole, and green practices. Klassen (2000), for example, demonstrates “overlapping benefits” from the implementation of JIT and pollution prevention technologies. Pil and Rothenberg (2003) find that environmental practices have commonalities with the TQM, resulting in incremental benefits on the operational performance. Particularly, they demonstrate that not only a higher quality enhances environmental performance but also environmental practices drive a better quality.

A broad stream of literature deals with TQM and has coined the acronym TQEM (Total Quality Environmental Management) to investigate the synergies between TQM and environmental practices. For example, scholars argue that the combination of TQM with environmental practices leads to address identical problems in a more effective and efficient way, to avoid the duplication of efforts and to reduce the costs of compliance to regulations, internal and external audits (Willig, 1994; Angell and Klassen, 1999; Molina-Azorin et al., 2009).

Despite the general agreement on the synergies between lean and green, an in-depth, explorative approach is needed in order to unveil the actual interdependencies between lean and green practices and the conditions under which these interdependences yield maximum synergies.

### **3.3 Research Methodology**

Our purpose of exploring how lean practices and green practices interact and jointly affect the operational and environmental performance has been partially investigated in previous research. Indeed, literature lacks a thorough and qualitative understanding of the complex interactions between lean and green practices. These limitations do not allow it to capture

the conditions and the reasons underlying the synergistic effects among lean and green practices. Since our aim is to explore the interactions among lean and green practices, we adopt the case study as the most suitable methodology. The choice of a qualitative research method involving multiple case studies is in fact appropriate when exploration is needed to develop theoretical and managerial insights into the researched issue (Eisenhardt, 1989; Yin, 1994; Voss, Tsikriktsis and Frohlich, 2002).

### *3.3.1 Cases selection*

The cases were selected following a theoretical sample procedure (Glaser and Strauss, 1967). We looked for plants with the following criteria: a high commitment to both lean and environmental management; similar manufacturing processes; and comparable sizes. In order to control for location-based effects (Anand et al., 2007), we further narrowed our sample to the plants located in the Veneto region (North-East of Italy). In order to find a sample of plants that meet our criteria, we collected information about potentially interesting plants utilizing Internet, local business associations and archival data. Finally, we contacted two multinational firms that we call Alfa and Beta for confidentiality reasons. Two of the four authors already knew the firms and had valuable personal contacts with the CEOs and some top managers of the Italian branches.

Firm Alfa (350 employees) is a multinational company with approximately 12.000 employees and revenues of about US\$4 billion in 2010 (-5% compared to previous year). The company's core business is based on three products families: heat transfers (57% of the revenues), separators (22% of the revenues) and fluid handling products (11% of the revenues). The plant located in Veneto produces air heat exchangers, including air-cooled condensers, dry coolers and unit coolers for both commercial and industrial use.

Firm Beta (680 employees) is part of an American corporation (US\$11 billion revenues in 2010, slightly better compared to 2009, and 40.000 employees worldwide), a company operating in three different business segments: water and fluids management, global defense and security, and motion and flow control. The plant located in Veneto

produces water-pumping systems for residential use (70% of total revenues) and OEM (30% of total revenues).

The two manufacturing plants are highly committed to environmental issues (the plant of firm Alfa has an ISO14001 certification while the certification process of the plant Beta is underway) and they both have a 10-years-long experience in lean production.

Both the plant general managers, during the first interview, highlighted their strong personal involvement in the adoption of environmentally driven strategies, confirming these plants respected our criteria selection.

As literature showed (Aragon-Correa, 1998; Bansal and Roth, 2000; Klassen, 2001), a proactive firm orientation towards environmental issues increases the likelihood of investments on pollution prevention projects that are normally associated with positive performance implications. Following such approach, pollution prevention projects turned to be our unit of analysis. Indeed, at the outset of the research, we meant to carry out our investigation at the plant level but, after our preliminary interviews with the plant general managers, we shifted our attention at the project level. This different, more micro level of analysis, helped us to focus our analysis by better identifying which lean and green practices have been adopted and what characterizes their jointly implementation.

We firstly selected four projects (two for each firm). After gathering information about the projects, we decided to rule out one of the plant Alfa's projects since it presented very different structural characteristics. This project was about the reengineering of the global supply chain for heat exchangers and involved different organizations around the globe. The remaining three projects were all confined within the plants and were aimed at improving single stages of the production processes. The first project (plant Alfa) concerned the elimination of the washing plant for one family product (project A). The projects of plant Beta concerned the elimination of the washing plant for some components of the water pumps (project B) and the introduction of a painting booth for electrophoretic painting (project C).



### 3.3.2 *Data collection*

Our case studies started with the development of a research protocol, whose content was based on the above theoretical framework. This protocol dealt with the following issues:

- (1) Which lean and green practices have been adopted within the projects;
- (2) How lean and green practices have been implemented;
- (3) How lean and green practices both separately and jointly affect environmental performance and operational performance.

As the use of multiple investigators is a good way to reduce biases and create more reliable data (Eisenhardt, 1989; Yin, 1994; Pagell, 2004), we personally conducted all the interviews. In both cases, preliminary interviews (with the plant general managers) were followed by a visit at the plants, which enhanced our understanding of the manufacturing processes analyzed in the projects. In the following meetings, we interviewed operations managers, quality managers, manufacturing engineering managers, environmental managers, project managers and some operators from each company (see Table 9 for details of interviews).

Thanks to their distinct roles and functional levels, these key informants were able to provide insights from different perspectives. Each meeting information had been enriched by follow-up telephone calls and emails. All the interviews and follow-up information were recorded and typed for the subsequent analysis. The firms also provided detailed PowerPoint presentations with qualitative and quantitative additional data on the three projects. We also had access to other data sources such as internal documentations and intranet websites. These multiple data sources allowed us to “triangulate” the information thus reducing the biases related to the dependence on a single source (Eisenhardt, 1989; Martin and Eisenhardt, 2010).

Table 9. Overview of the Interviews

<b>Firm</b>	<b>Type of informants</b>	<b>Duration of interviews</b>
Project A	Plant Manager	3 hours
Plant Alfa	Supply and Operations Manager	6 hours
	Quality Manager	2 hours
	Environmental Manager	4 hours
	Project Leader	8 hours
	Operator A	2 hours
	Operator B	2 hours
Project B	Plant Manager	4 hours
Plant Beta	Operations Manager	4 hours
	Manufacturing Engineering Manager	4 hours
	Environmental Manager	4 hours
	Project Leader	8 hours
	Operator A	2 hours
	Operator B	2 hours
Project C	Plant Manager	2 hours
Plant Beta	Operations Manager	3 hours
	Manufacturing Engineering Manager	3 hours
	Environmental Manager	2 hours
	Project Leader	4 hours
	Operator A	2 hours
	Operator B	2 hours

### 3.3.3 Data analysis

Following Eisenhardt (1989), Eisenhardt and Graebner (2007), Eisenhardt and Ozcan (2009) suggestions, we conducted both within and cross-case analysis at project level.

First of all, we studied separately each project writing detailed reports. Neither patterns nor hypotheses were defined *a priori* in order to avoid pre-established biases and to encourage any plausible explanation.

In particular, two researchers developed for each project individual write-ups and causal flow charts identifying tentative relationships among the involved constructs. The other two researchers separately revised the work, formed their individual interpretation and came out with either confirmation or refinement of the analysis.

Table 10. Overview of the Projects

<b>Project Description</b>	<b>Practices</b>	<b>Performance</b>
<p>Project A                      Ex- ante situation: The solvent-based washing process was inter-operational activity between the printing process and the mechanical expander process. The washing machine was complex and not under vacuum, thus causing high solvent concentration in the workplace.</p>	<ul style="list-style-type: none"> <li>-Collaboration with a thermal laboratory</li> <li>-New layout</li> <li>- Pull system</li> <li>- Pollution Control: gas analyzer and gas counter</li> <li>- Pollution Prevention: mechanical expansion, evaporative oil</li> </ul>	<ul style="list-style-type: none"> <li>- Shorter lead time (from 4 to 3.5 days)</li> <li>- Space saving (250mq)</li> <li>- Cost savings</li> <li>- No water and soil pollution</li> <li>-Safer microclimate in the working units</li> </ul>
<p>Project B                      Ex-ante situation: The solvent-based washing process was an inter-operational activity between the printing process and the welding process. The washing machine was complex and under vacuum, thus causing an ongoing scrutiny of the solvent volatility level.</p>	<ul style="list-style-type: none"> <li>- Proprietary equipment</li> <li>- Collaboration with new suppliers (machinery and painting)</li> <li>-Pollution Prevention: Development of water-based paint; zero-emissions equipment</li> </ul>	<ul style="list-style-type: none"> <li>- Longer durability to corrosion</li> <li>- Higher productivity</li> <li>- Higher flexibility</li> <li>- No water and soil pollution</li> <li>-Safer microclimate in the working units</li> </ul>
<p>Project C                      Ex-ante situation: The cataphoretic painting process was positioned between the washing process and the assembly process. This step was very important for the product quality standards, i.e. uniform paint thickness. The painting machine was as dangerous as the washing machine.</p>	<ul style="list-style-type: none"> <li>- Collaboration with suppliers (machinery and solvent)</li> <li>- Proprietary washing equipment</li> <li>Pollution Prevention: development of water-based surfactants (acid-based inorganic); zero-emissions equipment</li> </ul>	<ul style="list-style-type: none"> <li>- Higher productivity</li> <li>- Higher quality</li> <li>- Cost savings</li> <li>- Space saving</li> <li>- No water and soil pollution</li> <li>-Safer microclimate in the working units</li> </ul>

Secondly, we moved to cross-case analysis to probe whether the relationships identified in each project could fit also the others. As suggested by Eisenhardt (1989) and Martin and Eisenhardt (2010), we compared pairs of cases in order to investigate the similarities and the differences among our three projects. Some causal relationships identified in the within case analysis were confirmed and others were refined. At this stage of the analysis, we mainly relied on the cross-case casual network technique (Miles and Huberman, 1994).

As our theoretical framework clarified, we compared our results with the extant literature to highlight similarities and differences. By comparing our results with the extant literature, we strengthened the internal validity and generalization of our findings (Eisenhardt, 1989; Ozcan and Eisenhardt, 2009). This process led us to refine the research construct definitions and advanced a set of final testable propositions.

### **3.4 Cases Analysis**

In this section, we present the results of our within and cross-case analysis. In Table 10, our three projects have been briefly outlined. Besides the constructs involved in our research questions (i.e. lean practices, green practices, environmental and operational performance), the drivers of the projects have emerged to be important in order to understand why in our projects lean and green practices have been implemented together. Consequently, we decide to dedicate a section of our analysis to the relationship between the drivers and the type of projects under investigation. The remaining two sections of the analysis are focused on the relationship between lean and green practices and their implications on the environmental and operational performance. In all sections, we describe the most salient parts of our case studies that, ultimately, helped us contextualize and support the propositions that emerged from our analysis. The propositions will be presented at the bottom of each section.

#### *3.4.1 The drivers of pollution prevention projects*

Scholars argue that firms' environmental awareness is mainly driven by pressures exerted by stakeholders that are traditionally grouped in: government regulations, organizational stakeholders such as suppliers, customers and competitors; community stakeholders; and the media (Henriques and Sadosky, 1996; Ammenberg and Sundin, 2005; Zhu and Sarkis, 2006).

At an operational level, all these environmental drivers do not necessarily have the same importance and might be translated into multiple and diverse investment decisions. When a firm decides to undertake a project, any decision depends on an accurate

assessment of all benefits and costs of the investment and its associated net value. In our study, plants' choice to implement the three projects was determined by a set of drivers. Each of our projects was not due to compliance needs as all the required governmental pollutant levels were perfectly under control. For example, in project A, the washing plant was equipped with some pollution control technologies, i.e. carbon filters, gas analyzer and counter, which guaranteed the respect of all pollutant parameters. As the operations manager said:

Our solvent concentration was about 0.5mm/mq when the maximum limit was around 20mm/mq.

Also, in both project B and project C, the washing plant and the painting plant were equipped with the appropriate pollution control technologies to cut down the solvent (project B) and painting (project C) volatility.

Though our focus is on environmental projects, all three of our cases did not show an environmental pressure as first-order driver. Indeed, our interviews shed light on other most important operational drivers (cost, quality, dependability, speed, flexibility). The main driver for project A was the reduction of the high running costs of the washing process, due to energy and solvent-additive consumption caused by the machine complexity and the expensive pollution control technologies. The investment was facilitated by two additional facts. First, plant Alfa had already experienced how to eliminate the washing process of another product line and, therefore, had knowledge on the type of interventions needed to be adopted. Second, most competitors had already removed the washing machine out of their manufacturing processes and, therefore, were operating at lower costs. As the project manager pointed out:

The initial objective was not environmental-driven, we could keep using the washing plant (...) but, because of the high costs and our previous experience, we thought to go for it [the elimination] and benefit from solving a series of collateral problems.

Besides the urge to reduce the manufacturing costs, the elimination of the washing shop allowed plant Alfa to cut off those chemical products, i.e. solvents, that the washing machine made use of. These chemical products were expensive to handle and had dangerous contamination risks due to the fact that the washing machine had to be processed without any covering.

The paramount importance of operational drivers over environmental drivers in our projects is even more evident on the remaining case studies. Project B was mainly determined by the decision of improving the washing plant's operational performance. Such big and complex machine worked on batches and therefore lacked the necessary flexibility and efficiency. Moreover, it did not match the cleaning standards required by more recent downstream steps, i.e. the laser beam welding process. As in the previous case, the environment was only a second-order driver since the elimination of the solvent in the washing plant was not a prominent explanation for the project. As the operations manager argued:

The investment decision was not based on that aspect [elimination of the solvent] as, even if it was dangerous, we had a series of procedures that allowed us to use it in a safe way.

Also project C was mainly justified by an operational driver. The painting process used an obsolete technology that hindered the quality of painted components and, therefore, it needed to be changed. The search for a more environmental-friendly painting process was considered important by managers but it would have never determined the project investments.

Table 11. Drivers of the Projects

<b>Project</b>	<b>Type of drivers</b>	<b>Quotes</b>
Project A	Operational	<p><i>“The measuring tools' dismissal allowed us to save 50% of the costs in the washing process” (Plant Manager)</i></p> <p><i>“ We had high operating costs because one product family went through the washing process whereas the other one did not” (Supply and Operations Manager)</i></p>
	Green	<p><i>“We used tons of solvent and additive per year [...] we knew that was causing a huge impact on our pollution production” (Quality Manager)</i></p> <p><i>“We had to continuously watch out for possible leakages” (Operator A)</i></p>
Project B	Operational	<p><i>“We needed to be more flexible” (Plant Manager)</i></p> <p><i>“Pieces were not washed correctly [...] the low washing quality caused many problems to the welding process” (Operations Manager)</i></p> <p><i>“We used a high quantity of solvent” (Operator B)</i></p>
	Green	<p><i>“The operator had to carefully handle the solvent” (Operations Manager)</i></p> <p><i>“Every month we had to manipulate the used solvent and manage its disposal” (Manufacturing Engineering Manager)</i></p>
Project C	Operational	<p><i>“Our assembly department claimed higher quality” (Manufacturing Engineering Manager)</i></p> <p><i>“Painting technology was obsolete” (Operations Manager)</i></p>
	Green	<p><i>“We used 30 tons of solvent-based paint per year. It was extremely toxic” ( Environmental Manager)</i></p> <p><i>“Our painting process was sealed inside a booth [...] that released a huge quantity of pollutant air” (Operator B)</i></p>

Overall, our case studies show that projects involving environmental aspects are not justified if the manufacturing process is already compliant with regulations. According to previous literature, environmental regulations exert the highest pressure to environmental investments (Henriques and Sadorsky, 1996, 1999; Zhu and Sarkis, 2006). Thus, governmental pressures represent the principal environmental driver for undertaking pollution control technologies, such as carbon filter regeneration (project A, B, C) and machines under vacuum (projects B and C).

Our case studies take a step further into the relationship between stakeholder pressures and green practices. They highlight that, once pollution control technologies are implemented, operational drivers, rather than environmental-oriented drivers, lay the most important role to financially justify pollution prevention projects.

*Proposition 1: The introductions of pollution prevention technologies are likely to be justified by operational drivers (such as cost savings or quality improvements).*

### 3.4.2 *Lean practices and green practices: how and to what extent they interact*

Extant literature has empirically shown that lean practices and green practices share several similarities in terms of the ultimate benefit of reducing waste. For example, JIT and pollution prevention technologies can work together in order to improve delivery performance (Klassen, 2000) whereas buffer minimization and waste minimization lead to an efficient use of water and energy (Rothenberg et al., 2001; Pil and Rothenberg, 2003).

Even if the joint benefits of lean and green seem to be clearly demonstrated, previous studies, given their quantitative nature, do not delve into the complex interrelationship between the two types of practices. Moreover, the controversial results of the relationship between lean practices and environmental performance on the one hand and, between green practices and operational performance, on the other, highlight that previous literature missed to clarify how the two types of practices enact higher performances. Though the natural resource based view has shown that green practices might drive a radical change of the managers' approach to lean production and *viceversa* (Klassen, 2000; Gonzalez-Benito, 2008; Hajmohammad et al., 2011), scarce attention has been paid on how and to what extent lean and green practices interact and draw a manufacturing rethinking and, ultimately, impact on both operational and environmental performance.

Our projects involve two types of pollution prevention technologies, i.e. material change and process change.

Our study shows that both the timing of implementation and the nature of the practices shape the interdependences between lean and green practices. Two temporal



patterns are identified: a sequential implementation of practices and a simultaneous implementation of practices.

The sequential implementation is found in project A where a process change and a material change unveiled some operational problems/opportunities that called for the introduction of other lean and/or green practices. In particular, the process started with the introduction of the mechanical expansion and the use of evaporative oil for one product line (ACC- Air Cooler Condensers) in order to eliminate the washing step. This allowed the firm to significantly reduce the processing costs and the production lead time. The successful implementation of these changes convinced the management to gradually extend the adoption of the same pollution prevention technologies to the UCC (Unit Cooler Condensers). However, the elimination of the washing step for this product brought some qualitative problems since it needed to be perfectly clean in order to perform its functions. These problems led managers to further change the process by both eliminating the pressing step for one component (this reduced the residual internal fine dust) and switching to another oil (from evaporative oil to an oil with vegetable derivatives). Once plant Alfa successfully eliminated the washing plant also for UCC products, managers realized that such change paved the way for further process improvements. In order to do so, the firm planned the introduction of a bundle of lean practices. In particular, the elimination of the washing plant allowed the firm to rearrange the process layout one-piece-flow wise, to introduce a pull system, to bring the machines closer and to drastically reduce the inventory buffers.

Projects B and C are examples of the simultaneous implementation of lean and green practices. Specifically, plant Beta recognized at the outset both operational and environmental problems and decided to tackle them simultaneously.

In project B, the environmental manager decided to introduce a material change (use of water-based detergent instead of solvent products) and lean practices (smaller and dedicated washing machines). The former change prevented the use of pollutants while the latter increased process flexibility and lower inventory. As the project manager pointed out, lean and green practices required a jointly implementation:

We focused on dedicated machines because we wanted them to wash as soon as the pressing process released new components or, said differently, in a one-piece-flow fashion. Anyhow, these lean practices could be implemented only if we shifted to a technology that allowed us to use detergent instead of solvent, because operators could easily handle solvents without following particular safety procedures and, thus, work closer to the machines.

Along the same vein, the manufacturing engineering manager maintained that:

If we haven't had this set of objectives [jointly implementation of lean and green practices], we would probably have bought different machines with different technologies.

The simultaneous approach generated the need to solve different problems at the same time. Indeed, plant Beta had to identify the right water-based detergent and matched it with the right washing technology. In order to do so, the firm decided to involve external suppliers of both detergent and washing machines. First of all, it started working with three suppliers of detergent and ended up collaborating with one of them in order to find the right detergent. At the same time, they started collaborating with one trustworthy supplier of washing machine. A team composed of members from all three firms where formed and after few months the right match between detergent and washing technology was found.

..

Table 12. Process Timing of Lean and Green Practices

<b>Project</b>	<b>Process Timing</b>	<b>Quotes</b>
Project A	Sequential	<p><i>"We went through different sequential steps. It was like having different projects coming u (Project Manager)</i></p> <p><i>"The decision to eliminate the washing step forced us to rethink the upstream process. The opportunity to green the process" ( Plant Manager)</i></p> <p><i>"As soon as we eliminated the washing step, we could rethink the entire production proces (Supply and Operations Manager)</i></p>
Project B	Simultaneo us	<p><i>"We wanted to have water-based surfactants that matched our dedicated washing machines in order to get the best quality possible. We knew everything had to fit together" (Project Manager)</i></p> <p><i>"We defined the process parameters: to have the highest quality given our machines, we knew we had to respect or adjust the throughput time" (Manufacturing Engineering Manager)</i></p>
Project C	Simultaneo us	<p><i>"When you decide to go greener, lots of problems arise and higher attention is needed to keep the production process smooth" (Plant Manager)</i></p> <p><i>"We knew that we had to look for a simultaneous collaboration with both the paint supplier and the machine supplier for reaching our objectives" (Operations Manager)</i></p> <p><i>"We wanted smaller painting machines and lower buffers. For this reason, we needed to change our paint. A pollutant paint is risky and must be handled carefully and under certain conditions. (..) We had to go for an environmental-friendly paint. " (Project Manager)</i></p>

Table 13 Coordination of Lean and Green Practices

<b>Project</b>	<b>Modes of coordination</b>	<b>Quotes</b>
Project A	Planning	<p><i>"We removed the washing step for one product line and then we planned to repeat the experience with the other product line" (Plant Manager)</i></p> <p><i>"Once we completely removed the washing step, we decided to leaning the overall production process" (Supply&amp;Operations Manager)</i></p>
Project B	Mutual Adjustment	<p><i>"Our supplier suggested to add a meter to pour the correct amount of surfactant into the dedicated machines. Thus, we were able to completely standardize the washing step and the operator was not more needed" (Manufacturing Engineering Manager)</i></p> <p><i>"Let's face the truth: solvents gave higher quality standards than water-based surfactants. That's why we had to find the best technology that could meet our quality standards under the constraint of water-based surfactants" (Operations Manager)</i></p>
Project C	Mutual Adjustment	<p><i>"Once we chose the type of paint, our machine supplier warned us to think about a pre-treatment step where product pieces could be washed. This guaranteed the paint adherence to be of high quality" (Project Manager)</i></p> <p><i>"We chose a certain type of water-based paint because it gave us a better solution for highly flexible machines" (Manufacturing Engineering Manager)</i></p> <p><i>"It has been a progressive process: at the outset, we didn't think to get a certification ACS for our pumps. Then our paint suppliers showed us the opportunities related to the certification [i.e. entrance in the drinking water pumps niche] and we decided to collaborate with our supplier in order to get the certification" (Manufacturing Engineering Manager)</i></p>

Similar to project B, in project C the project manager decided to implement both a material change (use of water-based surfactants instead of the solvent-based ones) and lean practices (smaller and dedicated painting machines). As in the previous project, project members teamed up with suppliers of both chemical products and painting machines in order to identify and test what painting technologies and water-based surfactants worked better together. In this collaborative effort, suppliers also suggested to consider the introduction of a pre-treatment cycle in order to guarantee a higher durability of the paint

The case evidence shows that the interdependencies between lean and green practices are of a different nature depending on the type of implementation, i.e. sequential *vs* simultaneous. Drawing on Thompson (1967), we distinguish between sequential interdependencies and reciprocal interdependencies.

When the implementation is sequential, managers first introduce one set of practices and then plan the introduction of another set of practices based on the feedback from the initial introduction. In such context, the sequential interdependencies between the two set of practices are managed by means of planning. Planning becomes the main coordination mechanism to be leveraged in order to successfully implement complex projects that involve lean and green practices. As in project A, an early adoption of environmental practices gave the opportunity to later plan a successful implementation of lean practices.

When the implementation is simultaneous, managers have to manage reciprocal interdependences between lean and green practices. The coordination of practices, that need to be implemented simultaneously, is mainly attained through mutual adjustment. Mutual adjustment becomes the coordination mechanism for tackling with different problems and potential drawbacks at the same time. As in project C, the adoption of a certain type of paint was strictly determined by the decision about the type of the painting process technology and *viceversa*.

Finally, as projects B and C show, the coordination of practices is often performed by different actors. It clearly emerges that the role of suppliers is prominent in those projects that simultaneously implement lean and green practices. Indeed, project B shows that the identification of the right match between water-based detergent and process technology was the result of an ongoing discussion among project

members, suppliers of paints and suppliers of machines. It follows that knowledge sharing and collaborative relationships allow the firm to leverage on technical expertise and access to external information of the suppliers to successfully create and implement pollution prevention technologies (Vachon and Klassen, 2007, 2008).

Propositions follow:

*Proposition 2a. A sequential interdependence between lean and green practices calls for planning in order to be managed.*

*Proposition 2b. A simultaneous interdependence between lean and green practices calls for mutual adjustment in order to be managed.*

*Proposition 3. A simultaneous interdependence between lean and green practices is more likely to be associated to the involvement of external suppliers than a sequential interdependence*

### *3.4.3 Performance: how the nature of relationships between lean practices and green practices influences performances*

Literature has suggested that lean practices and green practices may be synergic (Florida, 1996; Rothenberg et al., 2001; King and Lenox, 2002). On the one hand, lean practices, considered as proxies of distinctive organizational competences and capabilities, create a unique organizational environment where green practices and, more generally, environmental strategies can flourish. On the other hand, green practices related to pollution prevention technologies, rather than “end-of-pipe” pollution equipments, can lead to the development of unique bundles of organizational competences and capabilities (Shrivastava, 1995; Russo and Fouts, 1997; King and Lenox, 2002).

Our case studies confirm that lean practices and green practices synergically yield operational and environmental results. Project A, for example, cut the cycle time from 4 days down to 3.5 days and eliminated the use of solvent with major benefits to water contamination. Similarly, projects B and C recorded both operational improvements, such as higher quality and efficiency, and environmental improvements, such as zero-emissions machines. Overall, our projects highlight that lean and green practices should be implemented together: in project A, the implementation of lean practices paved the way to adopt green practices; in projects B and C, the simultaneous

implementation of lean and green practices was needed to find the right alignment between these practices in order to achieve the targets. All in all, our study confirms the synergic relationship between lean and green practices.

However, besides these common traits, one important difference is found to affect the relationship between the implementation of lean and green practices and operational and environmental performance, , i.e. the sequential vs simultaneous process timing.

Our cross-case analysis suggests that timing influences the impact of both lean and green practices on operational performance. From a qualitative viewpoint, projects B and C undertake more innovative and complex changes along the manufacturing process than project A, which mainly replicates what plant Alfa's competitors already implemented. Moreover, as Table 14 outlines, projects B and C are more efficient in terms of budgeting, number of people involved and planning time. In particular, plant Beta cut the costs for the realization of its projects whereas plant Alfa spends more (€100.000) than what budgeted (€90.000). This is most likely related to the drawbacks encountered in the project span. Indeed, project A had to go through several oil tests before understanding that a process change at the pressing step was needed to solve the quality issue. Once the change was implemented, additional oil tests were required to adjust to the new process setup. A sequential approach thus highlights tension over the imminent drawback, forcing to keep a closer focus and eventually narrowing the set of potential practices to choose from.

Table 14. Performance Metrics

<b>Metrics</b>	<b>Project A</b>	<b>Project B</b>	<b>Project C</b>
Lead time	2 years	5 years	1 year
Planning (N° people involved)	3	2	2
Planning (hours per person)	100h	150h	75h
Budget	€90 000	€100 000	€130 000ca
Actual cost	€100 000	€90 000ca	€108 000ca
Production cost savings	€100 000	€120 000	€60 000
Productivity	not relevant	400%	40%
Quality	slightly worsened	improved	improved
Flexibility	unchanged	improved	improved

Referring to the annual production cost savings, project A shows to be better off than projects B and C. The reason might draw on the nature of these projects. Indeed, the former leads to the elimination of the washing plant and its running costs whereas the latter leads to a process and machinery change, that caused only a reduction of the running costs. More comparable data are those on productivity and product quality, where projects B and C produced higher results. In case of project A, instead, the project manager decided to slightly worsen the washing product quality as no test of evaporative oils allowed a better result. It follows that projects B and C did not face any trade-offs and were able to create the conditions to attain the desired impacts on productivity and product characteristics.

We posit that the simultaneous approach helps implementing practices more quickly, leveraging on different distinctive organizational competences and capabilities, and allows to promptly face potential trade-offs, to avoid major bottlenecks and, finally, to be more efficient and effective.

The proposition follows:

*Proposition 4. Compared to a sequential interdependence, a simultaneous interdependence between lean and green practices is likely to be associated with higher operational performance.*

## **3.5 Discussion**

### *3.5.1 Drivers of pollution prevention projects*

To increase environmental awareness among firms, several researches show that a direct link exists between stakeholders pressures and an higher environmental stance (Henriques and Sadorsky, 1999; Buysse and Verbeke, 2003; Delmas and Toffel, 2008). Different are the reasons underlying the importance of stakeholders. For example, Sharma and Henriques (2004) find that stakeholders involved in environmental issues claim for greener production processes and products as long as they possess or have control over resources that are valuable to the plant. Moreover, the need for gaining social legitimation encourages firms to positively respond to stakeholders' environmental demands (Bansal and Roth, 2000; Cespedes-Lorente et al., 2005). Despite the several studies on the drivers that foster green strategies and processes,



extant literature has scarcely investigated if and to what extent environmental drivers are trade-off for operational drivers when plant strategies have to behold both competitive and environmental priorities (Klassen, 2002).

As literature on manufacturing strategy suggests, any strategic decision takes into consideration different competitive dimensions with the ultimate objective to meet the overall business target (e.g. Boyer and Lewis, 2002; Joshi et al. 2003). Our case studies show that the environmental dimension is not the main driver for environmental projects. Instead, the common pattern is that operational drivers such as cost reduction and quality improvements get the necessary financial resources for the projects. Therefore, the impact of stakeholders' environmental pressures is mitigated by the relevance that other operational dimensions, i.e. cost, quality, flexibility or delivery, have in projects management and, more generally, in manufacturing strategy.

Moreover, as our evidence points out, operational drivers are likely to be a basic condition to undertake environmental projects based on pollution prevention technologies. Because of their high costs, pollution prevention projects require high investments and are normally associated with pressures from stakeholders other than regulatory (Henriques and Sadorsky, 1999; Buysse and Verbeke, 2003). For example, our case studies show that the adoption of pollution prevention technologies occurred even if firms already complied with legislative environmental standards by using end-of-pipe technologies. The urge for taking a step from pollution control technologies towards pollution prevention technologies does not draw on stakeholders' environmental pressures. Instead, operational issues (e.g. cost reduction, quality improvements, flexibility enhancements) are the actual drivers that lead firms undertaking pollution prevention projects. Our case studies thus confirm that plant managers do not assess environmental issues in isolation but tend to balance them against other operational issues, especially in pollution prevention projects.

### *3.5.2 Interdependences of lean and green practices*

RBV literature on environmental management has mainly investigated the relationship between lean and green practices in three different ways. A first venue of interdependency identifies that green practices have a mediating role in the relationship between lean practices and environmental performance (Yang et al, 2010;

Hajmohammad et al., 2011). Second, lean practices and green practices synergistically interact with each other with the ultimate objective to positively impact both operational and environmental performance (Christmann, 2000; King and Lenox, 2001; Rothenberg et al. 2001). Finally, operational competencies and capabilities, such as lean practices, play an antecedent role to environmental management, thus paving the way to the adoption of proactive environmental strategies and prompting higher environmental performance (Florida, 1996; Aragon-Correa, 1998). Though three possible ways of interaction have been identified, no attempt of reconciliation has been done to our knowledge. The role of timing, as outlined in our case studies, may shed some light on these interactions.

Specifically, when timing is related to a sequential interdependence (project A), green practices directly affect environmental performance and indirectly affect operational performance through the implementation of lean practices. It results that the two bundles of practices are never perceived as two sides of the same coin, rather they are two separated operational styles with a consecutive interaction, i.e. one practice leads to some benefits that in turn trigger the adoption of the next practice. This type of interaction recalls the situation in which green practices have an antecedent role with respect to lean practices, thus supporting the extant literature. Instead, when timing is related to a simultaneous interdependence (projects B and C), the mutual adjustment between lean and green practices allows gaining better results at both environmental and operational levels. More precisely, lean and green practices go hand in hand to address issues, overcome possible drawbacks and anticipate potential opportunities. This type of interaction recalls the synergic/complementary relationship of lean and green practices identified by RBV literature.

It thus emerges that the possible interactions defined by extant literature are not exclusive strategies of implementation, neither their differences depend on underlying constraints or contextual factors. Rather, they just highlight the choice of timing related to the adoption of lean and green practices. In conclusion, the relationship between the two bundles of practices can be interpreted from a time perspective, that represents a watershed to define interdependencies and managerial styles to undertake in environmental projects.

### 3.5.3 *Performance of lean and green practices*

Timing not only describes how lean and green practices interact with each other. More importantly, timing plays a crucial role to affect plant performance. Indeed, though the jointly implementation of the two bundles of practices does lead to positive performance metrics, we highlight that the simultaneous approach shows to reap higher benefits in terms of both environmental and operational performance. This finding is a first attempt in the RBV literature on environmental management to compare to what extent lean and green practices positively affect plant performance.

Based on the natural resource based view, researchers show that lean and green practices foster together the development of distinctive competences and capabilities and ultimately the firm's competitive advantage (Hart, 1995; Russo and Fouts, 1997; Yang et al., 2011). Anyway, the different interactions, identified in previous section, seem suggesting there should be a pattern of implementation of lean and green practices (Christmann, 2000; King and Lenox, 2001; Sharma et al, 2007; Yang et al. 2010). We thus advocate that the simultaneous approach is more likely able to build and develop unique operational competences and capabilities that, thanks of mutual adjustments between lean and green practices, are so closely and smoothly intertwined and eventually realize higher performance than a sequential approach.

Given the scarce investigation on whether there are possible differences in the attained performances, we hypothesise that there is still room to better understand whether simultaneous interdependences allow gaining competitive advantages and getting better plant performances compared to all the other possible interdependences.

## **3.6 Conclusion**

While lean practices and green practices have alone received broad attention in extant literature, there is still a lack of understanding on how they interact to enact higher environmental and operational performance. Our case studies show that the interplay of lean and green practices can be synthesized by using two patterns: sequential interdependencies and simultaneous interdependencies. Project A shows the existence of a sequential interdependence. Precisely, the elimination of the washing plant and solvent products gave the opportunity to completely re-engineering the overall process

in a one piece flow-wise. Instead, projects B and C show the existence of a simultaneous interdependence. In these cases, a mutual adjustment among practices helped easily overcome problems and drawbacks. Thus, our analyses highlight that how lean and green practices interact is important and leads to possible differences in terms of both environmental and operational performance.

In addition, our case studies suggest an interesting insight in terms of drivers to pollution prevention projects. We see that all of our projects were undertaken in order to meet operational improvements such as cost reduction and higher qualitative standards. Compared to previous literature (e.g. Henriques and Sadorsky, 1996, 1999), it thus emerges that environmental drivers do not play a pivotal role in the decision making process and they become important as they trigger green practices that contribute to gain better results out of a plant's projects.

Important implications can be found for managerial activities as well as for public policy. When a plant manager aims at implementing practices of lean and green management, it is important to recognize whether these practices are somehow interdependent and a sequential *vs* simultaneous approach can be applied. Our research analyses suggest that managers should pay attention on the timing of implementation of both lean and green practices as it leads to different managerial styles, i.e. planning *vs* mutual adjustment, that in turn affect plant performance. Moreover, practitioners have to decide whether the natural environment might be a part of the firm's operational strategy and try to encompass it as a solution to strategic issues. Finally, for policy makers, one way to strengthen the efficacy of their pressures is to stress out the profitable aspects of pollution prevention technologies. They should support voluntary green programs that demonstrate having a positive link to increased efficiency and quality in plants' processes and products.

Like all studies, much remains to be explored to overcome limitations of our investigation, thus opening up for future research avenues. First, our research does not voluntarily take into consideration the possible effects of contingent factors. Indeed, the types of projects, organizational characteristics and other contextual variables, such as industry type or region type, may somehow affect the interplay between lean and green practices. Moreover, showing the effects of operational and environmental drivers on pollution prevention projects does not allow us to understand which factors are

functional to formulate projects with sequential *vs* simultaneous interactions. Thus, it would be worth including additional case studies to exclude that other drivers or contingent factors to plant Beta created the differing timing, related to plant Alfa.

Another limitation is for generalization of our findings. As plant Alfa had only sequential interdependences and plant Beta had only simultaneous interdependences, our study is not able to highlight whether firm-level characteristics are more relevant than operations-level characteristics (e.g., management behavior, available resources and competences, etc.). A quantitative approach may be more appropriate to generalize our findings. Besides cross-sectional empirical analysis, it would also be interesting to longitudinally research the link between lean and green practices. Timing has indeed a critical impact on both environmental and operational performance, hence to create a time lag between lean practices and green practices would empirically support or contradict our findings.

In conclusion, a better identification of the type of lean practices and green practices associated with the sequential approach and the simultaneous approach could be interesting to investigate.

# Appendix A. Description of variables

## Competitive Priorities

Manufacturing plants have many different requirements placed on them. For each of the following *competitive goals*, please indicate the importance senior management places on each for *your plant*. Allocate 100 points across the six performance goals below to indicate their relative importance. (For example, 0-30-20-50-0-0 or 20-30-20-10-10-10)

Competitive Goal	Relative Importance
A. Manufacturing cost	% _____
B. Quality (conformance to specifications)	% _____
C. Delivery speed and timeliness	% _____
D. Manufacturing flexibility	% _____
E. New product design/innovation	% _____
F. Environment/safety	% _____
Total =	100 %

## Production Outlook

Please estimate the probability that this plant will be operating at or above its current production level (Check one probability for each row)

- Next year....  0%  10%  20%  30%  40%  50%  60%  70%  80%  90%  100%
- In 5 years....  0%  10%  20%  30%  40%  50%  60%  70%  80%  90%  100%

## Plant Ownership

What percentage of the plant ownership is international?

## Export Orientation

What percentage of the plant's sales is generated from exports?

## Import Orientation

What percentage of the costs of your plant's materials, parts, and components are purchased from international sources, i.e., plants outside Canada?

% purchased internationally                      *now* .....%                      *2 years ago* .....%

### Geographical dispersion of suppliers

Please indicate where your plant's suppliers of materials, parts and components are located around the world: (1= not at all, 4= some extent, 7= great extent)

- A. Canada
- B. United States
- C. Latin America, including Mexico
- D. Europe
- E. Asia, including Russia, India and China
- F. Africa

### Plant Size

Approximately how many employees (full-time equivalents) work for the plant?

### Environmental Investments

Approximately what percentage of the total capital budget is allocated to investment in environmental projects over the last two years? (Please check one)

<1%    2%    4%    6%    8%    10%    12%    other: \_\_\_\_ %

### Outsourcing

Approximately what percentage of the cost of the materials, parts and components that comprise your plant's products are fabricated within the plant?

% manufactured in your plant .....	<i>Now</i>	<i>2 years ago</i>	
		%	%

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