

UNDERSTANDING MANUFACTURING COMPANIES' ENVIRONMENTAL DECISION MAKING STRUCTURES

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This paper provides an understanding of the current environmental decision structures within companies in the manufacturing sector. Through case study research, we explored the complexity, robustness and decision making processes companies were using in order to cope with ever increasing environmental pressures and choice of environmental technologies. Our research included organisations in UK, Thailand, and Germany. Our research strategy was case study composed of different research methods, namely: focus group, interviews and environmental report analysis. The research methods and their data collection instruments also varied according to the access we had. Our unity of analysis was decision making teams and the scope of our investigation included product development, environment & safety, manufacturing, and supply chain management. This study finds that environmental decision making have been gaining importance over the time as well as complexity when it is starting to move from manufacturing to non-manufacturing activities. Most companies do not have a formal structure to take environmental decisions; hence, they follow a similar path of other corporate decisions, being affected by organizational structures besides the technical competence of the teams. We believe our results will help improving structures in both beginners and leaders teams for environmental decision making across the different departments.

Keywords: environmental decision making, environmental strategy, green operations management

Introduction

Amidst the Copenhagen global warming discussions, nations will be developing their strategies, objectives and goals to reduce carbon emissions. These decisions will have an impact on corporations and consumers as the policy decisions are cascaded into market incentives and emissions limits to each industrial sectors and product utilisation. As manufacturing has historically been appointed as one of the main sources of pollution, we expect that stricter laws will have particular focus on manufacturing industries.

In addition to the forthcoming demands for carbon emissions cuts, manufacturing has also to deal with decisions related to elimination of substances of concerns (for both consumers and employees), reduction of waste stream due to the scarcity of landfills, and water conservation issues amongst others.

Nunes and Bennett (2010) have evaluated how global companies in the automotive sector are taking environmental initiatives across all activities of operations function. In their classification, car manufacturers are investing in green building technologies (for manufacturing and non-manufacturing facilities), greener design choices, and more efficient manufacturing processes as well as extending their environmental principles to their suppliers through green supply chains including new concerns to the backwards flow of materials and product recovery (reverse logistics).

These new concerns in greening businesses have increased complexity and importance of environmental decision making in organisations. Thereby, it is the research problem we are addressing in this study.

Literature Review on environmental decision making

Most of the studies in environmental decision making have been carried out at the policy level (English, 1999; Hoffman, 1999; Azapagic, 2003). At company and departmental levels ISO 14001 structures have been used to take decisions although they do not include decision making methodologies. Current literature on the topic brings little to light about the particularities existing between environmental decisions in the different activities of operations function and technology choice. As policy is cascaded to business units and departments it becomes necessary to understand the different drivers and structures within them. Also the existing studies in the field are mostly quantitative, which leaves a gap to be explored regarding the processes behind environmental decision-making in manufacturing organisations (Presley, Meade, and Sarkis, 2007; Tsoufas and Pappis, 2008; Staikos and Rahimifard, 2007).

As mentioned earlier, environmental decision making has been explained as developing environmental policies. For example, English (1999) offers an approach for information-gathering and analysis for environmental decision making, consisting of 8 categories: (1) determine goals/values, (2) characterise the environment, (3) characterise the economic, social, political setting, (4) characterise the legal/regulatory setting, (5) integrate information, (6) forecast, (7) assess, refine, narrow options, (8) conduct post-decision assessment. Alternatively Hoffman (1999) presents a roadmap for organizational change to invoke environmental actions. The author designs 4 phases to encourage change: diagnosis, unfreezing, movement, refreezing. After 'diagnosing' concerning issues, the 'unfreezing' phase includes establishing a sense of urgency, the forming of a guiding coalition, and creating a vision. 'Movement' requires communication of the vision, empowering others to act, planning for and creating change, and consolidate improvements. Finally, 'refreezing' relates to institutionalizing new approaches. These approaches are more change management.

A systems approach to environmental decision making has also been taken. For example, Van Der Vorst (1999) highlights that a systems approach should extend

beyond the environmental impact assessment, environmental management systems, and life-cycle assessment. Azapagic (2003) proposes a general 5 stage framework for Corporate Sustainability Management System, which is compatible with ISO 14000 environmental management systems standards, including: (1) sustainable development policy, (2) planning, (3) implementation, (4) communication, (5) review and correction actions. Azapagic locates the business strategy and vision in the centre of the model linking it to sustainable development policy and planning stages.

Presley, Meade, and Sarkis (2007) notice that most models support sustainability decisions at a broader dimension, as such studies include regional policy and industrial analysis. Thus, they present a Strategic Sustainability Justification Methodology (SSJM) comprising four phases: (1) identify system impact, (2) estimate impact, (3) perform decision analysis, (4) track operations. The authors test this in a reverse logistic outsourcing example including economic, social and environmental dimensions.

Also on environmental decision making in supply chains, Tsoulfas and Pappis (2008) used a multi-criteria decision-making (MCDM) technique to include environmental performance indicators in the analysis of supply chains. They chose MCDM to analyse objectives and criteria that were conflicting, multi-dimensional, incomparable and incommensurable and needed to accommodate quantitative and qualitative data. Another multi-criteria approach is presented by Staikos and Rahimifard (2007) who combined Analytical Hierarchy Process (AHP) with life-cycle and cost benefit analysis to analyse shoe waste management. The authors used quantitative (for economic and environmental factors) and qualitative (for technical factors) analyses for a complex range of alternatives: (1) reuse: shoes are reused in less-developed countries; (2) recycling: shoes are shred as a whole; (3) recycling: shoes are dissembled to shred separated materials, (4) recover: incineration to generate heat and electricity; (5) disposal: in a landfill. This example shows a range of alternatives that make environmental decision making more complex.

Indeed, supply chains have been studied to bring business sustainability into a broader arena. On supply chain design, Tsoulfas and Pappis (2006) classify environmental principles into 6 categories: (1) product design, (2) packaging, (3) collection/transportation, (4) recycling/disposal, (5) greening internal/external business environment, (6) other management issues. Thus, supply chain design stretches the scope of environmental analysis, increasing its complexity and uncertainty and other business trends (e.g. market globalisation) brings other complexities to evaluate/manage business performance (Hill, 2007).

This is daunting for the management of supply chains given the high number of players and strong trade-offs. Consequently, while questions of why a company should implement sustainable supply chain practices may have been addressed, other issues remain e.g. how companies make environmental decisions or how to select between, methodologies to optimise strategic investments, the implementation of environmental initiatives while aligning with corporate goals e.g. profitability. For example, on this last point, while some business practices return profits, environmental protection is recognised more as a public good (Orsato, 2006) which may not return profits but may conflict with corporative objectives under an opportunity cost analysis. This extends to the public good created by the supply chain, as Seuring and Müller (2008) identified the objectives of corporations for greening supply chains which included: (1) supplier management for risks and performance

(e.g. avoiding risk from suppliers with poor environmental and social performance); (2) supply chain management for sustainable products as a more proactive strategy. However, as businesses consider the importance of managing (their and suppliers') intangibles, environmental issues may become more valuable. Following this trend, environmental/green operations management has gained special attention and, due to the complexity of issues and range of resolutions, a systemic approach seems necessary to analyse how decisions impact on environmental aspects and the business/operations strategy. In fact, authors have already claimed the need of systems view of environmental issues (Corbett and Klassen, 2006; Klassen, 2001; Graedel and Allenby, 1995, Kleindorfer et al, 2005; Orsato, 2006).

The extended view of environmental management towards supply chain is justifiable given the transfer of environmental impacts within outsourcing practices and the different legislations in countries (Brown, 2008). In conjunction with outsourcing trends, Child and Tsai (2004) explain that companies face different institutional constraints in different countries that could affect their strategy (proactive or reactive environmentally). In addition, Van Hoek (2002) discusses the integration of environmental issues and business strategy, "The point being that it should not be an add-on characteristic; it is a strategic choice that has to be managed consistently and accordingly". Van Hoek adds the importance of market willingness to pay for the green product and other market issues e.g. barriers to imitation, and by adding new criteria to assess greening alternatives we increase the decision complexity.

In the 1990s, when the scope of environmental decisions was more narrowed within only manufacturing processes, many authors have published seminal studies to show that environmental decisions towards pollution prevention technologies were superior as well as better aligned with business goals than pollution control technologies (Klassen and Whybark, 1999; Sarkis, 1995; Shirivastava, 1995; Beamon, 1999).

Given these complexities and economic, social and natural contexts in which companies operate, we have studied the main drivers for environmental decision making, the origin of ideas for environmental improvement, performance measurement, and the structures used for environmental decision making.

Next we present the research methodology, with a brief description and the research method employed in each case.

Research Methodology

Our research methodology is predominantly qualitative and the research strategy was based upon case studies. The main reason for such choices resides in nature of the problem being researched which changes accordingly to the context of the company. For instance, environmental pressures will change according to factors such as industry sector and location. In order to have control over research variables, we have used decision making teams as our unit of analysis and explored different industries (automotive industry (2), textiles (2), food processing (1), and chemical (1)) in developed and developing countries. To understand cross-sector and location differences, other industries in developing and developed countries were investigated

(See table 1). In short, our investigation is more interested in the process of decision making rather than the decision themselves, and we tried to answer three main questions:

1. What are the main drivers for environmental decisions?
2. Where do environmental ideas come from?
3. What are the processes and nature of environmental decision making?

We have used different research methods relevant to the different settings investigated. In some cases, data were collected through personal interviews and using semi-structured questionnaires when access to interviewees was limited. On the other hand, when the time available for individual interviews was limited, we used focus groups to collect the data adapting the same semi-structured questionnaire used for personal interviews.

In the empirical research, our interviews were undertaken in different functional areas of the companies, namely: product development, environment & safety, manufacturing, and supply chain management. It is important to note the difference taken between supply chain management and manufacturing areas. When dealing with supply chain management, we have considered the internal operations decisions and initiatives and the issues associated to supplier and customer relationship, while the research on manufacturing areas only looked at internal issues.

Table 1 shows the list of cases, industrial sector, area of research, and research method used. Due to confidentiality reasons, we have used fictional names.

Table 1 - Cases, brand nationality, industrial sectors, plant location, area of research, research methods, number of participants, hours of data collection

Case (Brand nationality)	Industrial sector (Plant location)	Area of Research	Research Method	Number of participants (job position)	Hours (total)
Premium cars (German)	Car manufacturer (Germany)	Product development	Focus Group	6 (engineers / product development team)	2h 30 minutes
Luxury cars (British)	Car manufacturer (UK)	Manufacturing	Personal Interviews	1 (Environmental Manager)	2 hours
Thai Garments (Thai)	Garments (Thailand)	Manufacturing / Supply chain	Personal Interviews	1 CEO	1 hour 40 minutes
Sea food (Thai)	Food processing (Thailand)	Manufacturing / Supply chain	Personal Interviews	1 Managing Director Assistant	2 hours
Chemical (Thai)	Chemical (Thailand)	Manufacturing / Supply chain	Personal Interviews	3 people (Top administrator)	4 hours
Premium Carpets (British)	Carpets (UK)	Manufacturing / Supply chain	Personal Interviews	1 Environmental manager	1 hour

Findings and Data Analysis

From our exploratory research, most managers admit they do not have a robust and structured approach for environmental decision making. Decisions are sometimes based on experience using rudimentary tools which examine the financial performance of alternatives.

However, some companies use decision structures making environmental decisions go through the same path and procedures as any other business decisions. Other companies were taking decisions based upon an isolated driver (e.g. customers) without considering the implications for other important drivers (e.g. cost, competitors, and environmental performance).

In one case, environmental decisions were viewed as easy but getting harder. For instance, the environmental decisions were considered easy because the interviewee felt it was obvious what should be done – e.g., a requirement from the law or from the customer. Nevertheless, they predicted future complications as the company meets basic requirements so a more strategic and proactive approach will be needed.

Three of our cases had a very structured approach for business decisions which end up being used for environmental decision making. In a case from the automotive sector, we found the payoff being modified to meet the viability and reality of environmental initiatives.

The issues relating to an understanding of what green means in terms of products, process, and technology were also brought into consideration.

A special context was also found in sectors where environmental-related legislation was very strong (e.g. hygiene for food processing and safety for chemical). In these cases, meeting the legislation was very close to meeting customer requirements as well as the industry environmental benchmarks. Nevertheless, these companies were also moving towards more proactive behaviour due to brand image, cost reduction opportunities, and benefits of environmental management systems certification.

The following sections will present the data analysis.

Main Drivers for Environmental decisions

Table 2 shows the different issues that each company pointed out to be the drivers for environmental decisions.

Table 2 – Drivers for environmental initiatives

Case (Area of research)	Drivers
Premium cars (Product Development)	Internal policy, Legislation (specifications), Functionality, Customer, Profitability, Workers' conditions
Luxury cars (Manufacturing)	Legal compliance and stay ahead of the environmental legislation, cost savings, ethics and environmental issues, better environmental performance, rapid return on investments, awareness about international Group benchmarks and environmental management systems standards.
Thai Garments (Supply Chain)	Cost reduction and improvements in workers' conditions
Sea food (Supply Chain)	Safety and hygiene controls, the drivers for certification also include federal and local government legislation (e.g. Ministry of Industry, Ministry of Public Health, etc), customers' standards and special requirements Alongside with the changes in international business, the company named the following drivers for taking environmental initiatives: electricity costs, legal issues in water treatment, customers' requirements, local and federal legislation, local and international competitors and social responsibility (brand image).
Chemical (Supply Chain)	Company's environmental awareness, cost reduction, corporate image, and legislation compliance.
Premium Carpets (Manufacturing)	Customer requirements (commercial customers) Government grants Moral (internal) responsibility Environmental social Policy – to lead the sector 2015

Our data shows that legislation compliance and cost reduction continue to be the main drivers. Despite of this fact, companies' interviewees say that the environment is getting more and more important in the business agenda and their initiatives are starting to become broader than the legislation, therefore, becoming part of companies' internal policies. The Garment case, with weaker environmental legislation and less pressure from commercial customers, demonstrated fewer initiatives beyond manufacturing. On the other hand, we found pressures from commercial customer having a stronger weight than legislation in Premium carpet case. Most of the environmental initiatives were customer-driven, because without environmental certification both the image of the company or the commercial relationship could be in jeopardy. In the automotive industry instead, because individual customers are numerous and perhaps more important for most market segments than commercial customers, their actions are more driven by legislation with regards to product development.

Environmental initiatives are seen mostly from their impact on environmental performance and return over investment perspectives; very few companies related

environmental initiatives as part of the corporate strategy or important for the overall business.

An important factor is reveal from our data analysis: Environmental competition is still very low and in its early stages regardless the sector or location. Hence, the level of ecological innovation and competition to take the environmental leadership is not evident, and mostly related to brand image. Only the sea food company demonstrated a explicit concern in being ahead of competitors in environmental performance.

Origins of ideas for environmental initiatives

Table 3 shows the different issues that each company pointed out to be the origins of their ideas for environmental initiatives.

Table 3 – cases and origin of ideas

Case (Area of research)	Origin of ideas
Premium cars (Product Development)	Mostly from internal sources, some influence from suppliers and group standards
Luxury cars (Manufacturing)	External consultants, in-house experts, local teams and group “best practices database”, internal surveys.
Thai Garments (Supply Chain)	Most of ideas are generated in house. Working group, consultants, External sources, and Industry Federation.
Sea food (Supply Chain)	External sources such as customer, suppliers, auditors, and governments contribute sometimes as part of the company’s environmental learning. Experts are usually hired for special projects. Internally, all the departments report their performance and bring their suggestion for better environmental performance.
Chemical (Supply Chain)	Most of ideas implemented come from the company owners and the environment committee. For special projects like the biomass power plant, it uses external consultants. Decision makers also visit other companies (not competitors though) that have similar process to know more about a possible solution and analyse its results. There is also cooperation with universities evaluating technical solutions.
Premium Carpets (Manufacturing)	Consultants, University (researchers), Safety and Risk Management department, Employees

According to our data, companies have mixed sources to create ideas for environmental initiatives, which includes their own personnel at all organization levels, industry experts, consultant, customers, suppliers, industry federations, group database and standards, and suppliers.

A closer analysis shows that technical issues and big projects usually receive external help (consultants and industry experts). In-house experts also contribute for technical decisions; while top administration always participates in big project decisions. We could also notice that customers play a minor role in suggesting environmental ideas, and middle management and shop-floor associates have a strong role in finding solutions for continuous improvement.

Differently from manufacturing activities, product development (PD) ideas are dealt mostly internally to the PD teams due to issues of confidentiality. It does indeed receive the influence of suppliers and top administration; however, as Hoek (2002) mentioned, it is not very well integrated with other areas and the overall business environmental strategy.

Process of decision making

Table 4 describes the environmental decision making processes companies follow.

Table 4 – Environmental decision making process

Case (Area of research)	Environmental Decision Making Process
Premium cars (Product Development)	All in all, ideas to be implemented need to go through the stages of research, preparation of the proposal, evaluation and approval of the proposal, and finally, the implementation. It usually takes 3 months in research and preparation, and if the idea is well received by the committee it may be evaluated and approved within 3 months. One of the first steps Making environmental decisions in product development is to identify and synchronize the decision to the connected parts, and then, prepare a proposal to be presented and approved by a committee. The committee joins people from different areas such as production, product development, and finance. They are mostly internal people, and the committee can have top managers providing their say. Environmental issues are naturally a multiple objective decision as the transformation to be greener should be done along side to getting cheaper, lighter and smaller. Just like any other business decisions, environmental decisions are susceptible to the organization structures and internal power.
Luxury cars (Manufacturing)	Regarding the decision making process, the decisions are usually taken by hybrid teams. The EM says that these teams are composed of “appropriate people” (i.e. people whose department is related to the decision). For instance, maintenance, environment, small projects and production planning are often among the departments that have representation in the decision making teams. So far, there is not a structured approach to take environmental decisions although an improvement model is in the course of being introduced in order to aid the strategic and operational decisions.
Thai Garments (Supply Chain)	Environmental decision making in the company is divided in two groups: big and small projects. Big projects, such as the 10-million Bahts water treatment station, needs to go through the scrutiny of top administration for viability analysis. Small projects which can be ideas from employees and the working group are only presented to the managing director (MD), who evaluates the benefits from the investment, and finally, approves or rejects its implementation. The criteria used to assess the environmental projects in the company are: (1) Worker condition, (2) Amount of the Investment, and (3) Return over the investment (ROI) – in this priority order.
Sea food (Supply Chain)	Environmental decision making in the company seeks consensual decisions across departments; although the final decision is given by the MD, the owner of the company. Decision making process includes cost-benefit analysis and an evaluation of what would happen if the company does not take or implement the decision. Decision criteria considered in the company meetings are: cost, benefits, image of the company, and the risk of not doing anything. Environmental decisions vary in their levels of difficulty. While some are easy and straight-forward; other are very difficult. The interviewee reckons that access to technical information could help the company in some situations; mainly, to confirm that the information from the Energy & Safety department is reliable.
Chemical (Supply Chain)	Environmental decision making policy in the company divides projects according to its size. Big projects are evaluated by the top administration and a project manager will need to take responsibility in studying the initiative pros and cons to help the team in taking decisions. Small projects have a less structured approach – they are evaluated in the environmental committee, appraised by the MD and taken forward by the departments. Decision making process considers the investment amount and ROI, pros and cons assessment, corporate social responsibility culture and image. Decisions tend to vary in the level of difficult. If it is a decisions associated with the core part of the business, which decision makers are familiar with, they say they can handle it well. On the other hand, if it is a new area, they may need technical help. There is not a structure process to take environmental decisions in the company; mainly when it is an internal discussion. Nevertheless, consultants have been using decision making tools to help the company on its environmental decisions. As the company does not own these tools, there is not much

	detail about them. As a rule, decisions are taken in meetings and through discussions where experience plays an important role.
Premium Carpets (Manufacturing)	The decision making process follow two main steps: (1) Preparation (research), and (2) presentation to Executive team. Consultants are usually contacted to provide help during the process. Environmental decisions are now expanding towards supply chain level which may make it harder and less obvious. New decision criteria will be added shortly including Environmental and social policy, and Brand image and group values. No specific environmental decision tool was mentioned

The processes of environmental decision making in our cases have major similarities. First, they tend to follow similar paths and criteria of other business decisions. Environmental issues are usually seen as threshold to be achieve, a qualifier rather than an order-winner criterion in most decisions. However, once they are seen as important strategically for the overall business they may emerge as the main business criterion. For instance, an auto company in our sample changed the business criteria for viability of environmental projects. Instead of the usual 2-year period to pay off; they extended the pay off period to 5 year when evaluating and approving environmental initiatives. Image is also considered an important criterion. The chemical company, for example, weighted image the most important criterion rather investments, cost or legislation when eliminating a strong smell from the factory's emissions that was affecting the neighbourhood, although the emissions were already within the required legislation levels.

Second, most companies have no specific environmental decision making tool. Decisions are evaluated using the business decision tools such as cost-benefit analysis. An auto company was developing a framework for environmental decisions. Its improvement model is still in a conceptual stage but it seeks to integrate strategically the engineering and business plans. Also, the model should take into consideration short term activities such as recycling, energy saving and materials as well as long-term leadership action to make the company a credible green company.

Third, as a consequence of the business-as-usual behaviour for environmental decisions, they are strongly influenced by organizational structures. It is less bureaucratic for small decisions in all areas but product development (where every new change needs approval). For big projects, environmental decisions will go through a very structured approach until they get the positive response from top administration. In the end, the chances of having a new idea approved are reduced if the idea is not completely aligned to organisation's main goals, overall strategy or corporate philosophy.

Relationship between environmental decision making and reactive and proactive behaviours

Figure 1 shows that companies moving from reactive to proactive behaviour tend to also have environmental initiatives to non-manufacturing activities. Initially, they were mostly concerned about meet minimal standards for legislation compliance, evaluating their initiatives based upon return over investment and meeting customer requirements.

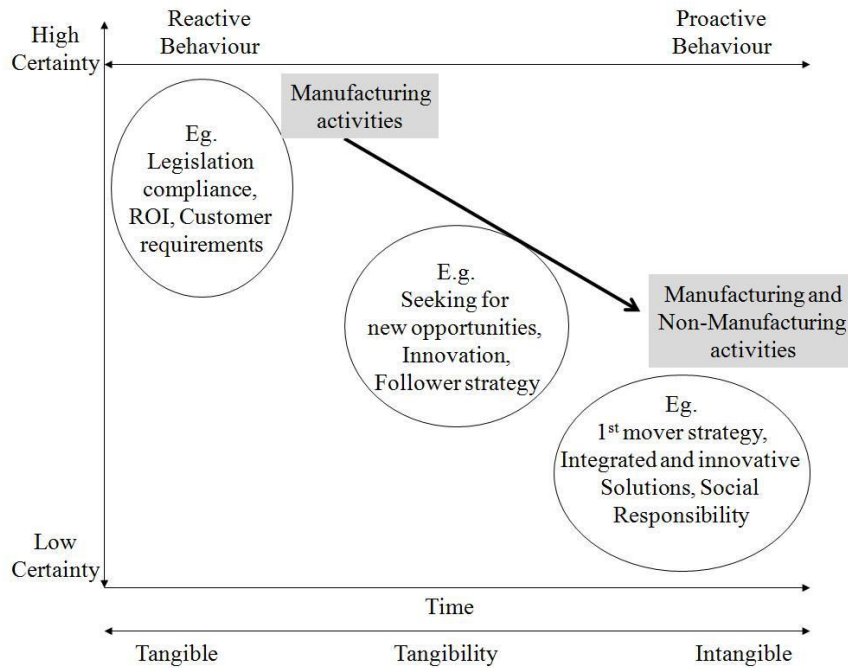


Figure 1 - Relationship between environmental decision making and reactive and proactive behaviours

Looking at our cases, several interviewees have explained how they moved from a reactive to proactive behaviour. For most of them, it implied doing more than the required by law, anticipating customer requirements, seizing on competitors' experimentation in order to innovate and seek for new opportunities.

We could notice that by doing that, they were incorporating non-manufacturing activities in their range of environmental initiatives. However, we noticed this movement was associated with a decrease of certainty and tangibility in their decisions. For instance, in manufacturing processes it is fairly easy to control and calculate emissions and cost reductions. Usually, there is little transformation on the product and the environmental gains are strongly associated with efficiency gains, mainly in programmes like energy use, water conservation and waste reduction. These are all easy-to-measure variables and the environmental decision making process has a high level certainty in predicting the results of investments, new technology implementation, or environmental programmes.

On the other hand, towards the extremes of the supply chain (raw material suppliers or customers) complexity, uncertainty and intangibility are added to environmental decision making process. Environmental initiatives on the product, for example, may not be accepted by customers although they provide great environmental impact minimisation. Green supply chain initiatives are also difficult to handle due to cost increase for lack of certainty in reducing environmental impacts.

Relationship between environmental decision making and green operations practices

Figure 2 supplements the information shown in figure 1. Figure 2 shows that companies expand their range of environmental initiatives from manufacturing to non-manufacturing activities.

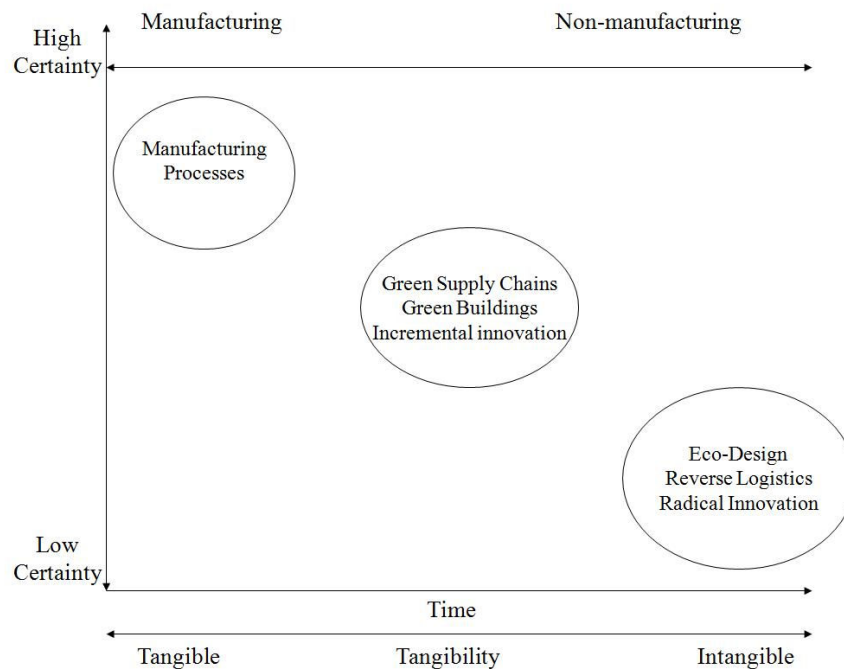


Figure 2 - Relationship between environmental decision making and green operations practices

Expanding the environmental policy and actions from manufacturing to non-manufacturing activities implies the use of a wider range of environmental practices. Within manufacturing, companies are mostly concerned with the 4Rs (reducing, reusing, remanufacturing, and recycling) of greener manufacturing concept. The programmes are well defined around hazardous and non-hazardous waste, energy and water consumption, emissions prevention and control.

One step forward is the inclusion of facilities management, for both manufacturing and non-manufacturing areas, and logistics, which are associated to green buildings and green supply chains, respectively. A further step is the closer to Hart's (1995) sustainable development strategy, which combines environmental concerns for both products and processes.

Nonetheless, we found in our research investigation that the farther the decision is from manufacturing processes the harder is getting, including the understanding of what green means.

Relationship between environmental decision making and internal technical competence

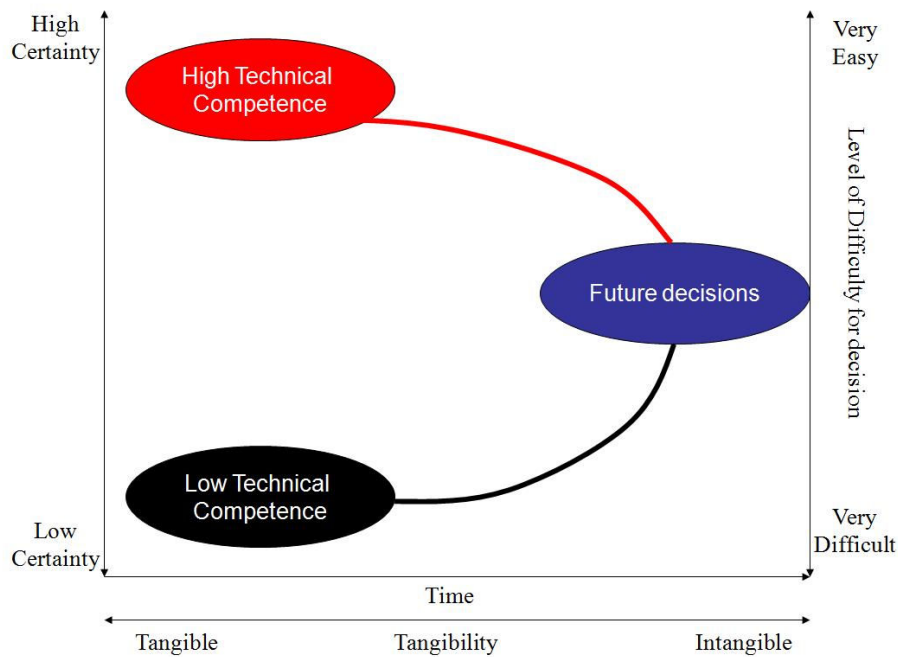


Figure 3 - Relationship between environmental decision making and internal technical competence

Our data shows that companies are initially pressured by legislation, customer requirements, or cost reduction policies, and all of which seem to be fairly easy decisions as they are single objective decisions, mainly for companies with high-technical competence. Interviewees report that the company responds to these requirements in order to continue in the business. Mostly, the initiatives are first implemented in the manufacturing processes; but when they are expanded at supply chain level, and mainly, for product development, they tend to get harder. For companies with low-technical competence, the start is also hard as they do not visualise the economic and commercial benefits of environmental programmes. Nevertheless, once they engage with environmental initiatives their future environmental objectives become clearer and the decisions easier.

By migrating from manufacturing to supply chain and product development decisions, companies will deal with a longer list of environmental decision criteria than the usual legislation, customer requirements and cost reduction. If in the beginning, they could understand that the risk of failing in meeting legislation, customer requirements or lowering the production costs would put their business in jeopardy; now, it is much harder to infer the impact of their environmental policy on suppliers and green features on the products.

Conclusions

This section presents the final considerations of this study, its limitations and contributions.

Final Considerations

From our study, we can draw major 4 major conclusions:

- (i) *When companies expand their environmental initiatives to non-manufacturing activities, which increases complexity to environmental decision making;*

We have noticed that the decision making teams within manufacturing activities had a clear view of what green means, and due to the strong link between firm and manufacturing performance and environmental technologies (Klassen and Whybark, 1999), the environmental manufacturing decisions were relatively less complex than other in supply chain and product development.

- (ii) *Ideas come from different sources depending on the nature of the problem. Drivers and measures to environmental decision making within manufacturing activities tend to be clearer, more tangible and easier than those towards non-manufacturing activities;*

When a company is deciding on a big environmental investment or initiative, there are more parts involved in the decision making process, including in the stage of raising ideas. On the other hand, with small projects personnel are set free to come up with ideas, mainly for continuous improvement. The exception seems to be product development teams in the automotive industry, where even small changes in components are very connected to the whole of a car. Changes in the product are usually difficult to measure the level of greenness as well as the future success or failure of new interventions. Similarly, manufacturing and supply chain decisions are dealt with a wider number of external players (consultants, industry federation and experts, etc); while product development tend to keep things more internally due to confidentiality reasons.

- (iii) *Environmental decisions are dealt rather similar to other business decisions although there are exceptions where environmental concerns are weighted higher than other traditional business measures;*

Environmental concerns are mostly seemed as a threshold to be overcome (emissions limit, ISO certification, level of recyclability, etc). In few occasions environmental concerns are really the main driver for an environmental initiative. This leads to the lack of environmental decision making models and a proper structure to support environmental decisions.

Companies that want to lead the environmental race will need to internalise environmental issues and develop a strong environmental policy beyond manufacturing. When environmental concerns hit the main stream of business, environmental criteria are better weighted in the business decision making instead of being an add-on feature.

(iv) *A systemic model for environmental decision making is necessary for complex and large environmental initiatives;*

Environmental decision making models will need to respect the current organizational structures that are already in place in the companies. This means that a structured approach for environmental decision making would be better accepted for complex and large environmental initiatives and more radical changes; while the continuous improvement initiatives could continue with unstructured approaches.

Limitations

In this paper, we have brought conclusions from a study with 4 different industries: automotive, textile, food processing and chemical. These are traditional industries may not reflect the same context and reality for environmental decision making of new fast-changing manufacturing such as electronics, nano and biotech firms, and alike. Similarly, this is a study with manufacturing firms, which although includes a number of non-manufacturing activities may not be generalised to service companies (telecommunication, tourism, etc). Hence, these are the first limitations that we should highlight in our study.

Secondly, we have investigated firms in 3 different countries and nationalities. We may found that in countries with different cultures and political systems, companies will behave differently of what we found here due to the different strength of drivers or even availability and level of transfer of technology. This leads us to the third possible limitation of our study, which is strongly related to industry and location, the type of technology. Most companies in our study did not belong to industrial clusters and the investigation dealt with main stream technologies in these traditional industrial segments. Environmental decision making may change according to the type of technology, and the behaviour of companies in taking decisions may not follow the steps we presented here. For instance, we did not discuss in detail issues of companies leapfrogging the decision making stages from manufacturing to non-manufacturing, without major problems in dealing with the complexity of environmental decision making.

Theoretical and Practical Contributions

The originality of this paper resides in its different angle of analysis for environmental decision making in manufacturing organisations. It contributes to the field of MOT by a better understanding of the multiple objectives green technologies may need to meet beyond the improvement of actual environmental performance.

A number of practical implications can be derived from this paper. As we have investigated companies in different stages of environmental leadership, and with different decision making experience, our results will be useful for both beginners

when implementing environmental initiatives and also experienced teams when facing new decision-making situations.

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