Sustainability in practice: A case of environmental packaging for ready to assemble furniture

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Abstract

While sustainability is gaining momentum as an important social and business objective, many smaller organisations struggle to put it in practice due to the weakness of the external driving forces in their business environment. Given the important role small and medium sized companies play in both developing and OECD economies, finding suitable practical approaches to introduce and integrate sustainability in these companies can, therefore, significantly contribute to the global quest towards sustainable economic development. This paper provides a practical account of a project aimed at improving environmental impact of product packaging in a New Zealand SME. A number of key factors were identified as main contributors to the success of this project. These include government funding, collaboration with the university, use of simple systematic methods, taking a holistic approach and developing both short-term and long-term solutions.

Introduction

Over the past couple of decades sustainability and social responsibility have been emerging as new themes in the realm of business strategy. Previous studies have provided extensive analysis of the drivers of corporate social responsibility [1-3]. Bansal and Roth [1] list three motivating factors for firms to take on ecologically responsive initiatives:

1. Legitimation – the desire to improve suitability of the firm's actions within an established set of regulations, norms and values [4].
2. Moral responsibility – the desire that stems from the concerns a firm has for its social obligations arising from its self-perception as a functional entity within the macro economical, social and natural environments [5].
3. Competitiveness – the desire to improve the potential for profitability through developing resources and capabilities that are difficult to imitate [6, 7].

Regardless of the motive, studies have shown that sustainability and social responsibility lead to improved competitiveness [6, 8, 9]. However, exactly how seriously a firm considers sustainability amongst its set of competitive objectives depends on the specific market, industry and society that the firm operates in [10]. For instance a manufacturing company operating in an environmentally conscious society such as Germany will probably classify sustainability as a hygiene factor - one that the firm must possess in order for its products and services to be considered by the customer. However, in countries such as New Zealand, where sustainability does not carry much weight in the market and there is an absence of effective environmental legislation, only a small minority of companies think about environmental certifications or sustainability initiatives [8]. This absence of strong external deriving forces for sustainability, coupled with the fact that the majority of New Zealand companies fall under the SME category and have limited access to financial and skilled resources, has resulted in a difficult environment for those who want to improve the environmental performance of their products and processes.

This problem is not specific to New Zealand as many developing economies experience similar challenges to those described above. Finding suitable practical approaches to introduce and integrate sustainability in SMEs operating in these economies can, therefore, significantly contribute to the global quest towards sustainable economic development. This paper provides a practical account of a project aimed at improving environmental impact of product packaging in a New Zealand SME, with the goal of highlighting the success factors in the approach taken in the project.

Project Background

CML is a panel furniture manufacturer in New Zealand producing and distributing its products for the local and international markets. In late 2004 CML's top management decided to investigate the potential benefits of embracing the sustainable manufacturing paradigm. A number of tools such as SWOT analysis, life cycle assessment and stakeholder analysis were used for this purpose, reaching the conclusion that there were great strategic benefits to be gained by the company, namely:

- Qualifying CML's products for entry into markets with tougher environmental legislation, such as Europe and Japan.
- Adding sustainability as a new order-winning criteria to CML's mix of capabilities, to further differentiate their products in the local market which is already under heavy competition from Chinese manufacturers.
- Reducing the cost of energy and waste disposal.
- Reducing the risk from impending environmental legislation.

The 'green manufacturing' project at CML is quite a recent initiative, which has been slowly gaining momentum. It has led to the development of an environmental policy statement which has given rise to a number of projects aiming to reduce the environmental impact of the company's products and processes.

One of the objectives outlined in CML's environmental policy, is to reduce the environmental impact of the packaging material used in their products, with the main concern being polystyrene. Over the years, a number of attempts had been made by various people at CML to reduce or eliminate the use of polystyrene. However, non of the developed ideas had been implemented at CML due to a number of issues, such as conflicting preferences from a number of key stakeholders, as well as the good performance of the current method of packaging.

Given the fact that cost reduction had been the main aim of these attempts to reduce polystyrene, the new environmental objective provided the motivation to revisit the packaging problem from a different view point. To gain the acceptance of all stakeholders, and due to lack of internal resources to be dedicated to this project, it was decided to use external resources. The collaborative relationship between CML and the University of Auckland provided a great opportunity to utilise a number of students for this project. Funding was also acquired for the project from the New Zealand Foundation for Research, Science and Technology.

Environmental Packaging Project

A systematic approach was used to achieve the objectives of the project as illustrated in Figure 1.

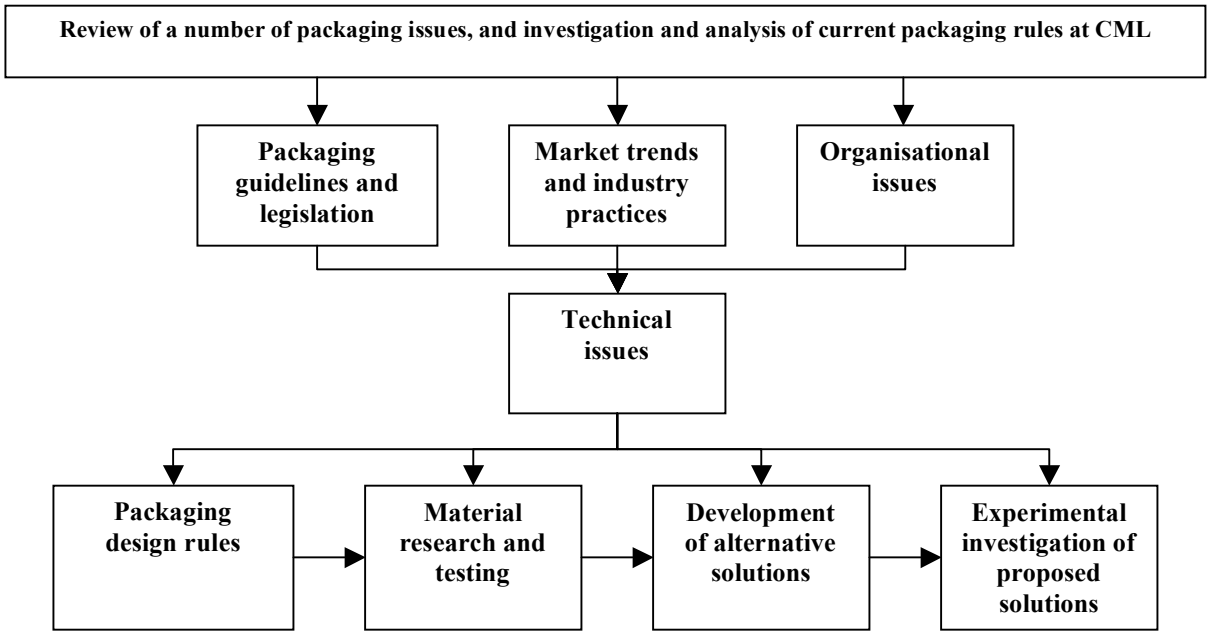

Figure 1: Flow diagram showing objective and methodology overview

Review of sustainable packaging issues

The first objective of the project was to summarise the relevant existing knowledge available in terms of sustainability in business, roles of packaging, packaging design, environmental legislation, current industry practice, and available alternative materials. Findings from the review provided the basis for an understanding of the process, requirements and benefits of introducing environmentally friendly packaging at the company, and have also been included in CML's environmental management database.

Investigation and analysis of packaging at CML

In order to achieve the overall project goal, it was important to identify the relationships between the business, market, social and strategic factors which are related to the introduction of environmentally friendly packaging. This information was obtained through discussions with CML staff, a detailed analysis of the existing packaging process and of the current packaging system, as well as through the application of the insights and knowledge gained from the literature review. The interrelationships between the various factors associated with sustainable packaging were modelled using a causal loop diagram. The results provided CML with a basis of understanding for their decision making with regards to the introduction of environmentally friendly packaging.

Packaging legislation and trends

There is currently no legislation in New Zealand which restricts the amount or type of packaging material used by local manufacturers or importers. The New Zealand Packaging Accord 2004 does, however, provide guidelines and advice to companies who wish to reduce the environmental impact of their packaging [11]. The government has stated that if the current voluntary approach does not provide sufficient improvements in reducing packaging waste, it is prepared to consider enforcing strict environmental regulations [11, 12].

Globally, legislation is becoming more stringent whereby the importation of products using polystyrene packaging is restricted. Some countries (e.g. Germany) already heavily restrict the import of polystyrene packaged products [13]. It is, therefore, in CML's best interest to replace polystyrene in the near future in order to anticipate local regulation changes, and to open restricted international markets to the importation of its products.

The Packaging Council of New Zealand has developed a Code of Practice for the packaging of consumer goods, which outlines the recommended steps that should be taken when designing environmentally friendly packaging [12]. When designing new packaging for a product, or redesigning existing packaging, the following waste management factors should be taken into consideration in this order [11, 12]:

1. Reduction – to reduce or refrain from the use of excess packaging material that is not performing a role in the delivery of products to the consumer.
2. Re-Use, Recycling – re-use packaging on multiple occasions, or utilise recyclable material in the packaging medium.
3. Disposal – The least preferred design alternative is to use material which cannot be recycled and will, therefore, end up in a landfill. Currently, there is no polystyrene recycling facility in New Zealand, and CML's packaging unfortunately falls into this category.

The design and waste management objectives mentioned above are not mutually exclusive, meaning that although a reduction in the packaging may have been achieved, re-use and recycling factors should still be investigated [12, 14]. It is also important to understand that the type of material used in the packaging has an effect on the environmental impact, i.e. some materials have more harmful effects on the environment than others in terms of landfill disposal [11, 12, 15]. PAC.NZ promotes the use of its Code of Practice in terms of ensuring the compliance with two fundamental and equally important principles: Packaging must have the minimum net impact on the environment, while fully preserving the integrity of the products it contains and meeting the customer requirements in terms of information and conversion [12]. A real packaging breakthrough is defined as being a new, innovative, light-weight and environmentally friendly solution which does not compromise the protective and preservation properties of the packaging [15].

Expanded Polystyrene is widely used to package a vast range of products around the world. The following important benefits are reasons as to why polystyrene is such a popular packaging material:

- Polystyrene is currently relatively low in price compared with other materials such as corrugated board [12].
- Polystyrene provides excellent impact protection [16].
- Its 'memory property' allows polystyrene to return to its original form after being compressed [16].
- The material is lightweight [11, 12].

On the other hand, polystyrene has disadvantages which have many people lobbying to decrease the amount of the material used by companies in their packaging. For instance, although polystyrene manufacturers offer recycling facilities, most polystyrene used in product packaging ends up in the landfill as there is no kerbside recycling of polystyrene available in New Zealand [17].

This has many environmental impacts such as:

- The release of hydrocarbons which react with nitrogen oxides in the presence of sunlight forming tropospheric ozone [15, 18].
- It takes up a significant amount of space (in volume) in landfills [11, 12].

The introduction of more stringent environmental legislation, coupled with the continually increasing price of benzene (one of its main ingredients), has led many experts to predict that the cost of polystyrene products will continue to increase in the coming years [13].

Organisational issues

CML demonstrates many characteristics of owner managed SMEs, such as:

- Limited financial resources and managerial skills
- Centralised decision making
- Distribution of resources dominated by a number of strong personalities
- Selective communication to stakeholders in the lower levels of the organisation
- Focuses mostly on short term performance

Miller and Toulouse [19], point out that in the organisational settings described above, success is correlated with the use of structural features that must support a strategy of innovation and empowerment. It was therefore crucial to setup an appropriate team structure and approach the project in a systematic and scientific fashion.

The project team consisted of CML's executive director, a project engineer (internal project champion), a design engineer (internal packaging expert), two students and an academic advisor. Acquiring funding and utilising of students to carry out the majority of the projects tasks, ensured that CML's limited financial and human resources were not tied up in the project. This was critical to gaining across the board acceptance for the project. Furthermore, involving the executive director as well as the design engineer, proved an effective way to include ideas from both operational and strategic viewpoints. The shop floor staff (the packing line) were also consulted on a number of occasion to include their thoughts and concerns in the project. The role of the project engineer was also crucial to guide and co-ordinate the project and ensure the projects objectives were met.

In order to avoid bias towards any specific idea, it was decided from the outset, to systematically analyse the packaging problem and conduct scientific experiments to draw conclusions. It was also decided to produce short term as well as long term solutions for the problem on hand, so that the company's limited financial resources would not hinder the implementation of any proposed solutions.

Technical issues

The literature review, investigation and analysis of packaging at CML created the basis for the development of a specification for the functional and environmental requirements of a viable replacement package. The packaging properties of the alternative solutions needed to compare well against the roles which the polystyrene currently fulfils.

The primary role of packaging is in the protection and containment of the product. Under normal conditions, a package can be subjected to various potentially damaging situations during

storage, transportation and handling, whereby its protecting and containing properties are tested [20].

In the ready-to-assemble (RTA) furniture industry, distribution of the products poses hazards such as impact, vibration and compression [21]. Bruising and breakage of panels occur as the result of impact during handling and transport. Bruising is generally the result of inadequate cushioned coverage, particularly along the edges, around the corners, and over the flat panel surfaces of the furniture unit [21, 22]. For ergonomic reasons, packages are usually handled in an upright manner. The short ends of furniture packages are therefore the most common areas damaged due to impact.

Scratching can occur on panel surfaces as a result of dust and dirt, as well as loose fittings, screws, handles or other components, which are allowed to move about within the package during transport and handling [21]. Another common cause of scratching is the use of stapling to close the packages. The stapling operation needs to be closely monitored to ensure a furniture finished surface is not damaged with the clinching tines of the stapling apparatus [23]. The possibility also exists that the customer accidentally scratches a panel surface on the staples while lifting the piece of furniture out of the package [22].

Indentation damage occurs when the packages are stacked on pallets in warehouses awaiting distribution to customers. Uneven distribution of components or voids within the RTA furniture package under heavy load, can sometimes result in indentations and impressions (such as 'flute line' damage from corrugated cardboard) in panel surfaces [21].

Other important considerations taken into account were the impact of change on pack volume, cost and the availability of the packaging alternatives.

Packaging material research and testing

Samples of the available packaging alternatives identified in the review needed to be initially tested for their impact and compression properties. This objective aimed to develop a knowledge base of relevant material properties, and to eliminate unsuitable materials and thereby conserve furniture pack resources used in the final testing phase. Another important aim of this objective was to develop a set of 'reduced polystyrene rules', to give CML the opportunity to implement an interim solution prior to converting completely to a more environmentally friendly material.

Development and testing of packaging solutions

The final objective of the project was to develop a range of alternative packaging designs using materials with low environmental impact. These packaging designs then had to be prototyped. In order to gauge the capacity of each solution to protect the contents from impact, compression and vibration, they were tested using standard ISO procedures. The three final alternative materials selected were compared with a control package using CML's current complete polystyrene based packaging. Recommendations for CML were then developed with regards to the possibilities of implementing an environmentally friendlier packaging method.

Modelling of furniture package

The testing and investigation in this project concentrated on one of CML's audio stand models, which is among the company's best selling products in New Zealand. CML manufactures over 200 different products, and it was, therefore, necessary to select a 'standard' product to be used in the analysis phases of the project.

The package contained glass, non-rectangular panels, and sharp hardware components, which were identified as requiring special attention in terms of packaging. The philosophy behind the selection of this particular product for analysis and testing was, that if this could be packaged safely, ensuring the customer received the product intact, then CML's other products, without the critical components, could also be packaged using the same method.

Design Specification

The following section summarises the functional and environmental requirements of an alternative package design which were identified from the literature review and the analysis of the current packaging system at CML.

The environmental specifications important in furniture packaging are:

- New materials used in the packaging should be recyclable/re-useable and in line with the overall objective of the project.
- At worst, a reduction in the volume of polystyrene used in the packaging should be achieved, to ensure a net improvement in the overall environmental impact of CML's packaging.

The functional specifications identified as being important are as follows:

- An alternative design should have the ability to protect all contents of the package from impact, scratching and other damage during distribution and handling.
- The total volume of the package must be minimised and preferably lower than the current package to ensure that the shipping container volume is optimised.
- The material used in the packaging should preferably be available to CML at similar or lower cost to polystyrene. However, overall packaging cost can potentially be decreased through savings achieved in the packaging line processes.
- The package should be relatively user friendly in terms of its ability to be opened and resealed.

Initial Testing of Material Samples

The initial material sample testing was made up of two phases, namely impact and compression testing. An A-frame testing rig was designed and built in order to test material samples for their impact properties. Suitable materials, identified in the literature review, were tested using the impact testing rig, each sample having a surface area of $0.03m^2$.

In order to test the compressive resistance of the packaging materials, new samples were made up of the same material types. Using an H-frame press, a compressive load was progressively applied to each material sample. It was found that honeycomb cardboard had the best resistance to compression, and that a fully bio-degradable corn starch material (Pop Starch^{TM}) held the lowest load, while reducing in thickness by the highest amount (see Figure 2).

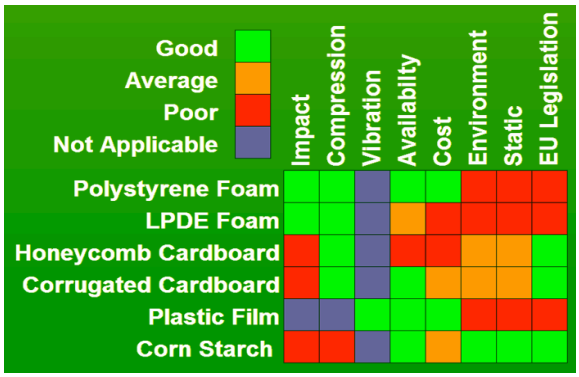

Figure 2: Comparison of packaging materials

The initial sample testing of materials resulted in a realisation that the volume of polystyrene used within each CML package was excessive. Lower polystyrene thicknesses could protect the packages in an adequate manner, with reductions of up to 20% being achievable.

Alternative Packaging Solutions

In the long term it is important that CML completely replaces polystyrene with a more environmentally friendly material. One of the primary objectives of this project was to develop environmentally friendlier alternatives to the current polystyrene based packaging at CML. The choice of packaging materials used in the final designs was based on the environmental considerations and functional properties of the material.

Although honeycomb cardboard was the best performing material in terms of its compressive resistance, it was not chosen as the basis for a packaging design in the final phase of this project. The material did not perform well in the sample impact testing and it is also not yet available on a commercial scale in New Zealand. This means that there would be an increase in environmental impact and at a higher cost to CML who would need to import the material from overseas. LDPE performed well in both sample tests. However, the material does not meet the environmental requirements of an improved packaging solution, and was therefore not considered further as an option.

In accordance with the functional and environmental requirements in the design specification, three package designs were developed utilising environmentally friendlier solutions, namely a shrink-wrap/reduced polystyrene model, a corrugated cardboard model and a Pop Starch™ model.

Final Testing Procedure

As mentioned in previous sections, CML product packs are exposed to various sources of potential damage between their completion on the packaging line and their arrival at the end customer. A viable packaging alternative not only needs to meet improved environmental requirements, but it also needs to ensure that the furniture inside the pack is guarded from damage. The major sources of damage occur during storage, transport, and handling of a package. The final functional testing phase of the project, therefore, concentrated on simulating the compression, vibration and impact conditions which a pack would typically be exposed to in a real life situation. In order to add integrity to this process, the procedures were designed in accordance with the appropriate ISO standards for the testing of transport packaging [24-26]. The three alternative packaging models outlined in the previous section were tested together with a control package using the current polystyrene design. Compression, vibration and impact testing

was performed sequentially, which most closely reflects the conditions in practice. The packages were kept intact through all three tests, and only opened for inspection after the final impact testing to allow a quantitative comparison of furniture panel damage from all three areas.

Overall Discussion of Packaging Alternatives

The overall characteristics of the packaging alternatives suitable for CML's RTA furniture are summarised in Table 1. Although the functional performance of the 'Reduced polystyrene package' was not directly tested, the outcome can be deduced from the results for the control package for compression and vibration, and from the shrink-wrap/reduced polystyrene alternative for impact. Figure 3 illustrates the performance of the various packaging solutions with respect to the criteria outlined in the design specifications.

Table 1: Main characteristics of packaging alternatives

	Control package (current method)	Reduced polystyrene package	Shrink-wrap/Reduced polystyrene package	Corrugated Cardboard package	Pop Starch™ package
Functional Performance and Test Results	- Minor scratches from vibration and impact. - Minor flute line impressions in bottom panel. - No chipping or bruising of panel components.	- Results can be deduced from control package and shrink wrap/reduced polystyrene package due to identical parameters	- Package sustained least damage of four tested packs. - Slight scratching from the impact testing. - No flute line impressions - No scratching due to vibration testing. - No chipping or bruising of panel components. - Overall best test result	- Similar damage as control package. - Minor scratch damage from vibration and impact. - Minor flute line and panel impressions from compression - No chipping or bruising of panel components.	- Most scratch damage due to vibrations and impacts caused by the higher relative movement of the panels. - Increase in material density is required. - No chipping or bruising of panel components.
Environmental Factors	- Worst option in terms of the environment.	- Reduction in polystyrene volume from current package.	- Same volume of polystyrene as in the reduced polystyrene package. - A secondary polymer is introduced to the package, as the shrink-wrap foil, however, this is low volume and less destructive than polystyrene	- All packaging components can be collected by kerbside recyclers throughout New Zealand. - Provides a vast improvement to the polystyrene.	- The best option in terms environmental factors. - Customer can dispose of the Pop Starch™ material in the compost and let it biodegrade.
Organisational and Cost Factors	- Restricts CML from establishing itself on the European market due to environmental legislation.	- Material cost savings of ~$100,000 p.a. - Additional savings in freight cost. - No changes to the current packaging system are required.	- Requires the investment in a shrink-wrap packaging system. - Efficiency and labour savings in packaging process. - The foil used in each package will make the material cost slightly higher than the stand alone polystyrene package.	- Would allow CML to export to Europe. - Much more expensive than the polystyrene (see Appendix C).	- Would allow CML to export to Europe. - Cost of this material is not yet available.

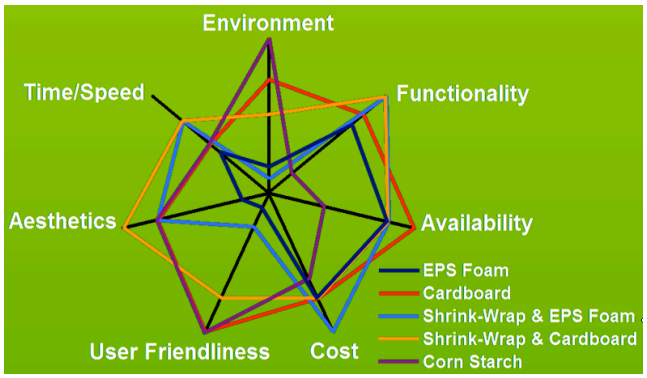

Figure 3: Qualitative comparison of packaging alternatives

Conclusions

The outcome of the case study presented in this paper, was a detailed report outlining various packaging solutions and their relative performance in multiple dimensions. CML has opted to immediately implement a number of the "reduced-polystyrene" rules, and look more closely at the other proposed alternatives involving cardboard and shrink-wrap.

Overall the project was deemed a success by all those involved. Analysis of the approach taken in this project revealed the following factors contributed to its success:

- Government funding: Given the limited financial and human resources available at CML, dedicating internal resources to a sustainability project was not possible since sustainability is not a top priority at CML (due to the lack of external market forces). Acquiring government funding was a critical requirement to undertake this project.
- Collaboration with the university: Students proved to be a great affordable resource. Their independent and scientific point of view also ensured that CML would consider ideas outside of those pre-conceived by its stakeholders. Collaboration with the university also provided CML with access to relevant literature as well as experimental equipment.
- Systematic approach: Systematic analysis of the packaging design process at CML provided an excellent framework for development of solutions. For instance, the original polystyrene problem was divided in to two independent puzzles of external protection and internal containment.
- Holistic approach: Although sustainability improvement was the main objective of the project, all other dimensions of performance such as cost, functionality, user-friendliness, availability, speed of the packing process as well as the pack's aesthetics were also considered. The project team was also structured in a way that viewpoints from various levels within the organisation were taken into consideration.
- Nature of the recommendations: It was also of critical importance that the project yields solutions that had both short-term and long-term paybacks. Cost saving was an important aspect of the short-term solution.

References

1. Bansal, P. and K. Roth, *Why companies go green: A model of ecological responsiveness.* Academy of Management Journal, 2000. **43**(4): p. 717-736.
2. Sharma, S., *Managerial Interpretation and organisational context as predictors of corporate choice of environmental strategy.* Academy of Management Journal, 2000. **43**(4): p. 681-697.
3. Epstein, M.J. and M.-J. Roy, *Sustainability in Action: Identifying and Measuring the Key Performance Drivers.* Long Range Planning, 2001. **34**: p. 585-604.
4. Schuman, M.C., *Managing legitimacy: strategic and institutional approaches.* Academy of Management Review, 1995. **20**: p. 571-610.
5. Garvey, G.E., *The Theory of the Firm, Managerial Responsibility, and Catholic Social Teaching.* Journal of Markets & Morality, 2003. **6**(2): p. 525-540.
6. Menguc, B. and L.K. Ozanne, *Challenges of the "green imperative": a natural resource-based approach to the environmental orientation-business performance relationship.* Journal of Business Research, 2005. **58**: p. 430-438.
7. Hart, S.L., *A natural resource-based view of the firm.* Academy of Management Review, 1995. **20**(4): p. 986-1014.

8. Burke, L. and J.M. Logsdon, *How corporate social responsibility pays off.* Long Range Planning, 1996. **29**(4): p. 495-502.
9. Waddock, S.A. and S.B. Graves, *The corporate social performance - financial performance link.* Strategic Management Journal, 1997. **18**(4): p. 303-319.
10. Shahbazpour, M. and R. Seidel. *Using Sustainability for Competitive Advantage*. in *LCE 2006, 13th CIRP International Conference on Life Cycle Engineering*. 2006. Leuven, Belgium.
11. Ministry of Environment, *New Zealand Packaging Accord 2004 - Sector Action Plans*. 2004, Wellington.
12. Packaging Council of New Zealand (Inc), *Code of Practice for the packaging of consumer goods - a self regulatory code of practice*. 2002: Auckland.
13. Raymond, M., *Extended producer responsibility laws: A global policy analysis*. 2002.
14. Sonneveld, K., et al. *Sustainable Packaging: How do we Define and Measure It?* in *22nd IAPRI Symposium*. 2005. Melbourne.
15. Xu, X. and S.G. Lee, *Design for the environment: life cycle assessment and sustainable packaging issues.* International Journal of Environmental Technology and Management, 2005. **5**(1): p. 14-41.
16. Lye, S.W., S.G. Lee, and S.B. Tor, *A parametric study of the shock characteristics of expandable polystyrene foam protective packaging.* Polymer Engineering & Science, 2004. **38**(4): p. 558-565.
17. Recycling Operators of New Zealand Inc (RONZ). *Polystyrene Packaging Information*. 2006 [cited 11 April 2006]; Available from: www.ronz.org.nz
18. Ministry of Economic Development, *Firm Foundations - A Study of New Zealand Business Practices & Performance*. 2002, New Zealand: Official Publications Office.
19. Miller, D. and J.M. Toulouse, *Strategy, structure, CEO personality and performance in small firms.* American Journal of Small Business, 1986. **11**(Winter): p. 47-62.
20. Oki, Y. and H. Sasaki, *Social and Environmental Impacts of Packaging (LCA and Assessment of Packaging Functions).* Packaging Technology and Science, 2000. **13**: p. 45-53.
21. Pira International ltd, *Furniture Best Practice Guide*. 2001: Surrey, England.
22. Shillito, G., *Packaging Design Rules*. 2005, Auckland: Internal Company Document.
23. Jahre, M., *Packages and Physical Distribution.* International Journal of Physical Distribution and Logistics Management, 2003. **34**(2): p. 123-139.
24. International Standards Organisation, *Packaging - Complete, filled transport packages - Vertical impact test by dropping*, in *ISO 2248:1994*. 1994.
25. International Standards Organisation, *Complete, filled transport packages - Compression and stacking tests using a compression tester*, in *BS EN ISO 12048:2001*. 2001.
26. International Standards Organisation, *Packaging - Complete, filled transport packages and unit loads - Vertical vibration test*, in *BS ISO 13355:2001*. 2001.