International Journal of Academic Research in Business and Social Sciences
January 2014, Vol. 4, No. 1
ISSN: 2222-6990

A Study of Selecting Criteria for Material Substitution under Green Environmental Consideration

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DOI: 10.6007/IJARBSS/v4-i1/553 URL: http://dx.doi.org/10.6007/IJARBSS/v4-i1/553

Abstract

To avoid global warming, climate change is actually a major challenge of human being. Enterprises shall take environmental issues into consideration when they engage in product design and operations management. Due to the trend of mass customization, the product structure is no longer stable and seldom changed. Actually, it's a common use strategy to adopt material substitution to fulfill customers' needs. However, there are many considerations when making the decision of adopting material substitution. This study concludes 21 factors for checking the decision effectiveness of material substitution. These factors can be classified into five categories: cost, quality, time, flexibility, and environment. Then, we use the 21 factors to construct an analytic hierarchy process (AHP) model and analyze their impact weighting. The results indicate that quality is the most important criterion for all of the studied companies in making decisions for material substitution. The items that used to be the significant factors in making material substitution decision are 'the supplier's capability' and 'quality improvement'. From the viewpoint of enterprises engaged in sustainable policy for a long time, the major

factors used to decide the material substitution is whether the material substitution meets the green design requirements.

Keywords: Material substitution, Analytic Hierarchy Process, Green design

1. Introduction

Climate change is a major challenge faced by the humans. In order to slow down and avoid the trend of global warming, global climate change conference in Copenhagen arresting the global attention has reached consensus on environmental issues and carbon emissions, requiring countries to adopt practices to reduce the generation of greenhouse gases and global warming. As a result, reducing carbon emissions is an important issue to be addressed by governments around the world. For businesses, in the product planning, design and production stages, factors relating to carbon emissions and pollutants should be taken into consideration. Therefore, environment and global warming related issues will become a trend in the future. Modular product design is a key element of large-scale customized production, which allows manufacturers to generate a variety of product modules through different combinations using a few or basic types of modular components (Pine, 1993). Moreover, flexibility is the basis to meet mass customization production. In modular production environment, it is an essential practice to use common parts to reduce product costs, and increase different opportunities and demand for material substitution.

There are many different angles of considerations and dimensions for the substitution factors; different thinking angles lead to different substitution options. From the perspective of the materials and parts, each department has its own considerations of materials and parts. For example, the production material control department concerns about the inventory status and the purchase of materials and parts issues. The business department pays attention to customer orders and delivery. R&D department places emphasis on functionality. As a result, there are conflicts among departments regarding considerations, and a comprehensive consideration of the substitution selection of materials and parts often cannot be reached. However, from the perspective of product life cycle, materials and parts substitution tend to be the substitution of functionality as it is relatively more difficult to improve the overall efficiency by cost consideration. In practice, most situations involve customers' material shortage or customer-designated substitution of materials and parts, and thus, it is unable to affect the substation conclusions by data-based discussion. Meanwhile, previous studies on material substitution consider the materials and parts selection substitution considerations from the cost and quality dimensions without exploring the environmental issues. Therefore, this study aims to discuss the affecting factors of material substitution. In addition to the considerations of general performance management, this study also considers the environmental issues, analyzes the impact of key factors on the substitution decision choice, and reduces the concern of the enterprises regarding the material substitution and environment issues, in order to provide a comprehensive consideration decision-making model for enterprises in the development of materials and parts substitution decisions.

International Journal of Academic Research in Business and Social Sciences
January 2014, Vol. 4, No. 1
ISSN: 2222-6990

This study applied Analytic Hierarchy Process (AHP) in the analysis of the key factors influencing the selection of substitution materials, and takes into consideration the environmental issues in assessment. The research purposes are as follows: (1) to provide enterprises with reference criteria for the selection of substitution materials, in order to facilitate the planning and implementation of materials and parts selection plans to better comply with the overall and actual benefits; (2) to allow managers and decision-makers to have correct judgments regarding the selection of substitution materials when considering environmental issues and regulations to make better decisions.

2. Literature Review

2.1 Relevant Literature of Material Substitution

The substitution of materials and parts can be categorized into the substitution of different commodities by retailer, the component substitution in production, and the materials and parts alternative substitution. The substitution relationships have different effects, and different substitution viewpoints can result in extremely different selection options. Therefore, this study aims to explore the substitution of materials and parts. The relevant literature is as shown in Table 1.

Table 1 Material substitution Literature Summary

	Application Environment	Method
Pentico (1974)	Manufacturing Industry	Downward Substitution
Balakrishnan and Geunes (2000)	Manufacturing Industry	Independent Substitutions
		Interacting Substitutions
Ram *et al.* (2006)	Manufacturing Industry	Dependent Demand Substitution
Farag (2008)	Manufacturing Industry	Quantitative Methods of Material Substitution
Tseng *et al.* (2008)	Assembly Industry	Quantitative Methods of Material Substitution

2.2 Relevant Literature of Green Management

Increasingly complex environmental issues and challenges has become a major problem for enterprises. The current development of environment management is not only the requirement of the compliance with emissions control standards, but also follows the direction of the establishment of a systematic conduct. Meanwhile, all environmental issues are managed, measured and improved by a systematic approach, and it has become a comprehensive enterprise management approach (Huang, 2001). Green management emphasizes the management innovations from the removal of unnecessary materials to material recycling, that is, the circular economic mode. The principles of reducing, repeatedly using and recycling of resources can save unnecessary expenses and cost while reducing pollution for the environment to improve the social, business and their own economic interests and get greater economic and social benefits.

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2.3 Green Design

With the high development of economic globalization, when faced with abnormal climate, the international community pays more attention to environment issues, so that various strategies for reducing environment pollution have been proposed in the manufacturing process. With rising environmental awareness, countries around the world have formulated environment laws and regulations related to project development. From the product life cycle perspective, Braungart and McDonough (2008) proposed the green design concept and thinking. To achieve prosperity, individuals must reduce the resources consumption and make effective use of resources, like a cradle-to-cradle system, and the system should generate no waste. Considering the impact of environmental issues on the enterprises, it is necessary to promote the thinking of green design to reduce the pollution of environment. Therefore, this study takes into account of the environmental factors in the selection of substitution materials to improve the overall effectiveness of business decisions.

3. Research Method

3.1 Research Framework and Method

This study first collected relevant literature of material substitution, and developed the basis for the selection of substitution materials. Then, it established the preliminary evaluation items and architecture before making modifications and adjustment of the overall architecture according to the expert opinions. Expert questionnaires were distributed to industries and companies, and the results were analyzed. AHP was applied to analyze the factor weighting and conduct consistency verification of conclusion. Finally, this study proposed the suggestions and improvements of the current status of the studied companies.

3.2 Performance indicators

To surpass competitors, enterprises must distinguish themselves from competitors. The most important factor is the competitive priority and the capacity of the competitor. Skinner (1969) proposed indicators to measure the performance including cost, quality, time and flexibility. Corbett (1998) argued that key performance indicators (KPI) for the consideration of manufacturing strategy include cost, quality, flexibility, delivery and inventory as shown in Table 2.

Table 2 Performance indicators for the measurement of manufacturing strategy

Scholar	Performance indicators of manufacturing strategy
Skinner (1969)	Cost, quality, time, flexibility
Corbett (1998)	Cost, quality, flexibility, delivery, inventory
Wacker (2000)	Cost, quality, due-date, flexibility
Yurdakul (2002)	Reliability, cost, quality, time, flexibility
Krajewski *et al*. (2007)	Cost, quality, time, flexibility

This study used four dimensions of cost, quality, delivery time and flexibility as well as the environment in the development of the assessment criteria for the determination of the factors affecting the selection of material substitution.

3.3 AHP

AHP was proposed by T.L. Saaty. For the simple theory and easy operation, AHP is extensively applied in various fields, and many AHP empirical studies have been conducted in various countries. However, many scholars are doubtful about the theory of AHP. For years of evolution, study, application, and verification, the AHP theory has become increasingly mature (Chien, 2005; Wei *et al.*, 2005). Saaty (1980) summarized types and the range of problems that can be solved by using AHP as described in Table 3.

Table 3 Types and the range of problems that can be solved by using AHP

Types and the range of problems that can be solved by using AHP	1. Set priorities 2. Generate a set of alternatives 3. Choose a best policy alternative 4. Determine requirements 5. Allocate resource 6. Predict outcomes 7. Measure performance 8. Design system 9. Ensure system stability 10. Optimization 11. Planning 12. Resolve conflict 13. Risk assessment

3.4 Research Steps

This study can be divided into three steps to analyze the factors affecting the selection of substitution materials as follows:

1) Step 1: collect relevant literature of material substitution for the construction of the initial hierarchical structure of influencing factors of material substitution;
2) Step 2: conduct expert interview or expert survey to collect expert opinions, modify the measurement indicators of the hierarchical structure of influencing factors of material substitution;
3) Step 3: use AHP to compute the weighting of various measurement dimensions and establish the key measurement indicators of the influencing factors of material substitution.

4. Analysis of Factors of Material Substitution

4.1 Research Subject

The research subjects include an equipment manufacturer, IC packaging manufacturers and network communications and multimedia manufacturers in Taiwan. The detailed content and company characteristics are as shown in Table 4.

Table 4 Company Profile

Industry	Machinery and equipment manufacturing	PCB panel and IC packaging manufacturing	Network communications and multimedia products manufacturing
Company profile	Founded in 1995, the company has now developed the semi-automatic wafer prober for wafer fabrication midstream manufacturers.	Founded in 2000, it is a stock listed company; the main shareholders are well-known manufacturers in Taiwan. It is mainly engaged in the development, production and sales of the BGA for IC encapsulation, flip chip (FC) plywood, and soft board (FPC) carrier board.	Founded in 2003, it is Taiwan's largest network equipment OEM manufacturer. The company's product line covers network routers, broadband networks, wireless networks, and network multimedia.
Environment strategy related deduction	Currently, the company only carries out quality improvement and has not deduced environment strategy.	(1) ISO 14001; (2) OHSAS 18001; (3) TOSHMS:2007	(1) ISO 14001; (2) OHSAS 18001; (3) TOSHMS: 2007; (4) environment regulations; (5) research and development of green products; (6) compliance with EU Directives; (7) improvement of resource recycling and reduction of the waste generation.

Although the above companies are in the manufacturing sectors, each industry and company have different degrees of strategy implementation and different dimensions of consideration. The results of expert questionnaire survey were analyzed and compared to provide references for decision-making, and provide a basis for making better decisions.

4.2 AHP Data Summary

The data collected from 19 expert questionnaires were summarized and converted into overall assessment results. After the computation and verification using various computational rules, as well as the pairwise comparison matrix, this study obtained the weights of the factors of all levels. When the selection of level factors are determined by a group of decision-makers, the preferences of all the decision-making members should be integrated to get the consistent evaluation as shown in Table 5. On the premise of reasonable assumption, Saaty (1980) proposed the method of integration. In general, the geometric mean values rather than the arithmetic mean values are used for integration.

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ISSN: 2222-6990

Table 5 Overall factor assessment analysis results

No.	No.2 level of factors of consideration	priority weight	No.3 level of factors of consideration	Priority weight	Overall priority weight	No.
1	Cost	0.200	Low price raw materials	0.137	0.027	19
2			Reducing setup cost	0.165	0.033	16
3			Reducing inventory cost	0.328	0.065	5
4			Reducing relevant consumable cost	0.211	0.042	11
5			Reducing development cost	0.159	0.031	18
6	Quality	0.277	Supply capacity of the supplier	0.361	0.090	1
7			Materials and parts quality improvement	0.334	0.083	2
8			Materials and parts improvement in design	0.305	0.076	3
9	Delivery time	0.222	Shortening lead time for the purchase of materials and parts	0.176	0.036	14
10			Successful delivery rate	0.292	0.059	6
11			Satisfaction of customer needs	0.355	0.072	4
12			Shortening process time	0.178	0.036	14
13	Flexibility	0.144	Using common parts	0.347	0.047	8
14			Shortening lead time	0.183	0.025	20
15			Temporary consideration	0.129	0.017	21
16			Consideration of avoiding lack of materials and parts	0.342	0.046	10
17	Environment	0.157	Labeling/certification	0.155	0.033	16
18			Corporate social responsibility	0.194	0.042	11
19			Compliance with EU directives	0.218	0.047	8
20			Compliance with energy saving considerations	0.237	0.051	7
21			Using green design	0.196	0.042	11
C.R.H.=0.016609						

In summary, after the overall questionnaire analysis and comparison of the priority weights, as shown in Table 5, among the No. 2 level indicators, all the experts believed that quality indicator is the most important. Regardless of the industrial background, experts all believe that quality is the basis for business development. Regarding the overall weights of No. 3 level, experts believed that the supply capacity of the supplier is the most important indicator.

4.3 Expert Assessment Results of the Application of Environment Strategy

Regarding the expert opinions on the implementation of environmental strategy, this study analyzed the expert opinions of implemented environmental strategy (9 questionnaires) and expert opinions about the environmental strategy of long term implementation (4 questionnaires) to compare their differences. The results are as shown below.

4.3.1 Expert Results of Implemented Environmental Strategy

According to the nine expert questionnaires concerning implemented environmental strategy, this study applied AHP for the overall analysis, and compared the priority weights. The results

revealed that among all the assessment factors, the experts believed that the impact of the environmental dimension is the greatest as shown in Table 6.

Table 6 Analysis results of expert overall factor assessment of implemented environmental

No.	No.2 level of factors of consideration	Priority weight	No.3 level of factors of consideration	Priority weight	Overall priority weight	No.
1	Cost	0.206	Low price raw materials	0.150	0.030	16
2			Reducing setup cost	0.146	0.029	17
3			Reducing inventory cost	0.331	0.067	4
4			Reducing relevant consumable cost	0.273	0.055	8
5			Reducing development cost	0.100	0.020	19
6	Quality	0.201	Supply capacity of the supplier	0.311	0.050	9
7			Materials and parts quality improvement	0.286	0.046	10
8			Materials and parts improvement in design	0.403	0.065	6
9	Delivery time	0.207	Shortening lead time for the purchase of materials and parts	0.173	0.034	15
10			Successful delivery rate	0.345	0.067	4
11			Satisfaction of customer needs	0.332	0.065	6
12			Shortening process time	0.151	0.029	17
13	Flexibility	0.121	Using common parts	0.327	0.038	14
14			Shortening lead time	0.157	0.018	21
15			Temporary consideration	0.173	0.020	19
16			Consideration of avoiding lack of materials and parts	0.343	0.039	13
17	Environment	0.265	Labelling/certification	0.132	0.043	12
18			Corporate social responsibility	0.138	0.045	11
19			Compliance with EU directives	0.220	0.072	3
20			Compliance with energy saving considerations	0.265	0.086	1
21			Using green design	0.245	0.080	2
C.R.H.=0.017343						

As shown in Table 6, the overall factor assessment results suggest that the most important factors are compliance with energy saving considerations, using green design, and compliance with EU directives. The overall level consistency ratio (C.R.H. = 0.017343) is below 0.1, indicating that the answers of the questionnaire are consistent. As many countries are promoting energy saving and environmental protection, the enterprises regard the environmental strategy as the priorities to enhance the long term benefits. Meanwhile, the compliance with the environmental directives and regulations of the exports is a challenge that the enterprises is faced with.

Based on the above overall questionnaire assessment (19 questionnaires) and implemented environmental strategy overall factor assessment results (9 questionnaires), this study summarized the comparison tables (Tables 7 and 8). The comparison results of the five dimensions and 21 factors are shown in Table 9. The degree of priority of environmental issues from the comparison of the overall questionnaire and the implementation of environmental strategies can be determined. The experts of implemented environmental strategy mostly consider the environmental dimension as the priority. Overall, most experts regarded quality

dimension as the most important consideration, followed by the environmental dimension. The comparison results suggested that the environment has become one of the key factors of material substitution of enterprises as they are increasingly concerned about the material substitution factors in the environmental dimension.

Table 7 Comparison of No. 2 level factor assessment results of the overall expert questionnaire and implemented environmental strategy questionnaire

No.	Overall questionnaire		Implemented environmental strategy	
	Assessment dimension	weight	Assessment dimension	weight
1	Quality	0.277	Environment	0.265
2	Delivery time	0.222	Delivery time	0.207
3	Cost	0.200	Cost	0.206
4	Environment	0.157	Quality	0.201
5	Flexibility	0.144	Flexibility	0.121

Table 8 Comparison of overall factor assessment results of the overall expert questionnaire and implemented environmental strategy questionnaire

Overall questionnaire			Implemented environmental strategy		
No.	No.3 level factors and overall priority weights		No.	No.3 level factors and overall priority weights	
1	Supply capacity of the supplier	0.090	1	Compliance with energy saving considerations	0.086
2	Materials and parts quality improvement	0.083	2	Using green design	0.080
3	Materials and parts improvement in design	0.076	3	Compliance with EU directives	0.072
4	Satisfaction of customer needs	0.072	4	Successful delivery rate	0.067
5	Reducing inventory cost	0.065	4	Reducing inventory cost	0.067
6	Successful delivery rate	0.059	6	Materials and parts improvement in design	0.065
7	Compliance with energy saving considerations	0.051	6	Satisfaction of customer needs	0.065
8	Compliance with EU directives	0.047	8	Reducing relevant consumable cost	0.055
8	Using common parts	0.047	9	Supply capacity of the supplier	0.050
10	Consideration of avoiding lack of materials and parts	0.046	10	Materials and parts quality improvement	0.046
11	Corporate social responsibility	0.042	11	Corporate social responsibility	0.045
11	Using green design	0.042	12	Labeling/certification	0.043
11	Reducing relevant consumable cost	0.042	13	Consideration of avoiding lack of materials and parts	0.039
14	Shortening lead time for the purchase of materials and parts	0.036	14	Using common parts	0.038
14	Shortening process time	0.036	15	Shortening lead time for the purchase of materials and parts	0.034
16	Labeling/certification	0.033	16	Low price raw materials	0.030
16	Reducing setup cost	0.033	17	Reducing setup cost	0.029
18	Reducing development cost	0.031	17	Shortening process time	0.029
19	Low price raw materials	0.027	19	Temporary consideration	0.020
20	Shortening lead time	0.025	19	Reducing development cost	0.020

21	Temporary consideration	0.017	21	Shortening lead time	0.018

4.3.2 Experts Results of Environmental Strategy of Long Term Implementation

Based on four expert opinion questionnaires regarding the environmental strategy of long term implementation, this study applied the AHP structure for overall analysis, and compared their priority weights. As shown in Table 9, among the five dimensions, experts believed that the environment dimension is the most important and its weight is 0.521 followed by cost (0.171). The overall factor assessment results suggest that the top three factors of concern to experts are using green design with weight at 0.185, followed by compliance with energy saving considerations (0.168), and compliance with EU directives (0.128). The overall level consistency ratio (C.R.H.= 0.045736) is smaller than 0.1, suggesting that the answers to the questionnaire are consistent. By the summary of the environment expert results of the questionnaire, it can be learnt the issues of environment have become the basis for the research and development and production of the enterprises in the future. In the past, the priority of the viewpoints about improvement is to reduce cost and improve quality. With the rise of the environmental awareness, enterprises have been regarded as the major polluters to the environment; hence, environmental issues cannot be ignored on the premise of social development. For the co-existence of the social economic development and the environment, enterprises should start planning and maintenance measures to achieve the sustainability objectives.

Table 9 Expert overall factor assessment analysis results of environmental strategy of long term implementation

No.	No.2 level factor	Priority weight	No.3 level factor	Priority weight	Overall priority weight	No.
1	Cost	0.171	Low price raw materials	0.080	0.009	19
2			Reducing setup cost	0.081	0.009	19
3			Reducing inventory cost	0.520	0.061	5
4			Reducing relevant consumable cost	0.240	0.028	12
5			Reducing development cost	0.079	0.009	19
6	Quality	0.133	Supply capacity of the supplier	0.407	0.046	7
7			Materials and parts quality improvement	0.172	0.019	15
8			Materials and parts improvement in design	0.421	0.047	6
9	Delivery time	0.104	Shortening lead time for the purchase of materials and parts	0.311	0.035	9
10			Successful delivery rate	0.333	0.037	8
11			Satisfaction of customer needs	0.267	0.030	10
12			Shortening process time	0.088	0.010	17
13	Flexibility	0.071	Using common parts	0.358	0.025	13
14			Shortening lead time	0.139	0.010	17
15			Temporary consideration	0.173	0.012	16
16			Consideration of avoiding lack of materials and parts	0.330	0.023	14
17	Environment	0.521	Labeling/certification	0.049	0.029	11
18			Corporate social responsibility	0.138	0.081	4
19			Compliance with EU directives	0.217	0.128	3
20			Compliance with energy saving considerations	0.284	0.168	2
21			Using green design	0.312	0.185	1
C.R.H.=0.045736						

The overall factor assessment results of the above questionnaires of the implemented environmental strategy (9) and questionnaires of the environmental strategy of long term implementation (4) are summarized into Tables 10 and 11. According to the comparison results of the five dimensions and 21 factors, in both the results of the implemented environmental strategy and the environmental strategy of long term implementation, environment dimension is the priority for consideration. Overall, regarding the results of the implementation of the environment strategy, the compliance with energy saving considerations is often regarded as the major development of the present and the future. Regarding the results of the environmental strategy of long term implementation, the consideration of the environmental dimension has been stable in development and thus using green design becomes the top priority. The consideration of energy saving will be added through green design to improve the environment impact and the benefits of the enterprise. In sum, environment issues have become the key factor that affects the selection of substitution materials.

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January 2014, Vol. 4, No. 1
ISSN: 2222-6990

Table 10 Comparison of No. 2 level factor assessment results of the implemented environmental strategy and environmental strategy of long term implementation

No.	Implemented environmental strategy		Environmental strategy of long term implementation	
	Assessment dimension	weight	Assessment dimension	weight
1	Environment	0.265	Environment	0.521
2	Delivery time	0.207	Cost	0.171
3	Cost	0.206	Quality	0.133
4	Quality	0.201	Delivery time	0.104
5	Flexibility	0.121	Flexibility	0.071

Table 11 Comparison of the overall factor assessment results of the implemented environmental strategy and environmental strategy of long term implementation questionnaire

Implemented environmental strategy			Environmental strategy of long term implementation		
No.	No.3 level factors and overall priority weights		No.	No.3 level factors and overall priority weights	
1	Compliance with energy saving considerations	0.086	1	Using green design	0.185
2	Using green design	0.080	2	Compliance with energy saving considerations	0.168
3	Compliance with EU directives	0.072	3	Compliance with EU directives	0.128
4	Successful delivery rate	0.067	4	Corporate social responsibility	0.081
4	Reducing inventory cost	0.067	5	Reducing inventory cost	0.061
6	Materials and parts improvement in design	0.065	6	Materials and parts improvement in design	0.047
6	Satisfaction of customer needs	0.065	7	Supply capacity of the supplier	0.046
8	Reducing relevant consumable cost	0.055	8	Successful delivery rate	0.037
9	Supply capacity of the supplier	0.050	9	Shortening lead time for the purchase of materials and parts	0.035
10	Materials and parts quality improvement	0.046	10	Satisfaction of customer needs	0.030
11	Corporate social responsibility	0.045	11	Labeling/certification	0.029
12	Labeling/certification	0.043	12	Reducing relevant consumable cost	0.028
13	Consideration of avoiding lack of materials and parts	0.039	13	Using common parts	0.025
14	Using common parts	0.038	14	Consideration of avoiding lack of materials and parts	0.023
15	Shortening lead time for the purchase of materials and parts	0.034	15	Materials and parts quality improvement	0.019
16	Low price raw materials	0.030	16	Temporary consideration	0.012
17	Reducing setup cost	0.029	17	Shortening process time	0.010
17	Shortening process time	0.029	17	Shortening lead time	0.010
19	Temporary consideration	0.020	19	Low price raw materials	0.009
19	Reducing development cost	0.020	19	Reducing setup cost	0.009
21	Shortening lead time	0.018	19	Reducing development cost	0.009

5. Conclusions

This study applied AHP to construct an assessment model for the consideration factors of decisions about substitution material selection, and conducted the in-depth study by using

expert questionnaires. The relevant analysis results and conclusions are reviewed and summarized as follows (as shown in Table 12): (1) overall (19 questionnaires), the No. 2 level key factors include quality, delivery time as priorities; (2) for the expert questionnaires of the implemented environmental strategy (9 questionnaires), the factor of environment is most concerned; the experts' priority of the environmental issues thus can be concluded; (3) for the expert questionnaires of the environmental strategy of long term implementation (4 questionnaires), environment is the most concerned followed by the delivery time; (4) in summary of the above, most enterprises regard quality and delivery time as the priority with the viewpoint starting from the customers. Among the three types of analysis results, the concern of flexibility dimension is relatively low. Although enterprises in different industries may have different material substitution response strategies, the considerations of the flexibility dimension are relatively low. From the results of the environment strategy, all the enterprises regard environment as the top priority. Hence, in the direction of economic and social development, enterprises aim to achieve the development goal of sustainable business. Meanwhile, it means that enterprises have begun to pay attention to the factors affecting the environment.

Table 12 Summary of No. 2 Level key factors assessment results

No.	Overall questionnaire	Implemented environmental strategy	Environmental strategy of long term implementation
1	Quality	Environment	Environment
2	Delivery time	Delivery time	Cost
3	Cost	Cost	Quality
4	Environment	Quality	Delivery time
5	Flexibility	Flexibility	Flexibility

Moreover, this study conducted the analysis of the overall weighting of No. 2 level key factors, and compared with the priority weights of No. 3 level factors as shown in Table 13. As seen, enterprises are most concerned about key factors including supply capacity of the supplier, materials and parts quality. Moreover, for the overall questionnaires, in the environment dimension, the concern of compliance with energy saving considerations is relatively low, meaning that the concern of the environment dimension by most enterprises for material substitution selection is relatively low. Regarding the expert results of the implemented environmental strategy and the environmental strategy of long term implementation, environment-related compliance with energy saving considerations, using green design, and compliance with EU directives are items of concern and they can be used to learn the impact of enterprises on future environment. Hart (1995) analyzed the sustainable competition strategy, arguing that enterprises may take pollution prevention measures to reduce cost or gain the leading position through product management or win advantageous position in the future environmental protection trends by the shaping of sustainability vision of the enterprises.

Table 13 Summary of No. 3 level key factor assessment results

No.	Overall questionnaire	Implemented environmental strategy	Environmental strategy of long term implementation
1	Supply capacity of the supplier	Compliance with energy saving considerations	Using green design
2	Materials and parts quality improvement	Using green design	Compliance with energy saving considerations
3	Improvement in materials and parts design	Compliance with EU directives	Compliance with EU directives
4	Satisfaction of customer needs	Successful delivery rate	Corporate social responsibility
5	Reducing inventory cost	Reducing setup cost	Reducing inventory cost
6	Successful delivery rate	Satisfaction of customer needs	Improvement in materials and parts design
7	Compliance with energy saving considerations	Improvement in materials and parts design	Supply capacity of the supplier

In summary of the above, enterprise are different in the implementation of policies and assessment criteria. Through the industrial development, enterprises are committed to environment management and maintenance. With green design thinking as the objective, enterprises expect to reduce the environmental pollution by environmentally friendly and low-pollution products and raw materials. Therefore, highly environment-oriented enterprise will distribute more resources in various activities, and some enterprise will follow the principle of legal compliance to maintain the environment.

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