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Description: Research Article

A multi-attribute framework for determining the competitive advantages of products using grey-TOPSIS cum fuzzy-logic approach

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Abstract
Competitive advantage (CA) is a manufacturing business idea that assists organisations to be at benefits over rivals by keeping additional customers and exhibiting superior trade levels. Literature on prioritising measures and resources with respect to their impacts on competitiveness is interesting, important, promising but limited. However, CA decisions are confronted with factors to be prioritised having unequal importance. Additionally, data may be scanty and uncertain but quality decisions must be made. Furthermore, factors employed to judge the CA ability of organisations are disjointed and limited and do not often account for environmental-friendliness in frameworks. Consequently, a new environmentally set of measures should be included in frameworks containing combined grey-TOPSIS and fuzzy-logic. Using the resulting framework, a case study approach, based on expert judgement was adopted to exemplify and articulate the concept embedded in the approach. Study results indicate framework application feasibility and validity in packaging manufacturing. The novelties of the paper are: (i) development of a comprehensive CA method using greenness factors; (ii) addition of a case-based CA method for the Nigerian manufacturing environment; and (iii) application of combined grey-TOPSIS-fuzzy-logic framework for CA. The presented framework may serve as an effective CA implementation tool.

Keywords: Grey-TOPSIS, competitive advantage, multi-attribute, multi-product, fuzzy decision-making

1. Introduction

Competitive advantage (CA) is a manufacturing business idea that assists an organisation to be at benefit over rivals (Devins & Kimbara, 1997; Cho & Olsen, 1998; Hill & Brennan, 2000; Singh *et al*., 2010; Beblavy & Kurekova, 2014). It permits organisations to perform at a superior trade level, hence, keeping additional customers compared to their challengers. Research on prioritising measures and resources with respect to their impacts on competitiveness is interesting, important and promising. Products are outputs of organisations that must be manufactured according to the pre-determined standard quality. They must be produced at the right quantities and price to guarantee the right level of income for the organisation. However, the consumer market is most often filled with competing products. Therefore, organisations with CAs would derive benefits that overrun those of their challengers (Obe & Pullen, 1989). Unfortunately very limited quantitative research is carried out on CA and competitive decisions are usually based on qualitative guides.

However, the evaluations of CA for manufacturing concerns are at present inadequate, especially in this era of increasing environmental consciousness in manufacturing. This unfortunate downplays of factors, criteria, attributes or measures in literature makes CA decision making unreliable and unrealistic. It is noted that in making manufacturing CA decisions, several factors with unequal importance are involved and must be prioritised. At present, the factors employed to judge the CA ability of organization are limited and do not often account for the greenness of manufacturing activities. For instance, Dirisu *et al*.'s (2013) product differentiation analysis does not account for the biodegradation of the product. It completely omitted information on the product waste disposal and completely missed out details on product life-cycle. Take the classic contribution of Powel & Dent-Micallef (1997), the work, although pushes information technology as a prerequisite for success in CA administration, has its focal issues on human, business and technology resources. It is deficient in information concerning greenness. However, the viewpoint of Dirisu *et al*. (2013) and Powel & Dent-Micallef (1997) could still be absorbed in a comprehensive framework of broad criteria of product's features and process, containing attributes product innovation and process capability, respectively.

This situation concerning the inadequacy of existing CA literature is aggravated in part by the paucity of data on CA for manufacturing decisions. Take the case study product packaging company of interest in this work, very limited CA data is kept and this makes complete viewpoint of system performance evaluation difficult for the manufacturing manager. This handicap leads to poor decisions, which many affect the long-run survival of the organisation in competition. In the Nigerian environment, poor information on CA has led to improper method of dealing with CA and this present serious concern for manufacturing managers. Moreover, to attain proper understanding of CA, case study analysis is a prerequisite. Unfortunately, there is little literature on case study approach (Yin 1981; Eisenhardt,1989) on the subject and consideration of expert judgment and how they are attained and also the identification of experts have been left out in CA research concerning manufacturing industries in the packaging industry in the Nigerian environment.

In the packaging industry and Nigeria as a case, poor knowledge and information on CA often misguide businesses thereby make strategy management inefficient. This is the cause of great concern for the manufacturing manager who must prioritise measure and resources. Moreover, to obtain proper empirical guidance from CA computations, adequate knowledge on prioritisation tools such as TOPSIS as well as an understanding of uncertainty control using fuzzy-logic is a prerequisite. Till date, most investigations on packaging have been based on environments other than Nigeria. This omission of Nigeria from enquiries only provides little relevance on the applicability of results obtained in such studies to the Nigerian manufacturing system. In fact, no study in Nigeria has provided a framework on the prioritisation of measures and resources in the packaging company. None of the studies has utilised the scientific tool of TOPIS, grey relational analysis and fuzzy-logic as a viable alternative to the traditional approach to CA analysis. Consequently, such absence of information hiders the development of effective measures and resource prioritisation approaches. Planning through the traditional approach and the use of intuition in CA planning is difficult and is still a problem in obtaining CA efficiencies. Thus, a scientific method incorporating grey relational analysis, TOPSIS and fuzzy-logic appears to be a better choice in the attainment of excellence in CA planning.

Furthermore, there is the problem of uncertainties and non-linearity in CA real-life situations. Until recently, practices in the industry have been based on the

traditional intuitive approach with qualitative contents in decision making about CA. No investigation in Nigeria has evaluated the CA paradigm by considering comprehensive measures, including greenness factors. Apart, no study has been reported for the packaging industry in Nigeria. In addition, the synergic advantage of combing the grey, TOPSIS and fuzzy-logic has not been previously exploited in literature. These tools, advocated for hybridization in the current study are with enormous advantages that must be exploited, as follows.

Grey has the advantage of employing specific concept of information, a situation in which part of the information is known while part is unknown. TOPSIS exhibits a number of advantages, including ease of decision making involving negative as well as positive criteria. Furthermore, a number of criteria are permissible in the decision process. Lastly, TOPSIS is simpler and faster than AHP, FDAHP and SAW. The advantage of fuzzy-logic is its ability to treat cases involving non-linearity as well as uncertainties. The three methodologies of grey, TOPSIS and fuzzy-logic show high level of practical validity and this promote its usage in the current paper. Unfortunately, very scanty studies have employed these models in management literature and none has applied it to CA. So, to address the problem advanced in this paper, an integrated model of grey relational analysis, TOPSIS and fuzzy-logic is studied and applied.

The current research aims to determine if prioritisation of measures and resources could be determined by scientific tools and method in order to gain better knowledge involved in CA planning. The purpose of this paper is to develop an innovative, robust approach in the solution of CA for a packaging manufacturing company using combined grey-TOPSIS- fuzzy-logic. The principal novelties of this paper are three. First, the development of a comprehensive CA method that account for environmental factors is new. Second, the case-based approach using a packaging company in a developing country, Nigeria, is rarely discussed in literature and a first account is given in this situation. Third, quantitative CA analysis is sparse in literature and the contribution of an integrated grey-TOPSIS-fuzzy-logic approach to CA analysis is a new account.

The breakdown of this study, starting from then next section is given. The literature review is presented in section 2. The proposed framework for a product's competitive advantage is presented in section 3. The demonstration of the proposed framework using a case study and discussion of results are presented in section 4. The conclusions of this study are provided in section 5.

2. Literature Review

With approximately over 1072 registered companies with the manufacturers association of Nigeria (MAN) and hugely diversified product brands, the number of competing products in the Nigerian manufacturing industry is exorbitantly high. Considering the pivotal function that CA plays in the sustenance of company existence, it is necessary to establish a scientific approach on the quantitative and reliable way of prioritizing measures and resources employed by these organizations. The seminal article of Grant (1991) has shown that CA is the life-wire of organisations and a tool for survival. As a result, a great deal of studies has focused on CA (Barney, 1991; Powel & Dent-Micallef, 1997; Carr, 2003).

The current paper develops a framework for the prioritisation of measures for a packaging manufacturing company in Nigeria. This area of research has been surprisingly ignored until now. This is so as majority of literature are qualitative in

nature and are often directed at other countries such as Hong Kong, China, Mexico and Japan while Nigeria is missing in the map of countries empirically tested for rigorous validation of CA models and analysis. Barney (1986) asserted that the main intention of an organisation in the industrial setup was the sustenance of intra-industry competition (see also Cosimato & Troisi, 2015; de Jorge Moreno & Carrasco, 2016; Luo & Zheng, 2016). To appreciate the impacts of scientific tools in planning, we must examine, in some details, the different tools embedded in the grey-TOPSIS cum fuzzy-logic technique. Traditionally, practitioners conveniently manage CAs of their organisations' products through intuition. However, such a non-scientific approach may not yield good results for decision making and may not fully give explanations for the sparseness of data as well as uncertainties in practice. Thus, the use of scientific tools promotes greater knowledge of the CA concept.

Prior to the development of the grey-TOPSIS cum fuzzy-logic model, in the course of implementing the research documented here, two streams of literature review were embarked upon. The first stream of literature review considered the general subject of competitive advantage. For the second research stream, the focus was on sustainable competitive advantage. There is extensive research on CA, sustainable CA and the challenge of identifying factors that contribute to sustainable CA (Barney, 1991; Grant, 1991). However, in the following sub-sections, some detailed information as well as the acquired knowledge during the course of carrying out the literature review is reported.

2.1 *Competitive advantage*

CA is a major research stream in strategy and the concept has been introduced to readers for more than two decades now (Cook & Cook, 1994; Kumar & Motwani, 1995; Bennett & Smith, 2002; Altintas *et al*., 2010). For example, the classical contributions of Ulrich (1991), Porter (1985) & Rummelt (1984) provided significant launch and understanding into the concept of competitive advantage, which now metamorphosed into a key research area of strategic management today. Even many years after the introduction of the CA concept to the management world there is still expressed concern that many managers are confused about the term CA, and some cannot distinguish it from associated terms. Sigalas (2015) provided empirical evidence on the fact that senior managers in organizations are still confused with differentiating competitive advantage as a concept from sources of competitive advantage. This claim may be valid for the developing country case also as no researcher has differed in this assertion. Clearly, no single case investigation for the packaging industry in Nigeria as an example was found in the comprehensive literature research conducted in this study. In addition, there is complete absence of quantitative evidence and modelling on how to quantify competitive advantage measures given the uncertainty in the business set up in Nigeria.

In a brief account of the CA literature, the following reports are relevant. Lin *et al*. (2012) advanced an approach to the execution of manufacturing strategies for the Chinese bus manufacturers. The orientation of the framework was time-directed in the achievement of competitive advantages. The results indicated that heightened productivity or even low price has ceased to be a determinant of competitive advantage. This assertion is consistent with the viewpoint expressed by Jin (2004) eight years earlier that cheap labour could however not sustain competitive advantage. These two cases demonstrated examples from the Asian market, involving China, South Korea, Taiwan and Hong Kong. However, this has become a controversy as Percival & Cozzarin (2010) six years after Jin's (2004) contribution opposed this view

with empirical evidence from Canada. It was stated by these authors that productivity as well as profitability are important pillars of competitive advantage. Rugraff (2012) proposed the application of competitive advantage in the automobile industry in a similar industry as reported in Lin *et al*. (2012). However, the author's contribution was the development of a model with voice behaviour and exist behavioural perspectives. The framework of the model was the global value chain, which combined hierarchy, market and relational linkage with a practical application to a Czech republic-based automobile company, Volkswagen-Skoda. It was concluded that competitive advantage was achievable with focus on switching and relational rents.

In the case of Cook & Cook (1994), the contribution was the elaboration of the managerial requirements needed to achieve advanced manufacturing technology competitive advantages. Bennett & Smith (2002) implemented a survey in UK to evaluate the factors related to competitiveness. It was concluded that SME organisations build up their strategies for specialisations purpose as well as differentiating own products from others. It was concluded that organisations improve on their trade relations with other countries and regions beyond their vicinities. Altintas *et al*. (2010) analysed the significant effect of private label manufacturers on competitive advantage in Turkey. Production efficiency, product selling and control as well as market embedded-ness were three factors identified to impact on competitive advantage in these manufacturing companies. Koksal & Ozgul (2010) assessed the differences in the competitive advantage between high and low performers in Turkey's manufacturing domain. It was concluded that three key factors, namely the image of the brand quality of product and goods' cost obtainable in the export market are the key determinants of success in the competitive market.

Several other studies have affirmed the significant impacts of CA in achieving sustainable businesses across the globes and industries. Notable contributions industry-wise include footwear (Ojeda-Gomez *et al*., 2007), products with private labels (Altintas *et al*., 2010) salmon industry (Felzensztein & Gimmon, 2014). These stated contributions have been carried out in diverse countries such as Mexico (Ojeda-Gomez *et al*., 2007), Chile (Felzensztein & Gimmon, 2014) and Turkey (Altintas *et al*., 2010). The common message from these three mentioned sources is that CA positively enhances the sustenance of the organization despite the economic environment surrounding manufacturing businesses globally.

Apart from these empirically-based studies with orientation in industries, a number of other contributors have made noteworthy additions to the literature on CA. Some are as follows. Swann (1989) suggested ways of enhancing the CA of UK over US through the introduction of advanced manufacturing technology. Beal & Lockamy (1999) presented a contingency method in the development of CA strategy. Tummala *et al*. (2000) noted that alliances among countries and CA in global competitiveness. This assertion was demonstrated in case examination of combined efforts of China and Hong Kong and yield in global competitiveness. Lee (2003) presented a new perspective in the design of a manufacturing systems information framework. Wei & Chunming (2012) reported an increase in the kinds of CA Chinese manufactured products exhibits in the US markets.

2.2 *Sustainable CA*

Over the years, the products produced by highly competitive companies were the delights of the customers. Customer had preferences to these products because the bundles of benefits that they offered were outstanding, attractive, value-adding and

sometimes unprecedented and noteworthy. After realising the progress made by leading organisations in the markets, challengers also evolved strategies that placed them ahead of the competing companies with time. So, the result is a dwindling competitive positioning of companies whereby a company that fails to excel at one time takes over benefits from its rivals in competition. Then, the world started considering the concept of sustained competitive advantage whereby a competitively advantageous company is expected to maintain its beneficial position for a long time. Sustainable CA is based on the idea that it is important to build-up a framework on CA, and constantly revising it based on new impacts of experiences of the production and operations workers, these inputs are obtained through the use of questionnaire in collecting the information from the workers.

Reed & De Fillippi (1990) elaborated on the manner in which firms could sustain advantage. Specifically, they mentioned a reinvestment of resources in causal ambiguous competencies. They advocated that it would and in the maintenance of barriers to imitation. Still on sustainable CA, Ahmad (2015) affirmed that CA sustainability is strongly influenced by business intelligence in its governance and characteristics. Henderson (2011) found out that strategies on cost leadership are ineffective in CA but the use of differentiation as well as focus strategies. Recall that this is in agreement with the viewpoint of Jin (2004) that earlier established this fact, noting that low price will not aid the current state of CA strategic game. Further on sustainable CA, Lewis (2000) established the influence of the core principles of lean, (including value, waste minimization as well as flow) on the achievement of sustainable CA.

Although, the core principles of lean are promoted in this case, however, the study is still at the centre of controversy as to the fact that productivity savings aid CA. well, viewing from our literature experience, while some scholar oppose reliance on productivity and performance issues (such as cost) to improve CA, our strong viewpoint is that it is still important to pursue reduced cost of manufacturing, as well as productivity improvement, but these should be complemented with a fast response to the demands of the customer (Lin *et al*., 2012), IT deployment as well as business intelligence (Ahmad, 2015). Furthermore, by adding to the literature in sustainable competitive advantage, Mazzarol & Soutar (1999) established a framework containing crucial factors in establishing and maintaining competitive advantage in a sustainable manner.

There is a non-resolved controversy on sustainable CA. some researchers' reasoning implies that only intangible criteria, such as corporate culture can support sustainable CA. Information technology has been both described as a source of CA, as well as a commodity (e.g. Powel & Dent-Micallef, 1997; Carr, 2003). While contributing to this controversy, Makido *et al*. (2003) advanced the notion that information technology is a source of CA and that labour could be empowered and enhanced through it. It was empirically confirmed that manufacturing companies in Japan exhibited an association between IT as well as CA.

It was also found out that studies in which the methodological tools of grey relational analysis, TOPSIS as well as the fuzzy-logic literature relating to the direction of research pursued here was not available in the direct area of CA.

3. Research Methodology

The analysis on the competitive advantage of a product in multi-product manufacturing systems is based on product, cost, process, market and customers

criteria. These criteria are further broken-down to examine the attributes that constitute each criterion (Table 1). The basic structure of the CA framework established in this paper, consists of five criteria and twenty-nine attributes. The first criterion, product's features, is divided into seven attributes, which are biodegradation, product life-cycle, rate of recycling, waste disposal rate, product innovation, return-on-investment and break-even period. Market, being the second criterion, consists of attributes, including, market attractiveness, market penetration rate, raw material availability, close substitute in market, export potential, and market shares.

Table 1: Criteria and their attributes used in the determination of competitive advantage of products

S/No.	Criteria	Attributes	Meaning of attributes
1		Biodegradation (A_{11})	Ease of a product or waste from a product to decay or breakdown into substances that can be recycled
2		Product life-cycle (A_{12})	The shelf life of a product
3		Rate of recycle (A_{13})	The ease of recycling a product
4	Product's features (C_1)	Waste disposal rate (A_{14})	The ease of disposing waste produced during manufacturing of a product
5		Product innovation (A_{15})	The tendency of a product to be improve upon in order to meet the changing needs of customers
6		Return on investment (A_{16})	The mainly widespread profitability ratio in which net profit is divided by the total assets
7		Break-even period (A_{17})	The length of time it takes to recur fund invested in producing a product
8		Market attractiveness (A_{21})	The ability of a product to appeal to customers needs
9		Market penetration rate (A_{22})	Ability of get new sets of customers for a product
10		Raw material availability (A_{23})	Closeness of source of raw materials to a plant
11	Market (C_2)	Close substitute in market (A_{24})	Availability of close substitute for a product
12		Export potential (A_{25})	Tendency of a product to be exported to external markets
13		Market shares (A_{26})	The amount of customers for a product within existing markets for the product
14		Customers complaint (A_{31})	The number of complaints received from using a product
15	Customer (C_3)	Customers retention (A_{32})	The number of customers which are retained after a product has been used by the customers
16		Customers satisfaction (A_{33})	The number of responses which are received on the satisfactory performance of a product that is sold
17	Process (C_4)	Energy consumption (A_{41})	The amount of energy (electrical) required to produce a product
18		Process capability (A_{42})	The ability of required technology or equipment for producing a product
19		Production rate (A_{43})	The number of product produced per unit time
20		Labour availability (A_{44})	The level of skilled labour that are available to produced a product
21		Defective product (A_{45})	The number of defective product produced from the different batches of a product
		Outsourcing need	The propensity of a product to be outsourced when a

22		(A_{46})	company does not have the capacity to produced a product or they lack sufficient time to produce a product
23		Inventory cost (A_{51})	The total cost incurred for keeping finished and raw material inventories for a product
24		Advertisement cost (A_{52})	Cost which covers the costs for promotional activities for a product
25		Research and development cost (A_{53})	The cost incurred in conducting researches and developing a new product or improving an existing product quality and packaging
26	Cost (C_5)	Raw material cost (A_{54})	The cost for raw materials used in producing a product. It exclude raw material inventory cost
27		Production cost (A_{55})	The cost incurred from equipment and labour used in producing a product by a production department
28		Maintenance cost (A_{56})	The cost incurred by a maintenance department for equipment which are maintained during the production of a product. This cost covers spare parts and labour costs
29		After sales service cost (A_{57})	Extra cost incurred from providing after sales services to customers of a product

For the third criterion, the three attributes involved are customers complaints, customers retention and customer satisfaction. The criterion, process, which is the fourth, contains five attributes, including energy consumption, process capability, production rate, labour availability, defective product, and outsourcing need. The last criterion has attributes such as inventory cost, advertisement cost, research and development cost, raw material cost, production cost, maintenance cost and after sales service cost. As perceived and presented in this paper, the minimum requirement for a CA framework for a manufacturing system is five criterion and twenty-nine attributed for the current study.

A wide-range perspective of manufacturing in contemporary times was taken into the evaluation of the criteria and attributes of CA. For example, it is a growing awareness that to deal with certain world-class organisations, the company's sustainable practices must be displayed and discussed. Thus, a company with weak sustainable practices cannot be competitive in that industry. This requirement has been incorporated into the first criterion, referred to as biodegradation, relating business practices to ability of the waste products from outputs to be renewable and biodegrade. Also, at disposal stage of the product it is expected that it does not constitute environmental nuisance. Another aspect also captured in the first criterion is under the rate of recycling and waste disposal rate. The evolving business enhancement concept of customer orientation, as dictated in total quality management, was applied in the formulation of the criteria and attributes. Elements of the total quality management surfaced in the third criterion, including customer complaints, customer retention and customer satisfaction. This element of quality is also dictated by the fourth criterion as defective products.

However, the main challenge is that these criteria and attributes are wide-ranging. They all have influences on the CA of products exhibited and sold by a company in one way or the other. But they do not impact on the CA of products in the same degree of importance. For example, something as crucial as labour availability under the process criterion, which means that workers need to be available for production, does not carry equal weight of importance with an attribute like advertisement cost to perform their CA role in the organisation? It implies that if the labour is not readily available to produce the required products in the right quantity,

with desired qualities, then there will not be any products to sell even if the advertisement was effective. There are some attributes that through experience, are known to be more important than others. The experiences utilised in the analysis of the CA framework are those obtained through the questionnaire administration on the company personnel that are understood to be on the job for a long time. These people must have acquired substantial experience and judgement to know and judge issues concerning the products are that to be placed on the competitive scale.

So, the target of the questionnaire was to the experienced personnel in the organisation and not to fresh intakes that did not understand fully the dynamics of the products and the process that they are working in. This experience is important in that if used to build an effective competitive framework, this structure can be transferred even to a new setup without an existing framework, so that the company could quickly position itself in the competitive ladder. The analysis is helpful to know where to focus the organisation's resources first so that the CA framework is built and it goes on well. This is with the background that company's resources are very limited and must be judiciously spent. So, adequate decision will be made on the CA system based on the resources available to the organisation. Thus, CA framework building in the event of multiple attributes reach competing for the limited organisation's resources is a challenge confronting the manufacturing manager in the organisation. The challenge to the manufacturing manager is how will to build the CA framework for the company so that the company's products attract the best possible attention in the market and make the highest profit for the organisation?

"How do I allocate the company's scarce resources appropriately?" is another key concern of the manufacturing manager. Every attribute in the CA framework must be touched but some must be given more priority than others due to their importance, so, this has been a major issue for the manufacturing manager since if a clear picture of how to allocate resources according to the CA criteria and attributes is not obtained, the manager may misappropriate resources and end up producing an ineffective CA system. That is, a criterion may be wrongly given more resources than it needs while another criterion will suffer shortages of resources to prosecute the CA goal. Thus, solving the above described problem that the manufacturing manager is confronted with is the basis of the current research. Thus, we need an approach to simplify the CA framework and provide the manufacturing manager a clearer picture of the critical CA attributes and the emergence of a product that has CA for the organisation.

This study ranked products' CAs using TOPSIS based on the above mentioned criteria. The combination of attributes of the criteria is carried out using GRA in generating a single index for each of the criteria. The weights for TOPSIS and GRA analysis are generated using fuzzy-logic approach (Figure 1).

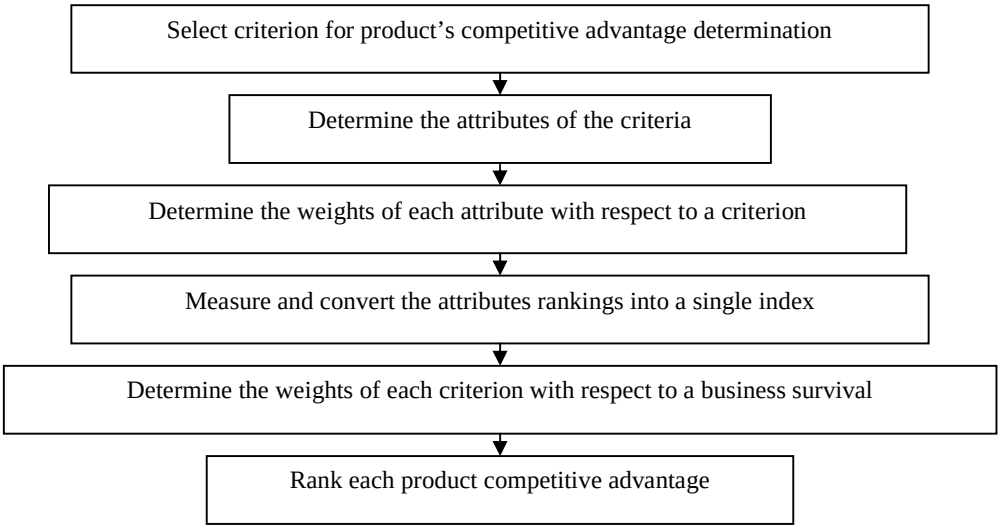

Figure 1: A framework for products competitive advantage ranking

Some of the notations used in presenting the proposed framework for ranking product's competitive advantage are defined as follows:

C_i Criterion i
D_i Decision-maker i
A_{ji} Attribute j from criterion i
R_i Rank for product i
$\overline{w}_i$ Crisp weight value for criterion i
w_{ji} Fuzzy number assigned to attribute j with respect to criterion i
M Total number of decision-makers
f_{ji} Linguistic values for weight assigned by decision maker j to criterion i
N Total number of products

3.1 Fuzzy-logic system

This study use trapezoidal membership function (Figure 2) to convert linguistic rating of the weights for attributes and criteria into fuzzy numbers (Chen, 2000). The weighting of the attributes and criteria (Table 1) are partitioned into five-parts (Table 2). The proposed framework requires the determination of two sets of weights (Figure 1). First, weights are required for applying TOPSIS. The weights required for the ranking products are expressed in crisp values (Equation 1). This is because the outputs from the fuzzy-grey relational analysis (FGRA) are in crisp forms.

Table 2: Linguistic variables and fuzzy numbers for attributes and criteria weights

Linguistic terms	Fuzzy numbers
Very low	(0.0, 0.0, 0.1, 0.2)
Low	(0.1, 0.2, 0.3, 0.4)
Medium	(0.3, 0.4, 0.5, 0.6)
High	(0.5, 0.6, 0.7, 0.8)
Very high	(0.7, 0.8, 0.9, 1.0)

This study uses centriod defuzzification method in converting linguistic values into crisp values (Equation 1). According to Shemshadi *et al*. (2011), a simplified version of Equation (1) is expressed as Equation (2).

$$\overline{w}_{ij} = \frac{\int \ll(\overline{w})\overline{w}\,¢\overline{w}}{\int \ll(\overline{w})¢\overline{w}} \tag{1}$$

$$\overline{w}_{ij} = \frac{-\overline{w}_{ij1}\overline{w}_{ij2} + \overline{w}_{ij3}\overline{w}_{ij4} + \frac{1}{3}\left(\overline{w}_{ij4} - \overline{w}_{ij3}\right)^2 - \frac{1}{3}\left(\overline{w}_{ij2} - \overline{w}_{ij1}\right)^2}{-\overline{w}_{ij1} - \overline{w}_{ij2} + \overline{w}_{ij3} + \overline{w}_{ij4}} \tag{2}$$

$$\overline{w}_{ij} = \left\{\overline{w}_{ij1}, \overline{w}_{ij2}, \overline{w}_{ij3}, \overline{w}_{ij4}\right\} \tag{3}$$

$$\overline{w}_{ij1} = \min\left\{\overline{w}_{ijk1}\right\} \tag{4}$$

$$\overline{w}_{ij2} = \frac{1}{k}\sum_{k=1}^{K} \overline{w}_{ijk2} \tag{5}$$

$$\overline{w}_{ij3} = \frac{1}{k}\sum_{k=1}^{K} \overline{w}_{ijk3} \tag{6}$$

$$\overline{w}_{ij4} = \min\left\{\overline{w}_{ijk4}\right\} \tag{7}$$

3.2 Grey-TOPSIS

The desire values for the attributes of the criteria (Table 1) are both benefit-oriented and cost-oriented. To generate a single criterion using benefit-oriented and cost-oriented attributes, a tool which account for these features is required. GRA is has been widely applied in dealing with this type of problem is adopted. The initial step for GRA application requires normalisation of items used in generating the grey relational grades (Equation 8). .

$$\bar{y}_{ij} = \frac{y_{ij}}{\sqrt{\sum_{j=1}^{n} y_{ij}^{\ 2}}} \qquad \forall i \in m; \forall j \in n \tag{8}$$

Since we are dealing with a system which as has uncertainty, the values of $y_i^0(k)$ are generating using experts judgements that are expressed in linguistic terms. The conversion of the experts' judgments on the attributes with respect to a criterion to crisp values is done using trapezoidal membership function. After the normalisation of the attributes of a criterion, the grey relational co-efficient of the attributes are generated using reference sequence $\left(y_o^*(k)\right)$, comparative sequence $\left(y_i^*(k)\right)$ and identification coefficient (,), Equation (10).

$$, _{ij}(k) = \frac{\Delta \min + , \Delta \max}{y_{o,i}(k) + , \Delta \max} \tag{9}$$

$$\Delta \min = \min_{\forall j \in i} \min_{\forall k} \left\| y_o^*(k) - y_i^*(k) \right\| \tag{10}$$

$$\Delta \max = \max_{\forall j \in i} \max_{\forall k} \left\| y_o^*(k) - y_i^*(k) \right\| \tag{11}$$

To obtained the GRA for each product ($¥_i$), consideration is given to the importance of each factor used in obtaining grey relational co-efficient ($, _{ij}$). According to Hasani *et al*. (2012), the value of $¥_i$ is expressed as Equation (12).

$$¥_{ij} = \frac{1}{n} \sum_{k=1}^{n} w_k , _{ij}(k) \tag{12}$$

The GRA results for each of the product are used in determining their competitive advantage. First, the raw GRA results are normalised (Equation 8) in order to generate a normalised decision matrix. Consideration is then given to the relative importance of each criterion. This is achieved by multiplying the normalised matrix by the weight of each criterion (Equation 13). This results in the generation of a weighted normalised matrix.

$$V_{ij} = \overline{w}_i r_{ij} \qquad \forall i \in m; \forall j \in n \tag{13}$$

V_{ij} is normalised value for grey relational value of product *i* for criterion *j*.

To determine the rank of each product using the weighted normalised matrix, the values of the ideal (Equation 14) and negative ideal (Equation 15) solutions for each of criterion are determined first. After which the proportional distance of each product value from the ideal and negative ideal solutions are determined using Equation (16) and (17).

$$A^+ = \left\{ v_1^+, \cdots, v_i^+ \right\} = \left\{ \left(\max v_{ij} \middle| i \in I' \right), \left(\min_j v_{ij} \middle| i \in I'' \right) \right\} \tag{14}$$

$$A^- = \left\{ v_1^-, \cdots, v_i^- \right\} = \left\{ \left(\min v_{ij} \middle| i \in I' \right), \left(\max_j v_{ij} \middle| i \in I'' \right) \right\} \tag{15}$$

$$D_j^+ = \sqrt{\sum_{i=1}^{n} \left(v_{ij} - v_i^+ \right)^2} \qquad \forall j \in n \tag{16}$$

$$D_j^- = \sqrt{\sum_{i=1}^{n} \left(v_{ij} - v_i^-\right)^2} \qquad \forall j \in n \tag{17}$$

where I' is the maximum performance index value and I'' is the minimum performance index value.

By applying Equation (18), the value for each product competitive advantage is determined. Ranking of the product is based on descending order of the competitive advantage value.

$$R_j = \frac{D_j^-}{D_j^+ + D_j^-} \qquad \forall j \in n \tag{18}$$

The method used is in this work is grey-based. The grey component refers to grey relational analysis, which seeks to reveal, in a complex CA situation, the attribute(s) that has/have the most important weight with respect to determining the success of the CA system. The method of grey relational analysis has wide applications in various fields, including medicine, airlines, etc. However, it has been downplayed with respect to its employment for CA modelling and analysis. It has never been used for CA in integration with TOPSIS and fuzzy-logic framework. Also, it has never demonstrated previously in literature, on any manufacturing system in the packaging industry in developing countries and in Nigeria particularly. So the differences between previous literature on CA and the current paper is principally that the current work seeks to assess the CA of a technical packing organisation according to what is required of the packaging system in order to be competitive.

The work proceeded to utilising the experience of the workers in this system over the years to relate things in order to decide on how to move forward. If the company has been lacking either not having enough advise on CA, or has misappropriated resources in wrong measures, to the various attributes of the CA framework, the proposed method seeks to control this. Thus, the major difference between previous research work and the current is that in this work, the authors assessed that system and applied a combination of grey relational analysis, TOPSIS and fuzzy-logic to provide the solution. This methodology was applied to bridge the gap in that system.

The design of the questionnaire is such that each experienced worker that filled it was asked to judge in his/her own view what he/she feels that the system is doing rightly and what the system is doing wrongly. What are the areas that, in their opinions, the CA framework can be well-captured in analysis? A fuzzy scale, comprising of five alternatives (very low (*VL*), low (*L*), medium (*M*), high (*H*) and very high (*VH*)) were used and converted to a bi-scale of 0 and 1. Any choice of answer by the respondents automatically receives a “1” while “0” is allotted to the other four options not taken. It method used has the characteristic and ability to convert qualitative descriptions of ideas into quantitative measures.

This removes subjectivity of some people by aggregating all the ideas of all respondents in a quantitative manner and the average of the quantitative outcomes result as main decision on the attribute being analysed in the CA framework for the packaging product of interest being researched on. So, the “0” and “1” scale adopted in this work has an inherent merit of bringing out objectivity from the facts given by all the respondents to the questions. The scale relates one’s feeling, idea or choice to a

number. For example, it says, on a scale of options "*VL*", "*L*", "*M*", "*H*" and "*VH*" of options, what do you think about this question? The choice of respondents equates a number which then serves as input to the grey relational analysis cum TOPSIS and fuzzy framework.

For this new procedure (current proposed framework) to work properly there is need for a number that would serve as input to the model. So, the scale transforms the judgement (decision) of these experienced personnel filling the form into quantitative values that could be applicable to the proposed model in this work. The responses to these questions are varied. While in the judge of some, certain attributes are important, to others, the same attribute is very important while it to others, it may not be important. The pool of these judgements, in numerical values, is then used for the work. So, grey relational analysis has a way of collapsing all their decisions into a space and then showing them that actually, these are the most important products in the group of products being assessed for CA basis. This is the summary of all the questions about the CA framework developed in the current paper.

The strong motivation for Deng's emergence of the grey relational analysis is the realisation of the fact that sometimes, there are not enough adequate data for decision making. There may not be access to adequate information, which is the case in CA evaluation in a number of times due to the many attributes to assess for the CA status of the organisation. The unique attribute of grey relational analysis is therefore the ability of the approach to utilise minimum data resources in the evaluation of a set of CA attributes for outcomes in a prioritise manner, that brings out the most important attributes and then attach them to particular products. Thus, a product will emerge as the best while another will be the worst in terms of CA. Thus, the reason for Deng's initiation of the grey relational approach is that even with little information, as low as four attributes, a decision to ascertain the most important product could be made. That is, what product has the best and which has the least CA strength in the organisation.

The grey relational analysis works that a grade for an attribute which is then related to particular product is obtained at the end of the analysis. Thus, the higher the grade, the more important that grade is. Now, to obtain the critical attributes of the system, the sum average of all the grades are obtained to yield the critical attributes for the system. These critical attributes are such that the manufacturing manager cannot go below. Thus, no matter how scarce resources are, for the organisation, resources must be channelled first to these critical elements with priority. So, any attributes that falls below this is not critical. Table 3 shows the details of this (i.e. the crisp value evaluation for the different attributes. Segment of the four products that the company produces, the product four is the most critical while product one is the least critical. It means that in all computations on the products, product four tops the list.

The implications that the organisation must be very committed to the production of product four and give the least attention to the production of product one since they each provide different weights of importance from the CA view-point. It further suggests that in promoting the company's products through advertisements, efforts should be well-pronounced at spending on product four more than any other products. Furthermore, the least expenditure on advertisement should be made on product one.

4. A Case Study and Discussion of Results

The research method employed in the work is the case study approach. The case study was employed to exemplify and articulate the idea embedded in the approach. A fully active plant located in Lagos, Nigeria, whose objective is the production of packaging sacks for cement and agricultural products, including packaging of rice, corn, millet, among others. Lagos exhibits one of the highest commercial activities in the country with about the highest population density in Nigeria. The expect judgment was considered appropriate for this work and questionnaires (see appendix) were employed and how it was attained has been explicated in the section on methodology. During the application of the proposed framework, four of the company's products were considered and labelled as products 1, 2, 3 and 4. Questionnaires were administered to five decision-makers in the company. Based on the decision-makers responses, crisp values were generated for the various attributes in the proposed framework (Table 3).

Table 3: Crisp values for the different attributes

	Products	A_{i1}	A_{i2}	A_{i3}	A_{i4}	A_{i5}	A_{i6}	A_{i7}
	1	0.30556	0.36111	0.50556	0.13704	0.50556	0.67778	0.36111
	2	0.29167	0.36111	0.50556	0.13704	0.49167	0.66389	0.36111
$i = 1$	3	0.28704	0.36111	0.50556	0.13704	0.48704	0.53333	0.36111
	4	0.28472	0.36111	0.50556	0.13704	0.48474	0.52639	0.36806
	1	0.65000	0.53334	0.36111	0.22793	0.50556	0.67778	-
	2	0.65000	0.53334	0.36111	0.21111	0.49167	0.5333	-
$i = 2$	3	0.65000	0.53334	0.36111	0.20617	0.48704	0.52407	-
	4	0.52639	0.53334	0.36111	0.20370	0.48472	0.51250	-
	1	0.10741	0.22593	0.67778	-	-	-	-
	2	0.10741	0.22593	0.67778	-	-	-	-
$i = 3$	3	0.10741	0.22593	0.67778	-	-	-	-
	4	0.10000	0.23333	0.67778	-	-	-	-
	1	0.67778	0.50556	0.67778	0.33333	0.27778	0.50556	-
	2	0.57745	0.49167	0.53333	0.33333	0.16667	0.51945	-
$i = 4$	3	0.51482	0.48703	0.52407	0.33333	0.15679	0.52407	-
	4	0.51250	0.36111	0.51945	0.32637	0.15185	0.52639	-
	1	0.33333	0.16667	0.30556	0.65000	0.65000	0.65000	0.33333
$i = 5$	2	0.30556	0.16667	0.30556	0.50556	0.65000	0.50556	0.21111
	3	0.29630	0.16667	0.30556	0.49630	0.52407	0.49630	0.19630
	4	0.28472	0.16667	0.30556	0.49177	0.39583	0.49200	0.18889

The grey relational co-efficient (GRC) for the different attributes (Table 4) were used in calculating the GRG values (Table 5) of each attributes for the four products based on the calculated weights for each attribute (Table 6).

Table 4: Grey relational co-efficient for the different factors

	Products	A_{i1}	A_{i2}	A_{i3}	A_{i4}	A_{i5}	A_{i6}	A_{i7}
	1	0.65660	0.66667	0.66667	0.66667	0.66074	0.64077	0.66774
	2	0.64553	0.66667	0.66667	0.66667	0.66696	0.64553	0.66774
$i = 1$	3	0.67074	0.66667	0.66667	0.66667	0.66906	0.69390	0.66774
	4	0.67252	0.66667	0.66667	0.66667	0.67011	0.69667	0.6650
	1	0.65660	0.66667	0.66667	0.65228	0.66074	0.62546	-
	2	0.65660	0.66667	0.66667	0.66750	0.66696	0.67972	-
$i = 2$	3	0.65660	0.66667	0.66667	0.67273	0.66906	0.68352	-

	4	0.70247	0.66667	0.66667	0.67238	0.67011	0.68833	-
	1	0.66290	0.66850	0.66667	-	-	-	-
	2	0.66290	0.66850	0.66667	-	-	-	-
$i = 3$	3	0.66290	0.66850	0.66667	-	-	-	-
	4	0.67867	0.66131	0.66667	-	-	-	-
	1	0.62323	0.64784	0.62612	0.66551	0.58214	0.67244	-
	2	0.68337	0.654166	0.68033	0.66551	0.70093	0.66645	-
$i = 4$	3	0.68531	0.65630	0.68412	0.66551	0.71358	0.66447	-
	4	0.68628	0.72031	0.68604	0.67018	0.72007	0.66349	-
	1	0.64702	0.6667	0.6667	0.62425	0.63478	0.62425	0.58990
$i = 5$	2	0.66663	0.6667	0.6667	0.68112	0.63478	0.68112	0.69430
	3	0.67343	0.6667	0.6667	0.68513	0.68311	0.68513	0.70952
	4	0.68213	0.6667	0.6667	0.68714	0.74053	0.68714	0.71738

Table 5: GRG values for products using different criteria

Criteria	Product 1	Product 2	Product 3	Product 4
C_1	0.24035	0.31914	0.27931	0.28038
C_2	0.31914	0.32575	0.32681	0.33165
C_3	0.27931	0.27937	0.27937	0.27925
C_4	0.28038	0.29848	0.29966	0.30457
C_5	0.19893	0.20716	0.21024	0.21358

Table 6: Crisp weights for attributes with respect to attributes

Criteria	A_{i1}	A_{i2}	A_{i3}	A_{i4}	A_{i5}	A_{i6}	A_{i7}
$i = 1$	0.16667	0.49167	0.39583	0.14445	0.233333	0.65000	0.47083
$i = 2$	0.53333	0.47083	0.31250	0.67083	0.45000	0.49167	-
$i = 3$	0.21111	0.51250	0.53333	-	-	-	-
$i = 4$	0.85000	0.37500	0.53333	0.49167	0.23333	0.16667	-
$i = 5$	0.29167	0.29167	0.23333	0.53333	0.27778	0.23333	0.27083

The most importance attribute in criterion 1 was return on investment, while the least important attribute was waste disposal rate. For criterion 2, the least important attribute was raw material availability, while close substitute in market was the most important attribute. Criterion 3 most important attribute was customers' satisfaction, while customers' complaint was the least important attribute. Energy consumption was the most important attribute in criterion 4, while outsourcing need was the least important attribute. Inventory cost and advertisement cost had the same importance in criterion 5, while research and development cost was the least important attribute in criterion 5. The most important attribute in criterion 5 was raw material cost (Table 6).

Table 7: Weighted normalised decision matrix using the GRA values

Criteria	Weights	Product 1	Product 2	Product 3	Product 4
C_1	0.69167	0.16625	0.16687	0.17008	0.17011
C_2	0.49167	0.15691	0.16016	0.16068	0.16306
C_3	0.39583	0.11054	0.11058	0.11058	0.11058
C_4	0.53333	0.14953	0.15919	0.15982	0.16244
C_5	0.53333	0.10610	0.11049	0.11213	0.11391

In terms of criterion 1 (product's feature), product 2 is the most important product, while product 1 is the least important product. For criteria 2, 4 and 5 (i.e., market, process and cost), product 4 was the most important product, while product 1 was the least importance (Table 7). The most important criterion for determining the company's products competitive advantage was product features, while customer

criterion is the least important. The importance of process and cost were the same and it was more than that of market criterion.

Table 8: Distances of each product values to ideal and not ideal solutions

	Product 1	Product 2	Product 3	Product 4
D^+	0.00028	0.00004	0.00002	0.00000
D^-	0.00000	0.00012	0.00017	0.00028

Based on Table 8, the proportional distance for product 1 is 0, while for product 2 is 0.74934. Product 3 has a proportional distance of 0.91574, while the proportional distance of product 4 is 1. Based on the TOPSIS outputs, the product with the highest competitive advantage was 4. This observation is consistent with the fact that product 4 had the highest value for attributes 1, 2 and 4. Also, product 4 had the same value with product 3 for criterion 3. Product 1 had the lowest competitive advantage among the products, this could be attributed to the fact that product 1 had the lowest values for all the attributes considered (Table 7). Product 3 had the second competitive advantage given that its attributes values were often second after product 4 attributes values (Table 7). The third product with the third competitive advantage was product 2.

5. Conclusions

This study presents a framework for ranking products' contributions towards business survival under an uncertainty environment based on external and internal criteria. These criteria were grouped as cost, product, customers, market and process. The combination of these criteria was carried out using fuzzy-logic, GRA and TOPSIS. An empirical ranking of the products produced by a company was used to demonstrate the applicability of the proposed framework. Based on the results obtained, the framework was able to produce ranks that were satisfactory.

The proposed framework is novel because is considers the external and internal attributes of a products in an uncertainty environment using fuzzy-logic, GRA and TOPSIS. Apart from being a promising decision-making tool for manufacturing stems, the proposed framework has the capacity to improve the quality of a country decision-making process when planning diversification of their economy. A contribution of this study is the extension of fuzzy-logic, GRA and TOPSIS under a single framework in improving the analysis of business survival decisions under an uncertainty environment. Another contribution of the proposed framework is that it can be used to identify the attributes of the most important criterion for that affects business survival. Furthermore, the framework contributes a means for identifying attributes importance which when properly managed will improve business survival.

A limitation of the proposed framework is that it requires at least two decision makers before it can be apply. This may limit application of the proposed framework when dealing with start-up companies that are small-scale. Further investigation could be conducted to combine the proposed framework results with theoretical model results in order to improve its application for long-term planning purpose. A natural extension of the proposed framework is to increase the number of criterion to include health, safety and environment (HSE). By including HSE into the model, business sustainability will be guaranteed.

5.1 *Managerial implications*

The resulting framework disarmed in this paper has some important managerial implications for CA research. The research is on prioritization and it is interesting to

note what is learned from the case in terms of prioritization of actions/ resources. There is necessity for the marketing unit within the organization to have linkage with the external customers for the exchange of information in line with the goals of the organization as it relates to CA. This information could then be diffused to other units such as purchasing which ensures certain quality standards of purchased items. The quality control also shares in this quality standard maintenance during and after production. The production unit ensures compliance with production specifications, while the packaging unit ensures that the products are protected according to international product specification standards.

Overall, the quality control function needs information about the features and the extra product characteristics needed by the organisation to excel in the market. This information is provided by the marketing department. The production department in turn needs to cost the design options, discuss with the accountant for cost approval and efficiency attainment. This information flow will certainly lead to improved business survival. The outcome is that the needs of the customers are met and this places the company at the top of competition. Fusion in decision occupies a significant position to in the success of the organization. It means that before the marketing department accepts a project of an intention to work on products, it ought to consult the production and quality units as some features of the products may at time be attainable in production.

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Appendix

Questionnaire

Dear Sir,

We are a research group based at the University of Lagos, Akoka, Lagos, Nigeria, working on products' competitive advantage determination. The current stage of our research requires real-life data from manufacturing industries. In view of this, we seek your assistance in filling a set of questions that would enable us move to the next stage of our research.

All information obtained from your organisation will be used for academic purpose only and handled with utmost confidentiality.

Yours faithfully,

Researchers

Section A

This section deals with rating of products with respect to profit making potential of an organisation.

Descriptions	Symbols
Very low	VL
Low	L
Medium	M
High	H
Very high	VH

Questions	VL	L	M	H	VH
How would you rate the features of your products with respect to your organisation survival?					
How would you rate marketing of your products with respect to your organisation survival?					
How would you rate the processes use for production activities with respect to your organisation survival?					
How would you rate customers' attributions with respect to the organisation survival?					
How would you rate the operation costs with respect to your organisation survival?					
How would you rate biodegradation has it affects a product?					
How would you rate product life-cycle has it affects a product?					
How would you rate product's rate of recycle has it affects a product?					
How would you rate product's rate of waste disposal has it affects a product?					
How would you rate product's innovation has it affects a product?					
How would you rate product's return on investment has it affects a product?					
How would you rate product's break-even period has it affects a product?					
How would you rate market attractiveness has it affects product marketing?					
How would you rate market penetration rate has it affects product marketing?					
How would you rate raw material accessibility has it affects product marketing?					
How would you rate close substitute in market has it affects product marketing?					
How would you rate export orientation has it affects product marketing?					
How would you rate market shares has it affects product marketing?					
How would you rate customers complaint has it affects product sales?					
How would you rate customers retention has it affects product sales?					

How would you rate customers satisfaction has it affects product sales?					
How would you rate energy consumption of a product?					
How would you rate process capability of a product?					
How would you rate production rate of a product?					
How would you rate labour availability for a product?					
How would you rate product damage?					
How would you rate outsourcing need?					
How would you rate inventory cost?					
How would you rate advertisement cost?					
How would you rate research and development cost?					
How would you rate raw material cost?					
How would you rate production cost?					
How would you rate maintenance cost?					
How would you rate after sales service cost?					

Section B

This section deals with rating of customers attributes with respect to a product

Questions	VL	L	M	H	VH
How would rate customers complaints for product 1?					
How would rate customers complaints for product 2?					
How would rate customers complaints for product 3?					
How would rate customers complaints for product 4?					
How would rate customers retention for product 1?					
How would rate customers retention for product 2?					
How would rate customers retention for product 3?					
How would rate customers retention for product 4?					
How would rate customers satisfaction for product 1?					
How would rate customers satisfaction for product 2?					
How would rate customers satisfaction for product 3?					
How would rate customers satisfaction for product 4?					

Section C

This section deals with rating of cost attributes with respect to a product

Questions	VL	L	M	H	VH
How would rate inventory cost for product 1?					
How would rate inventory cost for product 2?					
How would rate inventory cost for product 3?					
How would rate inventory cost for product 4?					
How would rate advertisement cost for product 1?					
How would rate advertisement cost for product 2?					
How would rate advertisement cost for product 3?					
How would rate advertisement cost for product 4?					
How would rate R&D cost for product 1?					
How would rate R&D cost for product 2?					
How would rate R&D cost for product 3?					
How would rate R&D cost for product 4?					
How would rate raw materials cost for product 1?					
How would rate raw materials cost for product 2?					

How would rate raw materials cost for product 3?					
How would rate raw materials cost for product 4?					
How would rate equipment usage cost for product 1?					
How would rate equipment usage cost for product 2?					
How would rate equipment usage cost for product 3?					
How would rate equipment usage cost for product 4?					
How would rate labour cost for product 1?					
How would rate labour cost for product 2?					
How would rate labour cost for product 3?					
How would rate labour cost for product 4?					
How would rate after sales service cost for product 1?					
How would rate after sales service cost for product 2?					
How would rate after sales service cost for product 3?					
How would rate after sales service cost for product 4?					

Section D

This section deals with rating of product features

	VL	L	M	H	VH
How would rate biodegradation of product 1?					
How would rate biodegradation of for product 2?					
How would rate biodegradation of for product 3?					
How would rate biodegradation of for product 4?					
How would rate product 1 life-cycle?					
How would rate product 2 life-cycle?					
How would rate product 3 life-cycle?					
How would rate product 4 life-cycle?					
How would rate product 1 rate of recycle?					
How would rate product 2 rate of recycle?					
How would rate product 3 rate of recycle?					
How would rate product 4 rate of recycle?					
How would rate product 1 waste disposal rate?					
How would rate product 2 waste disposal rate?					
How would rate product 3 waste disposal rate?					
How would rate product 4 waste disposal rate?					
How would rate product innovation for product 1?					
How would rate product innovation for product 2?					
How would rate product innovation for product 3?					
How would rate product innovation for product 4?					
How would rate product 1 return on investment?					
How would rate product 2 return on investment?					
How would rate product 3 return on investment?					
How would rate product 4 return on investment?					
How would rate product 1 break-even period?					
How would rate product 2 break-even period?					
How would rate product 3 break-even period?					
How would rate product 4 break-even period?					

Section E

This section deals with rating of process attributes with respect to a product

Questions	VL	L	M	H	VH
How would rate energy consumption for product 1 during production?					
How would rate energy consumption for product 2 during production?					
How would rate energy consumption for product 3 during production?					
How would rate energy consumption for product 4 during production?					
How would rate labour availability for product 1?					
How would rate labour availability for product 2?					
How would rate labour availability for product 3?					
How would rate labour availability for product 4?					
How would rate product 1 production rate?					
How would rate product 2 production rate?					
How would rate product 3 production rate?					
How would rate product 4 production rate?					
How would your rate outsourcing of part of production activities for product 1?					
How would your rate outsourcing of part of production activities for product 2?					
How would your rate outsourcing of part of production activities for product 3?					
How would your rate outsourcing of part of production activities for product 4?					
How would you rate amount of defective product 1 produced during production?					
How would you rate amount of defective product 2 during production?					
How would you rate amount of defective product 3 during production?					
How would you rate amount of defective product 4 during production?					
How would you rate process capability for product 1?					
How would you rate process capability for product 2?					
How would you rate process capability for product 3?					
How would you rate process capability for product 4?					

Section F

This section deals with rating of market attributes with respect to a product

Questions	VL	L	M	H	VH
How would you rate market attractiveness for product 1?					
How would you rate market attractiveness for product 2?					
How would you rate market attractiveness for product 3?					
How would you rate market attractiveness for product 4?					
How would you rate product 1 market penetration rate?					
How would you rate product 2 market penetration rate?					
How would you rate product 3 market penetration rate?					
How would you rate product 4 market penetration rate?					
How would you rate raw material availability for product 1?					
How would you rate raw material availability for product 2?					
How would you rate raw material availability for product 3?					
How would you rate raw material availability for product 4?					
How would you rate export potential of product 1?					

How would you rate export potential of product 2?					
How would you rate export potential of product 3?					
How would you rate export potential of product 4?					
How would you rate market shares of product 1?					
How would you rate market shares of product 2?					
How would you rate market shares of product 3?					
How would you rate market shares of product 4?					
How would you rate lose substitute of product 1 in market?					
How would you rate lose substitute of product 2 in market?					
How would you rate lose substitute of product 3 in market?					
How would you rate lose substitute of product 4 in market?					