A comparative study of factors affecting product quality and customer needs compliance in the New Product Development process

by

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Abstract

To succeed and survive in competitive markets, products need to be of the desired *quality*. *Quality* is how well the product, in its entirety, satisfies the needs of the intended customers. With products in industrial markets, there are many different types of customers to satisfy.

Research has been published that is of general use to help define the New Product Development (NPD) process and the management of its activities and this was useful as a basis for this research study. However, little previous work is available that details the specific aspect of designing for customer needs compliance.

An exploratory investigation, using analysis of selected cases and experience surveys, was undertaken to help direct conceptual work. A conceptual model was developed to help describe the NPD process and customer needs compliance. The hypotheses that guided the main study sought to understand the perceptions which the design team has of the product in terms of different customer needs. They also aimed to determine how information management during NPD may affect the final design and, consequently, the *quality* of the product.

With the objective of drawing conclusions across the four companies involved in the main study, collection methods and data analysis provided quantitative results on what is essentially qualitative types of information.

The findings conclude that each of the companies do perceive a difference in the needs of the customers between different product types. However, they also imply that specific types of customers have similar needs, no matter what types of products are involved. With a small set of respondents in each company, no evidence was found to suggest that the different perceptions the people involved in the design and development of the product had could be attributed to the functional, managerial or customer involvement groupings under investigation. However, there was some evidence that customer needs compliance may be affected by the way the company handled its information management during the NPD process.

Key words:

New product development; customer needs; product quality; design team perceptions.

List of publications relevant to this thesis

Elliott, A. C., Saunders, J. A. & Wright, I. C. (1998) "Successful NPD in Engineering Design: Meeting Customers Needs" in ***Design Reuse. Engineering Design Conference '98 Conference Proceedings.*** Sivaloganathan, S. & Shahin, T. M. M. (Eds). Professional Engineering Publishing, London UK. pp391-398.

Elliott, A. C., Wright, I. C. & Galer-Flyte, M. D. (1999) "Human Factors design priorities during NPD: An empirical study" in ***Contemporary Ergonomics. Ergonomics Society Annual Conference Proceedings***. Hanson, M. A., Lovesey, E. J. and Robertson, S. A. (Eds). Taylor and Francis, London, UK. pp369-373.

Elliott, A. C. & Wright, I. C. (1999) "Influences upon setting product design priorities" in ***Communication and co-operation of practice and science ICED '99 Conference Proceedings***. Lindemann, U., Birkhofer, H., Meerkamm, H. & Vanjna S. (Eds) Technische Universität München, Germany. pp1559-1564.

Contents

List of figures

List of tables

Chapter 1
Introduction

A quality product is one which satisfies the customer and complies with their needs.

New engineering design products are launched everyday: they are developed to provide solutions to common or specialised problems; to enrich our lifestyle; to release us from mundane and monotonous jobs; to give reliable alternatives to old solutions; to amuse us; to provide items which are more pleasing to the eye; or to be more ecologically aware. What the companies that develop, design, manufacture, market and sell these products are seeking is commercial compensation in the short or long term - *success* - however you measure it.

Innovation and New Product Development (NPD) are not enough by themselves, and companies must ensure they reap the rewards. Engineering design companies are bearing the costs of creativity and may be placed at a competitive disadvantage, taking financial losses if they do not exploit the innovations they have established (Foxall and Johnston, 1994). Foxall and Johnston note that "the issue revolves around the capacity to satisfy the customer requirements more effectively through the exploitation of technological innovativeness". (Foxall and Johnston, 1994 p167).

Indeed this relationship with commercial compensation is underlined in Drucker's discussion of quality, in that the customer will only pay for what they get out of the product: what is of use to *them* and gives *them* value (Drucker, 1986). The quality of a product is therefore entirely a customer-based value: the product with the highest quality for a particular customer is not always the one which is the most technically innovative, low in price, highest in performance or has the best service and warranty. Rather, it is the product which has the optimum (or most appropriate) combination of attributes.

The research, which is the basis for this thesis, is concerned with the issues surrounding such customer-based needs and optimum product design. The themes of quality, customer needs compliance and information transfer during product design are developed in this introductory chapter - providing aims and objectives for the research. The structure and contents of this thesis are detailed at the end of this chapter.

1.1 Problem statement: Developing quality products.

Many authors have empirically explored and discussed in detail the keys which separate successful product development from failures (for examples see Calantone *et al.*, 1995; Cooper and Kleinschmidt, 1995a; Cooper and Kleinschmidt, 1994; Cohen, 1995; Griffin and Page, 1993; Griffin and Page, 1996; Hise *et al.*, 1990). However, there are still many engineering design projects which fail. Why does this occur? A good indication is that innovation can be seen as a task of cross-functional information management and decision-making, in a complex environment. Understanding what will be successful in the marketplace and developing a new product for your customer is consequently a culmination of appropriately abstracting, transforming and transferring data, information, knowledge and skills.

This research project was stimulated by an interest in the process which multidisciplinary design teams use to ensure their products meet the needs of the customer. The initial issues in this discussion surround (a) the definition of a *quality* product; (b) who is the customer; and (c) how the process of design addresses customer needs.

1.1.1 What is quality?

Many companies use the phrase "a quality product", indicating an excellence or goodness which they have bestowed upon the item, as a matter of fact. However, the origin of this word is actually not biased positively. Mørup recalls that it comes from the Latin *qualitas* which "seems to be a neutral description of an object, where use of adjectives like good, bad, etc. make no sense. In other words, quality originally had an objective content, connected to the product itself - *as the object really is*" (Mørup, 1993, p89). In reality, *quality* is generally deemed to be a subjective issue - it is in the perception of the beholder, otherwise everyone would seek out exactly the same "quality" items which, clearly, they do not. Indeed, superior engineering product design and development pays attention to the *right quality* of the product, satisfying the right customer targets. Cooper and Kleinschmidt found this "product advantage" in the marketplace to be the most important factor for a successful design (Cooper and

Kleinschmidt 1986, 1994; 1995a; 1995b; and Kleinschmidt and Cooper, 1991). This is also emphasised in the definition used by the International Standards Organisation (ISO):

> "[quality] is the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs"
>
> (Rothery, 1993 p31 quoting ISO 8402).

Since the word 'quality' can be misconstrued by many, I must try to distinguish the context of the use of the word throughout this thesis. Therefore, wherever the word *quality* appears in italics it should be taken to read "*customer needs compliance and satisfaction by the product characteristics*". Wherever it appears in other forms, it should be taken that is not explicitly related to customer needs satisfaction and should be read within the context of the description and of the author quoted.

1.1.2 Who is the customer?

Product *quality* is therefore determined by the customer of the product, whether they be retailer, buyer, installer, end user or maintainer. Yet companies produce and sell products using the word "quality" as though it only has to do with how much the buyer will pay for the features which affect the main user. It is not surprising that, although engineering design companies in the industrial sector recognise that there are many people involved with the product, they often fail to consider all of the potential customers during the development of their products.

The customer is anyone who is involved with the product, or influences the buying decision either directly or indirectly. Some authors indicate that the 'user' and 'customer' are synonymous because they have to buy into a idea and invest themselves in the product (Mørup, 1993). However, this seems lacking in detail, especially for industrial products, where the end user may not have a direct influence over the purchase at all. Authoritative marketing texts from Jobber (1998) and Kotler *et al.* (1996) discuss the industrial customer as a Decision Making Unit (DMU) comprising six main roles, including buyers and users. These roles have their origins in research conducted into buyer behaviour in the nineteen-seventies and eighties (Webster and Wind 1972; Johnston and Bonoma, (1981). Although these descriptions may be changed to suit the organisation, the roles of the installer, maintainer and disposer are only hinted at in the form of the 'influencer' and not explicitly addressed. The more recent discussion of Owen and Hills (1996) identifies 7 main stakeholders who are customers for the whole life of the product, which include maintenance, service and disposal, but do not recognise roles such as influencers and initiators that are included in the classic DMU. Hill (1972) presents another view of the customer for industrial products. He identifies a number of separate, smaller, functional units which are the basis of the product buying group, but this analysis - by its nature - does not entirely satisfy the differing customer roles which interact with the product during its life.

As can be seen from this initial discussion, the customer is something which needs further investigation. During the progress of this thesis the definition and role of the customer will be explored and developed for a fuller understanding in the context of this research.

1.1.3 How does the design process allow for customer needs compliance?

The ISO definition of quality indicates a role for the New Product Development (NPD) process. It suggests that, to ensure they are developing a product which will satisfy the customer, designers have to include features and functionality in the product which will yield the required benefits. The design should meet the needs, expectations and values of the customer (whoever they are), so that the product is fit for the customers' purpose. Therefore, of prime importance during innovation, is the provision of the information which will help developers know what the customer needs are and provide a means of delivering them as a product which is unique and superior in the eyes of the customer.

New product development is carried out by companies following some sort of path, route or process which incorporates activities over a period of time to provide an output - the product. The activities which are undertaken during the development strongly affect the outcome of the project, how this outcome is determined a success or failure (Cooper, 1994) and also whether the product will be of the right *quality*. A single, workable, generic process for NPD cannot be defined easily due to the dependence upon so many subjective variables. However, essentially, it can be described as a series of steps or stages which are often iterative. These involve, or try to integrate, many different individuals, groups or functions within a company to supply a product offering to the market.

During early development, requirements are decided and priorities set for the further detailed design and build of a product. It is often during these front-end preparatory steps that decisions are taken that define the product and determine whether it will incorporate an ethos of design for customer needs compliance, either implicitly or explicitly. Information is important in generating and developing concepts which are oriented towards the customer. Building up a strong competence in the capture of information will, therefore, affect the competitive performance of the company (Bruce *et al.*, 1996). It has been found that information collected in a form which is understandable and usable by the design team that is then communicated clearly and effectively is extremely important to the final marketplace-success of the product (Cooper and Kleinschmidt, 1995a). The methods used for this communication has been the subject of many previous research studies by management, marketing and engineering design researchers. Descriptive and prescriptive models, tools and aids have been developed to understand and help this process and is the subject of a wider discussion in the literature review. Of particular interest to the direction of this work, is the lack of empirical research regarding the whole development process and the communication of information which may affect customer needs compliance for the product design.

1.2 Research focus

The research project is based upon an investigation of possible variables that might affect the success of product development, with the objectives of understanding more fully the implications of designing for customer needs compliance. The research also aims to understand the perceptions which the design team have of the product in terms of customer needs. It is also an objective to determine how customer needs compliance activities and information transfer methods during NPD affect the final design and, consequently, the *quality* of the product.

The findings provide analysis of a descriptive design process model and hypotheses developed during the preliminary work in this research. The model is evaluated in relation to in-depth empirical surveys in four engineering design companies in the

UK. The research focuses upon industrially bought products (not consumer products), where the end user does not actually buy the product.

The research is context-sensitive and does not claim to be definitive. Also, it does not aim to provide a prescriptive model of developing industrially bought products. However, the objective of this research is to add to the body of knowledge in the area of engineering design and management by providing new and detailed information on the role of customer-needs perceptions during NPD and the factors which may affect compliance to such customer-needs. Research objectives and hypothesises are developed and detailed in Chapter 3.

1.3 Confidentiality of data

Confidentiality agreements were made with each of the companies involved in the research study. Product customers and respondents to the study were also assured of their anonymity in the analysis and publication of results. All possible measures have been taken to ensure confidentiality of the interviewees, the organisations and specific products. As such, details of company background and products are limited to generic descriptions and groupings. The author believes that the lack of specific detail does not remove the importance and applicability of this research.

1.4 Outline of thesis

This research has been undertaken following a series of stages, which is reflected in the structure of this work. Figure 1.1 shows the structure and outlines the contents of the thesis.

The main body of the thesis is organised into eight chapters. This introduction is followed by an extensive literature review, in Chapter 2. Details of exploratory study work are given in Chapter 3, which leads to Chapter 4, where a theoretical model is developed. The methodology and approach for the research is then discussed in detail in Chapter 5. The findings from the surveys undertaken during the research are presented in Chapter 6, with a discussion of the outcomes in Chapter 7. The final chapter, 8, contains summary conclusions and considerations for further research .

Chapter 1. ***Introduction***	Introduces the concepts of *quality*, who the customer is, and the design process for customer needs compliance.	
Chapter 2. ***Literature Review***	Reviews issues of information requirements and the definition of customer needs and perceptions during NPD through previous research on theories, current practices and empirical studies.	***EXPLORATION***
Chapter 3. ***Exploratory study***	Details the requirements for an preliminary study, which feeds into the conceptual process for the main research.	
Chapter 4. ***The research problem: Conceptualisation and development***	Builds theories and develops a model to that provides the basis for specific research questions and hypotheses for the research.	***CONCEPTION***
Chapter 5. ***Methodology***	Discusses methodological issues of study design practices and proposes approaches for data collection and analysis.	***PROPOSAL***
Chapter 6. ***Customer needs compliance study findings***	Four different company studies are described. Important within company results are presented for each company. Findings are also compared between companies.	***TESTING***
Chapter 7. ***Discussion***	Discusses issues raised during the course of this research in terms of the specific research questions and hypotheses and compares them with findings from previous work.	***EVALUATION***
Chapter 8. ***Conclusions & Considerations for Further Work***	Summarises findings of the work carried out. Considers the contribution which this has made to design research and recommends further work which could take place in this field.	

Figure 1.1. Structure and outline of the thesis

Chapter 2
Literature review

The design and development of products has been, and is continually the focus for many different authors. The pre-occupation with design and development exists because getting it right is so important. A revealing comment from Norman and Peterson tells why companies are so desperate to understand what they do and how they can make things better: "all good companies can innovate, but fewer are able to be innovative again and again." (Norman and Peterson, 1999, p65). No one has been able to capture the ultimate prescription for success and even some of the same authors publish different observations, depending upon the orientation and audience. Therefore, this review begins with a comment on the rationale for the search, and then supplies a structure for the resulting literature found. This structure (as shown in figure 2.1) will be followed to present information in the rest of this review chapter.

2.1 Rationale and limitations of literature reviewed

There is a plethora of literature available about the design and development of products. Engineering design researchers and practitioners draw mainly upon their huge experience in practical design, providing examples of both good and bad design practice. Although an "engineering design" discipline exists in its own right, advocates of this have only emerged recently. Therefore, there are many other groups of academics and industrialists that must be included in any search for relevant engineering design literature. A concern of reviewing such a vast amount of work is that no one discipline can claim it as their own; and no one discipline has a monopoly on valid and useful research in this area. Researchers from the business studies area and, in particular, marketing provide many important views and some of the most relevant empirical research about the role of New Product Development (NPD) principles and practice with respect to the customer. In addition, design and technology experts discuss the creative, and often difficult to capture, aspects surrounding the design and development issues which are of interest to buyers and end users. Other engineers (of all classifications), ergonomists and human factors experts, organisational behaviourists and quality management gurus all have relevant and interesting contributions to make to this field.

As such, a systematic literature search was conducted with a view to understanding some of the most important issues to this particular facet of design and development. The research literature regarding the NPD process and the design of *quality* products and customer needs compliance was examined through on-line database queries, OPAC library book searches and citation from papers and books on related topics.

Unfortunately, the majority of literature available on NPD did not directly take into account the specific question of customer needs compliance. However, a number of important issues were identified as being related and important to this study, the rationalised results of which are discussed in this chapter. The literature review starts with a discussion about customer needs and requirements, then talks about NPD as a process. These two areas are then put into further context by the final main section which describes compliance during NPD.

Figure 2.1 Shows diagrammatically, the discussion areas that emerged from this extensive literature review.

2.2 Customer needs and requirements

As stated earlier, the ISO 8402 standard definition of quality suggests that product quality is determined by how well it meets the needs, expectations and values of the customer. The *quality* of the product is therefore a customer-driven value. Research on the nature of what customers regard as *quality* is difficult because it reaches into the depths of a person's psyche – why can one product be seen as "high *quality*" by one, yet disinterest another? It is probably because *quality* is a perception, scored against each customers' set of values. For example, a *Rolls Royce* is a "high *quality*" car for the discerning buyer who looks to brand image, high specification and durability, but places low importance on maintainability or through-life costs.

However, a *Skoda* driver may be more interested in buying a lower risk, shorter life car with good servicing and warranty cover - to them the *Rolls* is of lower *quality* because the values do not match the ones for which the mode of transport is being adjudged. Since the *quality* of any product is based upon the perception of how well a product will meet the needs, values and expectations of the customer this section will discuss how these customer needs and requirements change through an understanding of who the customer is and what they could want.

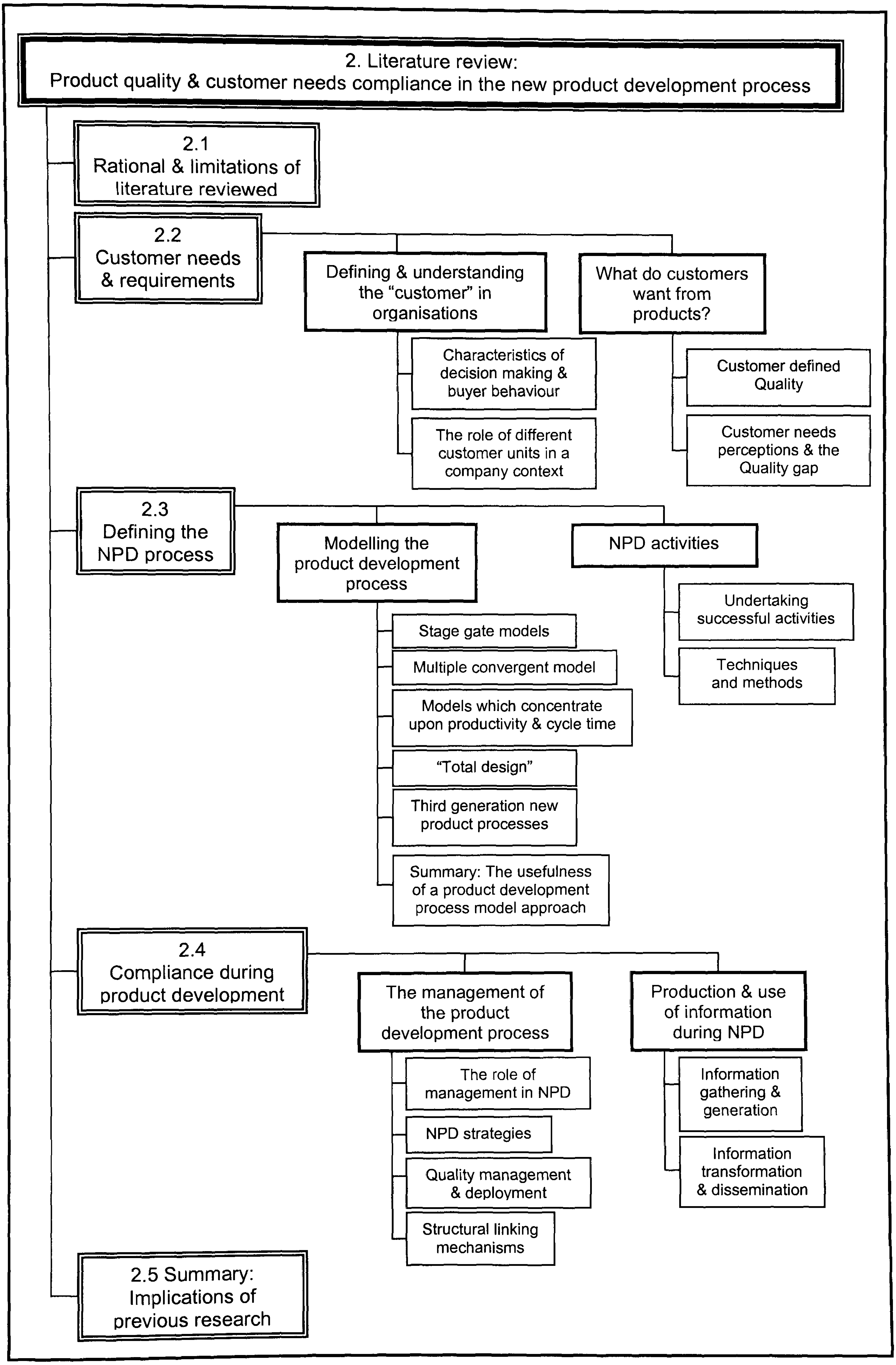


Figure 2.1. Structure of the literature review

2.2.1 *Defining and understanding the "*Customer*" in organisations*

Understanding the requirements for the design of engineered products for organisational and industrial markets is often more complex than for consumer goods. The demand for industrial and business products is derived from the ultimate demand in consumer goods and has high fluctuations – increasing and decreasing disproportionately to the demand for the consumer goods which the organisation eventually sells to the consumer (Hague, 1992). Thus, in an organisational or business context the "customer" of a product is often a whole group of people. They will be taken from differing backgrounds, management positions, interests and opinions and may affect the buying decision, partially based upon their understanding of what their customer, in turn, will require. Standard marketing texts refer to these groups within the buying organisation as the *buying centre* (Webster and Wind, 1972) or *the decision making unit (DMU)* (Jobber 1998, Kotler et al 1996), and the tasks they undertake as *the buying decision process*. This section discusses issues which have direct relevance to the understanding of customer needs compliance and product *quality* - of how the decision to buy is made and by whom.

2.2.1.1 Characteristics of buyer behaviour and decision making

It has long been recognised that buying a product within an organisational context does not purely relate to the lowest price one can obtain it for (see Bonoma *et al.*, 1977 for an extensive monograph on a conceptualisation of industrial buyer behaviour). Indeed, Webster and Wind in 1972 recognised 7 *non-task models* and 3 *complex alternative models* of organisational buyer behaviour on top of 6 simple *task-oriented models* (Webster and Wind, 1972). Table 2.1 provides an overview of models they discuss in their endeavour to find a suitable understanding of industrial buyer behaviour. Recent practices of long-term dependency and reverse marketing are examples of another type of buyer behaviour model. These *interaction models* place emphasis on the very nature of the relationships within and between both the buying and selling companies (Wilson et al, 1996).

Buyer behaviour

Buyer behaviour is inextricably linked to understanding why and how the customer buys a particular product. The needs and requirements of the task and non-task variables of the individuals and groups which make up the "customer" are linked to the behaviour they exert when they buy the product. For example, if it were purely a case of minimum cost then the "minimum price" and "lowest total cost" models would be the prevailing models buyers would stick to, and suppliers would not concentrate on anything but money. However, this is not the case and the seminal work of Webster and Wind concluded that, although most of the models suggested have a part to play in explaining *some* facets of the industrial buying process, a further, integrated model was required. The model they ultimately use to describe the organisational buying responses requires an understanding of four major aspects:

- the identity of the buying centre;
- the nature of the buying decision process and criteria for evaluation;
- the buying situation (new task versus modified re-buy versus straight re-buy);
- the nature of the factors affecting the buying decisions – the environmental, organisational, interpersonal, and individual characteristics.

(Webster & Wind, 1972, p110).

In effect, the activities of Webster and Wind in modelling buyer behaviour raised some basic questions which need to be asked by strategic marketing managers today: [a] How do business buyers make their decisions? [b] Who participates in the buying process and what are their influences upon the buying decision? [c] What are the unique company and product situations that affect the purchase? and [d] What are the strongest influences and prevailing circumstances of the company and individual buyers? (Hutt and Speh, 1992; Kotler *et al.*, 1996).

Table 2.1. A description of possible alternative organisational buying behaviour models (Compiled from extracts of Webster and Wind 1972, p12-27; Wilson et al., 1996, p130; Jobber, 1998, p92).

TASK ORIENTED MODELS	**Describe the pursuit of buying as the only objective to consider. They accentuate rationality & limited choice.**
Minimum price model	Simply an explanation of a firm to maximise its profits. Useful for undifferentiated, commodity products.
Lowest total cost model	An extension of the minimum price model, where factors (other than initial purchase price) are taken into financial account.
Rational buyer model	Prescriptive, generalisable model of buying as a rational, economic choice process.
Materials management model	Normative model of the flow of procured products' quality and quantity into the organisation. [Just-In-Time (JIT) procurement has links to this model].
Reciprocal buying model	Reciprocity is where suppliers to the company are expected to purchase the company's products in return.
Constrained choice model	Many buyers have a limited selection from which to chose a supplier. Thus, some suppliers will be "in" and others "out" at any one time. Source loyalty, inertia, habitual behaviour, and favouritism are all characteristics of this model.
NON-TASK ORIENTED MODELS	**Introduce non-task aspects of human, non-economic decision-making.**
Self-aggrandisement model	This model suggests that an individual buyer within an organisation may have the influence to gain personal benefits and gifts from favouring a particular supplier.
Ego-enhancement model	Similar to the above model, but the buyer is in some way recognised as an individual who is valuable.
Perceived risk model	This model states that the buyer is motivated by the requirement to reduce the amount of perceived risk and uncertainty as far as possible
Dyadic interaction model	Here the model presents the role of the seller-buyer expectations in the buying decision. The buyer will respond positively if the seller displays characteristics which they are expecting during interaction.
Lateral relationships model	Describes interactions between the buying group within a company. It concentrates upon the purchase agent and his/ her status relative to his/ her equals in other departments, such as production or R&D and the power which can be obtained by making particular buying decisions.
Buying influences model	Emphasises the limitations of concentrating on the purchase agent as the sole buyer within an organisation. It notes that there are likely to be many different influences upon the purchase decision & encourages investigation.
Diffusion process model	Considers the decision-making unit as part of a social system, through which new products and services "diffuse" into, over time.
MULTIDISCIPLINARY & COMPLEX MODELS	**Consider a multitude of elements (social, cultural, psychological & economic), which together influence the buying decisions.**
Decision process model	Emphasises the time dimension and buying process of problem recognition, searching and choosing between the alternative suppliers.
Competence-Activity (COMPACT) model	An involved and detailed abstract model which includes layers that attempt to capture: the decision process; the influencers (people) involved; and an individual competence scale.
BUYGRID model	Develops the decision process as eight stages from recognition to performance feedback. It also describes the need to understand why the product is required: a new task; a straight re-buy; or a modified re-buy?
INTERACTION APPROACH	**Places great emphasis upon the nature of process & relationships within & between the buying & selling organisations.**
Long-term dependency	Discusses organisational relationships based on mutual trust and long term support. Indicative of single source suppliers, where the selling organisation buys-in, using its own resources for products produced for single suppliers.
Reverse marketing	Describes trends towards purchaser strength & the stipulation of requirements. Accentuates the role of the buyer as a pro-active, aggressive purchaser.

The buying process

Research into industrial and business-to-business marketing has provided much discussion around the theory of buyer behaviour in organisational circumstances (see Hutt and Speh, 1992; Webster and Wind, 1972; Wilson *et al.*, 1996 for informed and detailed discussions). For example, Sheth, (1973); Howard and Sheth, (1969); Hakansson, (1981); and Choffray and Lilien, (1978) concentrate upon the role that individuals play in the formation of organisational preferences. Whilst Sweeney *et al.*, (1973); Puto *et al.*, (1985); and Chisnall (1989) all pay particular attention to risk taking for organisational purchases. Devised from the literature identified in this paragraph, figure 2.2 provides a rationalised diagrammatic form of issues that need to be considered as an integral part of industrial buyer behaviour.

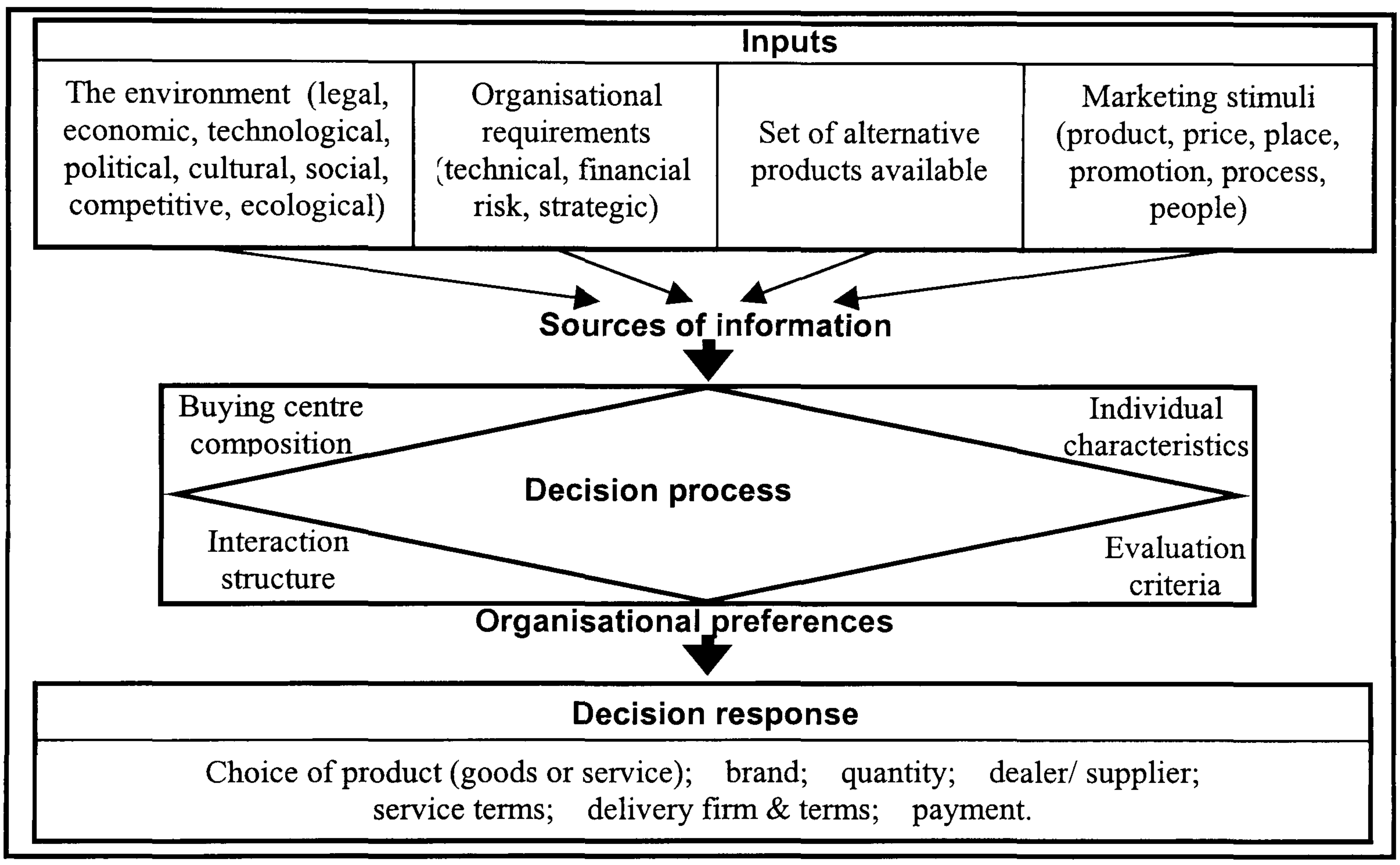


Figure 2.2. A model of business buyer behaviour issues.
(After Kotler et al., 1996, p315; Hutt and Speh, 1992, p120; Wilson et al., 1996, p103).

What these researchers have found, and what is highlighted by figure 2.2, is that organisational behaviour is complex, sitting within a context of environmental, organisational, group and individual forces (Hutt & Speh, 1992). The buying activity can be extracted from the different situations, giving a simplified decision making process (Robinson *et al.*, 1967). This is interesting and useful in terms of understanding the course of action buyers take during the purchase of goods and services (Jobber, 1998). The definition of this decision making process has changed little in thirty years. Kotler *et al.* in their 1996 edition of *Principles of Marketing*, use the same source for the decision making process as does Webster and Wind in 1972. Figure 2.3 shows these eight stages from Robinson *et al.*, 1967.

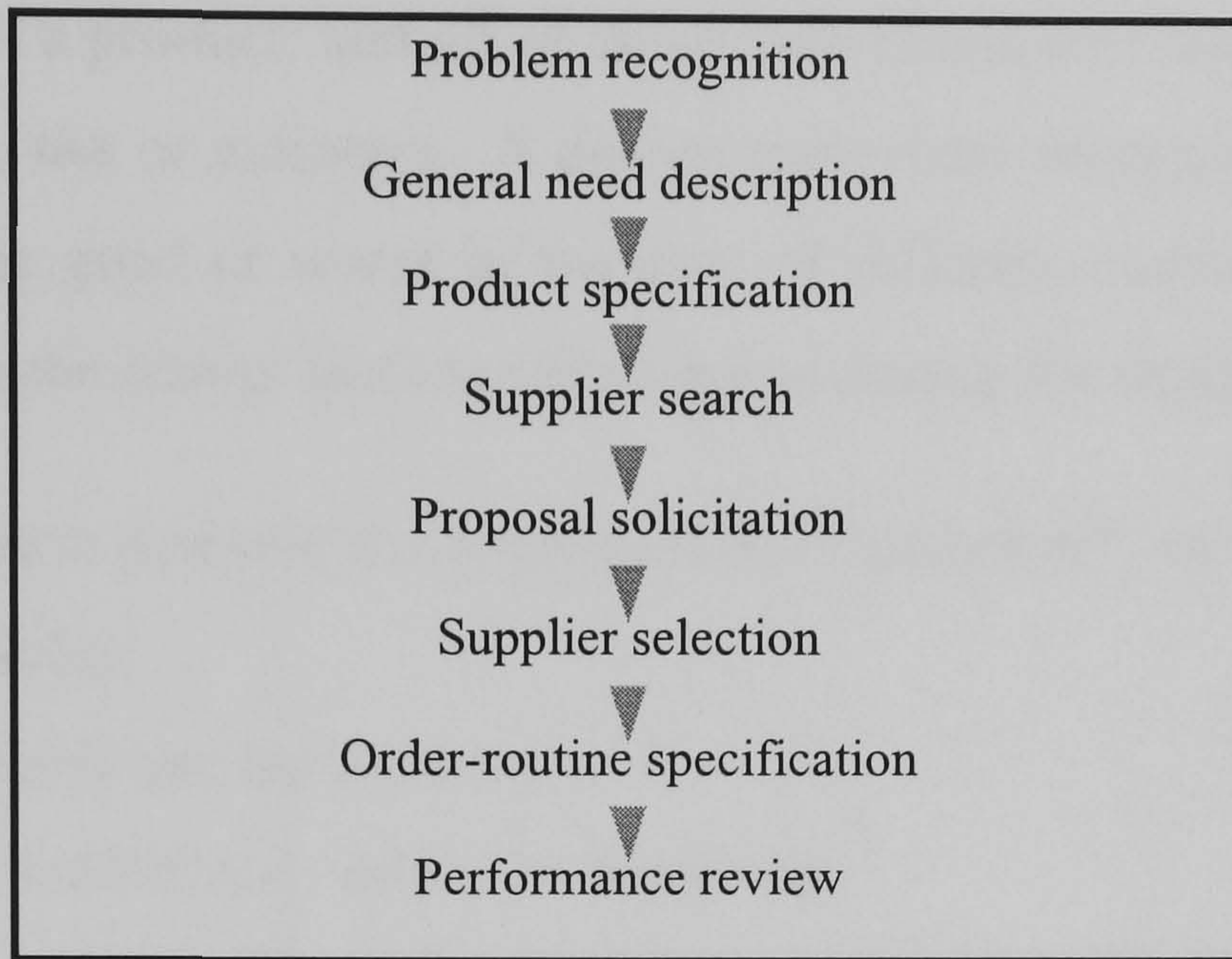


Figure 2.3. Key stages in business buying process (Source Robinson et al., 1967)

This temporally descriptive model of the stages which a business will go through as they buy a product is open to discussion, since stages maybe iterative or skipped altogether in certain circumstances, e.g. a straight re-buy of consumables. The period of time it takes to go through this process will depend upon the involvement, risk and implication of the purchase. Typically, each stage, and therefore the whole process, will take longer to buy a product which is expensive and complex (Jobber, 1998). Obviously, to extract the process of buyer decision making activity is inherently flawed, because there are so many different issues in the intra-organisational and inter-organisational context which will affect the decision and the transactional nature of industrial buying behaviour (Bonoma *et al.*, 1977). However, it is a general model adopted either consciously or unconsciously by most organisations (Kotler *et al.*, 1996; Jobber, 1998) and is used as a staging post for understanding buyer behaviour in many marketing principles texts.

2.2.1.2 The role of different customer units in a company context

It is apparent that to be able to meet the needs of customers, one must know who the "customer" of the product really is. This, however, is not particularly easy, Bonoma *et al.*, note "the complex, vague, and often changing composition of the buyer centre makes it difficult to ascertain empirically just who is involved in organisational buying" (Bonoma *et al.*, 1977, p80). This is because, in contrast to the consumer market, organisational purchases usually involve more buyers and a more professional purchasing effort (Kotler *et al.*, 1996) and these buyers are individuals behaving in an organisational context (Webster and Wind, 1972). Therefore, there are many different types of "customer" of a product: and all of these individuals will have an opinion on the products they buy, use or maintain. A design team must recognise that a product can be changed for the good or worse in the eyes of different customers, depending upon which customers the design team are thinking of during the design process.

Industrial marketing texts describe the organisational "customer", or buying centre as made up of five main roles:

Users who will actually use the product;
Deciders who have authority to select the suppliers;
Influencers who provide information and decision criteria during the process;
Buyers who execute the contractual arrangements;
and ***Gatekeepers*** who control contact or information.
(Webster and Wind, 1972, pp.77-80)

In some texts, there are six roles identified in this decision making unit (DMU). Jobber relays that Bonoma adds *initiators* as a necessary role, since they begin the purchase process (Jobber, 1998). However, the sixth group Wilson *et al.* include are *approvers*, who give authorisation for the proposals of the deciders and buyers (Wilson *et al.*, 1996). The difficulty in understanding the delineation of roles within the DMU is particularly prevalent. As Webster and Wind explain, these roles are often interconnected:

> "It is quite likely that several individuals will occupy the same role within the buying centre (e.g. there may be several users) and that one individual may occupy two or more roles (e.g. buyer and gatekeeper). All members of the buying centre can be seen as influencers, but not all influencers occupy other roles." (Webster and Wind, 1972, p77).

An alternative view of the industrial buyer as a group of functional units is offered by Hill. Wilson *et al.* describe his five units as:

control units which are responsible for the policy making which influences buying and which imposes certain constraints;

information units which provide information relating to the purchase;

the buying unit which consists of those with formal responsibility for negotiating the terms of the contract;

user units consisting of anyone who will be involved in using the product or service;

and ***the decision making unit*** which consists of those who will make the actual decision.

(Wilson *et al.*, 1996, p121)

Comprehension of the dynamics of the buying centre provides consideration of factors which need to be appreciated by the researcher when discerning who is involved in the buying process (Spekman and Gronhaug, 1986; Johnston and Bonoma, 1981). However, as mentioned in the introduction to this thesis, although the DMU is a basis for marketing principles, the roles require further depth and additional understanding if they are to include other specific individuals who play an important part in the entire life of a product. Owen and Hills (1996), describe 7 external "stakeholders" who are *the customer*, *the purchaser*, *the main user*, *other users*, *maintenance*, *service* and *disposal*. They include identifiable and important groups of people who will interact with the product during its life. However, their list appears to be an unhelpful derivation from explaining a decision making unit because they use the term "customer" and do not mention the importance of other influencers, for example managers who may assess the risk of a new product. A different approach to the aspect of buying decision influence, is to list departments in the buying organisation which the marketer may approach. Table 2.2 provides one industrial marketer's understanding of the influences which different departments can have (Hague, 1992). This view is more understandable for many design teams working on the ground because it is not pretentious and provides recognisable issues and fields of contact. However, it seems to be particularly about influencing the buying decision and, even more specifically, suited to looking at the choice of supplier. Also, it overlooks issues of overlapping departmental responsibilities.

Most marketing texts appear to provide groupings within the buying company as a precursor to understanding who influences the buying decision and, therefore, at whom marketing and sales efforts should be directed. According to Hill only three of the units he identifies – information, control and decision units– actually influence the buying decision itself (Wilson *et al.*, 1996). However, only looking at groups that influence the buying decision is not necessarily going to discriminate all of those who must be satisfied by the product – which is the objective of successful design in the context of designing for the customer. All of the above models are useful to the designer, in fact the optimum situation for this research may be a combination: Owen and Hills categories and Hague's list provide information on people at a level that directly interact with the product during its life, whilst Webster and Wind's model and Hill's groupings help tease out deeper individuals who will have contact with, or influence the specification of the product.

Table 2.2. Hague's interpretation of the areas of responsibility that company departments take in the buying decision (Hague, 1992, p83)

Department	Area of responsibility
Design/ technical/ standards	Setting standards; specifying suppliers
Production/ maintenance/ stores	Specifying suppliers; de-specifying suppliers; determining delivery requirements; determining order frequency and size
Sales/ marketing	Setting design parameters; specifying ,materials; setting selling price constraints and therefore manufacturing cost
Finance/ accounts	Approving terms of payment; agreeing budgets
Buying	Screening suppliers; specifying suppliers; negotiating price, delivery, specifications; obtaining quotes; placing orders; chasing progress of orders
Directors	Sanctioning sums for purchasing; approving choice of suppliers; setting buying policy (e.g. domestic source); setting overall design parameters (i.e. High quality/ high cost/ or low quality/ low cost)

2.2.2 What do customers want from products?

Mørup adjusts the ISO definition of quality to reflect that "true" quality is in the mind of the customer: "quality is the customer's experience (or perception) of how well the totality of quality properties of a product satisfies their stated or implied needs" (Mørup, 1993, p91). The importance of discussing the experience and perception of the customer is two fold. Firstly, that perception is different for each person and therefore the definition of *quality* must be discussed within this context, and secondly that the *quality* a customer perceives they get from the product may leave a "*quality* gap" to what they really wanted.

2.2.2.1 Customer defined quality

Perception has been described by organisational behaviourists as "the active psychological process in which stimuli are selected and organised into meaningful patterns" (Huczynski and Buchanan, 1991, p37). Thus, if this is accepted, when the *quality* of a product is perceived, it is within the phenomenological experience of the individual customer's perceptual world, which may be different to another customer's perceptual world (Atkinson *et al.*, 1990). Therefore, each customer will define and perceive the product *quality* differently.

Customer values

Also borrowing heavily from organisational behaviour are the theories of motivation and need. Two of the most prominent Western authors on this subject area are Maslow and Herzberg. In the 1950s Herzberg undertook studies to understand human motivation. He describes aspects as either "motivators" - issues which led to satisfaction, or "hygiene factors" - leading to dissatisfaction (Huczynski and Buchanan, 1991, p74). Maslow's hierarchy of needs has a structure which suggests that an individual has certain requirements which they look to fulfil in turn to provide satisfaction (Maslow, 1970). Among the lower order needs are physiological and safety needs. Once these are satisfied, Maslow suggests that a person will look for opportunities to provide for their social, esteem and self-actualisation needs. In terms of customers and products, a need is concerned with a lack of something that is wanted (Holt *et al.*, 1984). Therefore a customer will have motivation to satisfy any needs that they perceive they have.

Additionally, according to the European Standard EN29000, quality can be defined as 'fitness for purpose' (Wright, 1998). What kind of needs provide 'fitness'? Some needs are existing and are recognised currently by a customer, but there are also future needs which customers do not recognise at present, but will materialise in the future (Holt *et al.*, 1984). Also, needs may be rational (looking at the function and use of the product) or emotional (regarding issues such as novelty, style, colour and other things like aesthetics). Further, there are individual needs (e.g. convenience), which often require trading off against societal needs (e.g. environmental recycling) (Holt *et al.*, 1984). A company will look to develop a model (either consciously or sub-consciously) to understand all of these aspects, when they are looking to be successful at satisfying their customers by developing a product with the right *quality* values.

Indeed, Kano's much written model tries to help product developers look differently at their product offerings by suggesting that the customer gives significance to certain product attributes, but less to others (Mørup, 1993; Owen and Hills, 1996; Sauerwein, 1999; Jobber, 1998; Robertshaw, 1995). The model places three different values upon product *quality*. These distinct groups are defined by Kano as:

> ***Must-be quality,*** which relates to the customer's basic expectations, such as safety. Superior performance in this category will only lead to a state of "not dissatisfied";
>
> ***one-dimensional quality,*** which relates to the customer's articulated needs. The more one-dimensional qualities are increased the more satisfied customers will be;
>
> ***attractive quality,*** which relates to latent needs. They have a more than proportional influence on how satisfied a customer will be with a given product. If they are not met, however, there is no feeling of dissatisfaction.
>
> (Sauerwein, 1999, p431).

Mørup suggests that the most important things for a company to concentrate upon is the translation of latent needs into innovative products, since they will produce 'exciting quality' features and will help a company gain a leadership position in the marketplace (Mørup, 1993). This is born out in a recent empirical study. Customers, who classified a requirement as 'Attractive' had a significantly higher repurchase rate in comparison to customers classifying the requirement as 'Must-Bes' or 'One-Dimensional' concerning four product features. So, it was deduced that 'Attractive' can be decisive for the purchase of a product (Sauerwein, 1999). The author goes on to conclude that this empirical research supports the validity and reliability of the Kano method for describing product qualities but admits that some of the evidence is only weak and requires deeper research (Sauerwein, 1999).

Even though market research may be undertaken and customers asked in an appropriate manner to gain insight of 'must-be', 'one-dimensional' and 'attractive' qualities, there are further complications. Of course, because these *quality* values are perceptions, the values are relative to the customer's experience and knowledge of the attributes and this can be where the product designer has problems incarnating the *right* values into the artefact. Mørup determines that some product quality properties are positioning properties whilst others are obligatory (Mørup, 1993). Mørup's 'obligatory properties' are similar to Kano's 'expected quality' and Herzberg's 'hygiene factors' – they are aspects of the product which the customer perceives to be essential to be considered as a contender. 'Positioning properties' enhance a product's benefits and should position the product in the market and mind of the customer, and should be differentiating factors (Mørup, 1993).

Product positioning

Positioning the product in the mind of the customer by identifying psychological need characteristics has long been recognised by marketers (Urban and Hauser, 1980). The 'position' of the product is the description of the right value for the product characteristics in terms of product attributes, usage occasion, product classes, product remoteness and competitor comparisons (Wright, 1998, p68). Urban & Hauser sum up the importance of positioning customer *quality* perceptions for product development managers:

> "We view features as essential to substantiating a perceptual position... Although we could ignore perceptions and concentrate only on features, real opportunities might then be lost... Both psychological positioning and features are part of a good new product design... Since the most important dimensions are those the consumer uses in selecting a product, a manager is well advised to begin with consumers' psychological dimensions to find the structure of cognition and then use that understanding to direct the product design to produce the physical characteristic that will position the product effectively on the psychological dimensions."
>
> (Urban and Hauser, 1980, p194)

These product values need to be weighed out against the costs incurred and entered into a 'value equation' in the mind of the customer (Kotler *et al.*, 1996). Figure 2.4 shows a simple representation of this equation. In industrial situations, poor understanding of customer needs and market requirements can lead to incorrect product/ price positioning. Also, in previous studies of industrial products, poor product/ price positioning have been found to contribute to product failure (Cooper, 1975; Cooper, 1994; Briscoe, 1973)

	Total customer value	*(Product, services, personnel and image values)*
minus	*Total customer cost*	*(Monetary, time, energy and psychological costs)*
equals	*Customer delivered value*	*('Profit' to the customer)*

Figure 2.4. The concept of customer delivered value (Kotler et al., 1996, p439).

One set of authors have tried to offer an algorithm for evaluating customer satisfaction level. The principle is that, as the distance between the value calculated for the actual design and that of the customer requirements decreases, customer satisfaction increases sharply (Mousavi *et al.*, 1998). However, as is discussed by many authors, there is a fundamental flaw in trying to predict customer satisfaction in this way. The relationship between customer satisfaction and product design features can in no way be a linear relationship, because they will weight their perceptions in different ways, depending upon their needs.

All of this previous work on customer motivations, needs and requirements is far from offering prescriptive solutions when it comes to embodying the right *qualities* into a product, or dictating the process by which this can be done. However, in an age when markets are more competitive and aspects of design, rather than price, are so significant as influences on the customer (Cooper, 1999), understanding different product *quality* values, designers can be better placed to develop products which add-value and meet the needs of their customers (Mørup, 1993).

2.2.2.2 Customer needs perceptions and the quality gap

From the understanding of motivations, needs and values comes the necessity to place useable concepts into practicalities of understanding what it is the customer is actually buying. Industrial companies buy goods from their suppliers as component parts or facilitating equipment to ultimately produce something else to be sold on (Hutt and Speh, 1992). For example, machine tools are bought to produce mechanical parts: the customer is buying a product with certain *quality* values of finishing, of tolerance and of ease of use. From the discussions in the previous sections about the different customers of the product and the way in which even customers from similar situations (e.g. all installers or all maintainers) may differ in their perceptions of the *quality* of the product, there seems to be a lot of opportunity for making poor judgement calls during product development as the *quality* attributes are made operational in the product. In many companies this leads to a discrepancy between the needs of the customer and the characteristics of an artefact (Holt, 1990). This *quality gap* and the "failure to provide one or more of these [highly valued, quality] attributes in a product or service results in a mismatch between the user and the product" (Clipson, 1990, p98). Customer needs compliance requires the *quality* gap to be eclipsed.

A key element here is the interpretation of what the customer says they want, or doesn't want. Not only is it difficult for customers to articulate what they put value on, but then for the engineers, designers, managers and marketers to use the right engineering and design attributes to provide for these. A good example is cited simply by Wright. He says that that although the customer may say they want a hairdryer to dry hair 'more quickly', there is the problem of how engineers interpret 'more quickly' – what does it mean? And how can this be converted into engineering characteristics such as air velocity & temperature? (Wright, 1998). With industrial products this is especially important as the number of interpretations increases and can become more complex in nature.

Mørup introduces the differences between the customers' *quality* values of the product and those which are encompassed by the designer as "Big Q" and "little q" (Mørup, 1993). Figure 2.5 indicates the differences between the two - that Q-quality is evaluated by the customer against their particular needs, but that q-quality is determined by operationalised product definition to which the internal stakeholder (designer, researcher, marketer) can work.

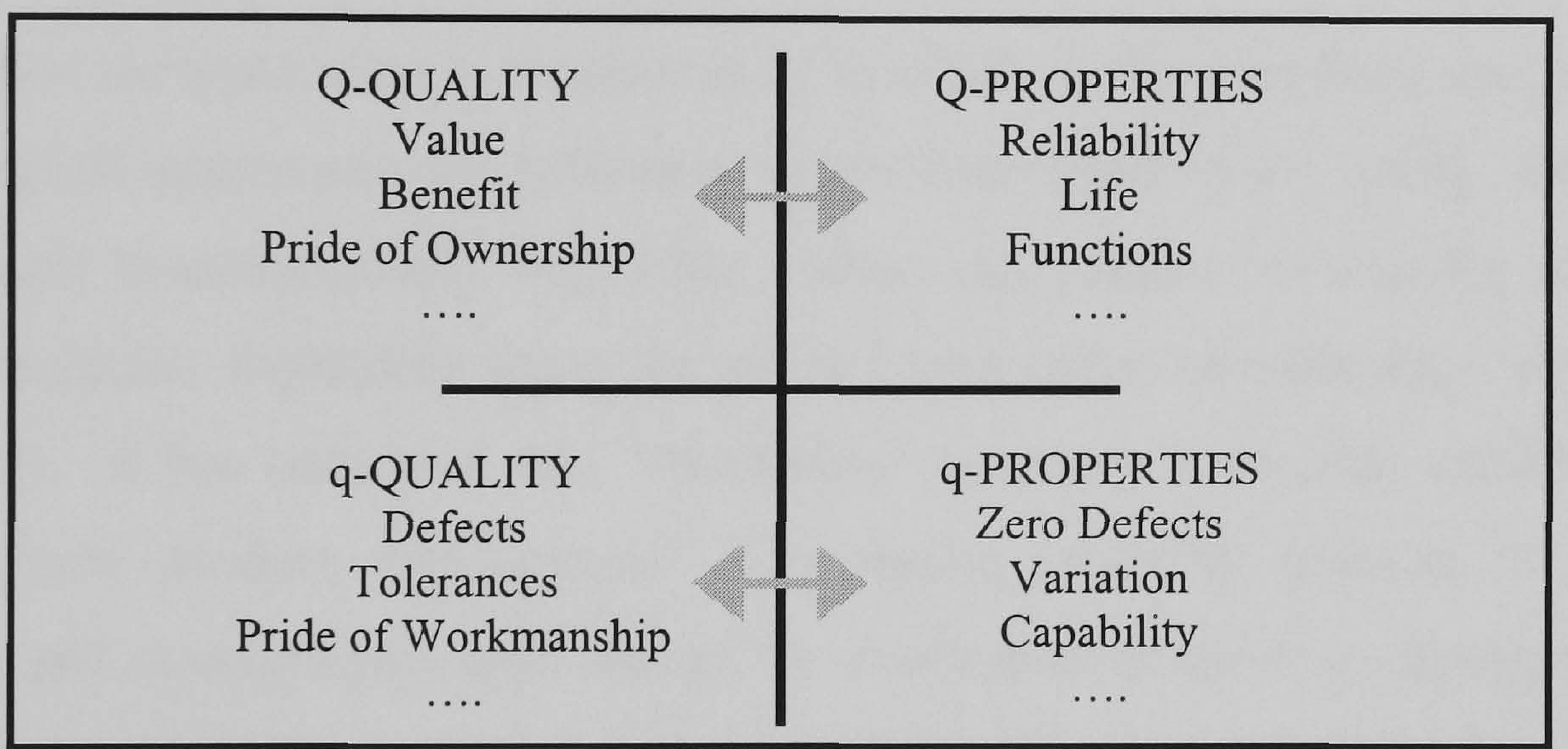


Figure 2.5. Big Q and little q: External customers and internal stakeholders have their own concepts of *quality* (adapted from Morup, 1993, p105).

Also, customers do not only buy the product, they also buy what the company has to offer. This can affect how well the product will do in the marketplace.

> "[quality] is an assessment by the customers of the product and the way it is delivered. Once having made that assessment, the customers render an opinion that is based on how well their needs were satisfied. It's that opinion that determines how much market share a product will gather. How the new product is designed and packaged, how it is delivered, how customer's complaints are handled, and how the employee-customer interface is managed all contribute to customer satisfaction. All these elements are important, and none can be ignored." (Himmelfarb, 1992, p60).

In order to ensure that the *quality* gap is bridged, it is axiomatic that paying attention to the customer during new product design and development is essential.

This section of the literature review has introduced a number of concepts which needed explanation in order to move forward and attempt to provide compliance with customer needs. The product design must take in and evaluate the issues of buyer behaviour and decision making; the role different people (customers) play in that decision; the values they place on *quality*; and how there is often a gap between what the customer wants and what they eventually get.

The rest of the review now looks at topics that confront matters of significance in terms of customer needs compliance in the NPD process. The subjects dealt with broadly come under two categories: (1) the definition of the NPD process and activities concerned with providing product *quality*; and (2) compliance during NPD through management contribution and the production and use of information.

2.3 Defining the new product development process

The potential for innovation is considered to be a fusion of a perceived user need and a technological opportunity for fulfilment of this need (Holt *et al.*, 1984). Innovation is often used interchangeably with other words and phrases, or can be used with varying emphasis, depending upon the subject area under consideration (Craig and Hart, 1992). It has been said that "innovation" is a term invariably used by R&D people; "new product development" is a phrase generally referred to more in marketing and management; and "design" is a common word in engineering (Story, 1998). However, to many who are embroiled in the act of new product development, will note that the three have subtle, but important differences. There appears to be a hierarchy of activities which these phrases encompass. "Innovation" can be considered as the unit of technological change and an invention, if one exists in the situation, is part of the process of innovation (Marquis, 1988). "New product development" (NPD), for all intents and purposes, can be viewed as a slightly less radical phrase such that the development of a "new" product does not have to involve innovation. New products are different from those which are already existing – in terms of major changes or minor changes (Kotler *et al.*, 1996). The 'newness' may be new creations (such as original innovations; or products new to the world or new to the company); additions, improvements and revisions (with greater emphasis on particular values); repositioning of the product (e.g. novel ways to use it in a different market segment, or possibly the use of branding); or simply cost reductions (lower price, or improvement in through life costs) (Booz, Allen and Hamilton, 1982; Souder, 1987). Figure 2.6 shows the typology of one accepted framework for product 'newness' categories. It is the product design and development that is the interest of this research. However, the driving force for this product innovation may be varied: anything from market and competitor action and reaction; information on customers' needs; technical fine tuning of the process; or entrepreneurial inspiration.

New to the world
A new product that created an entirely new market.

New to the company
A new product that, for the first time, allowed the company to enter an established market.

Additions to existing product lines
A new product that **supplements** the company's established product lines.

Improvements in/ revisions to existing products
A new product that provides improved performance or greater perceived value to **replace** existing products

Repositionings
An existing product that was targeted to new markets or market segments.

Cost reductions
A new product that provides similar performance at a lower cost.

Figure 2.6. Business strategy typology (after Miles & Snow , 1978)

"Good design" is said to be achieved when the product not only looks good, but it also does the job well (Service *et al.*, 1989). Indeed, "design can often add something to a product or service which the customer never expected, thus improving the overall customer experience" (Cooper, 1999). Thus here "designing" is differentiated, because it is a tool which can be applied during new product development to help turn an invention into a successful product, or to extend the usefulness of an existing innovation (Oakley, 1990). "New Product Development" (NPD) is a most appropriate term for this research, because it relies upon "design" activities carried out to deliver a product which may, or may not, be an "innovation".

In order to undertake NPD, it would be prudent to have "a formal blueprint, roadmap, template or thought process for driving a new product project from the idea stage through to market launch and beyond" – a NPD Process (Cooper, 1994, p3). However, as with many other things in the business world, a definitive process which provides continual success has not been forthcoming. This section now reviews some of the different models that have been put forward to describe the process and further examines activities, methods and techniques which have direct relevance to the area of developing *quality* products.

2.3.1 Modelling the product development process

Many researchers have found the need to try and capture the progression of the product during development either prescriptively, to tell students and industrialists how it should best be done; or descriptively, to define what actually happens in real life. Also, there are many researchers who discuss product development process models and take differing views upon what these 'models' actually look like. However, most are in agreement on one thing – that a *definitive* NPD model which is applicable for every situation *cannot* be produced.

There are a plethora of examples of different NPD models given by different researchers. Indeed, even in a single study by Cooper no two product processes were identified as being exactly the same and seven separate general types of processes were outlined from the fifty-eight companies involved (Cooper, 1983). In 1984 Saren undertook a study of the available product process models and classified them into five categories: departmental-stage models; activity-stage models; decision-stage models; conversion process models; and response models (Saren, 1984). Figure 2.7 provides a summary of these different models by type. Discussion points on the usefulness of each model for research work and their practical use in the management of NPD are also included in the figure.

Saren suggests that dividing methods into groups provides a useful starting point for an examination of how each model might purposefully be used in research e.g. who is involved in the innovation; at what point and in what order specified tasks are undertaken; upon what basis decisions are made; how inputs to a process become outputs; or the reactions to specified stimuli. However, he concluded that although each individual model is valid, in that it indicates something of the characteristics of the process, more work needs to be done on the holistic process of innovation in firms (Saren, 1984).

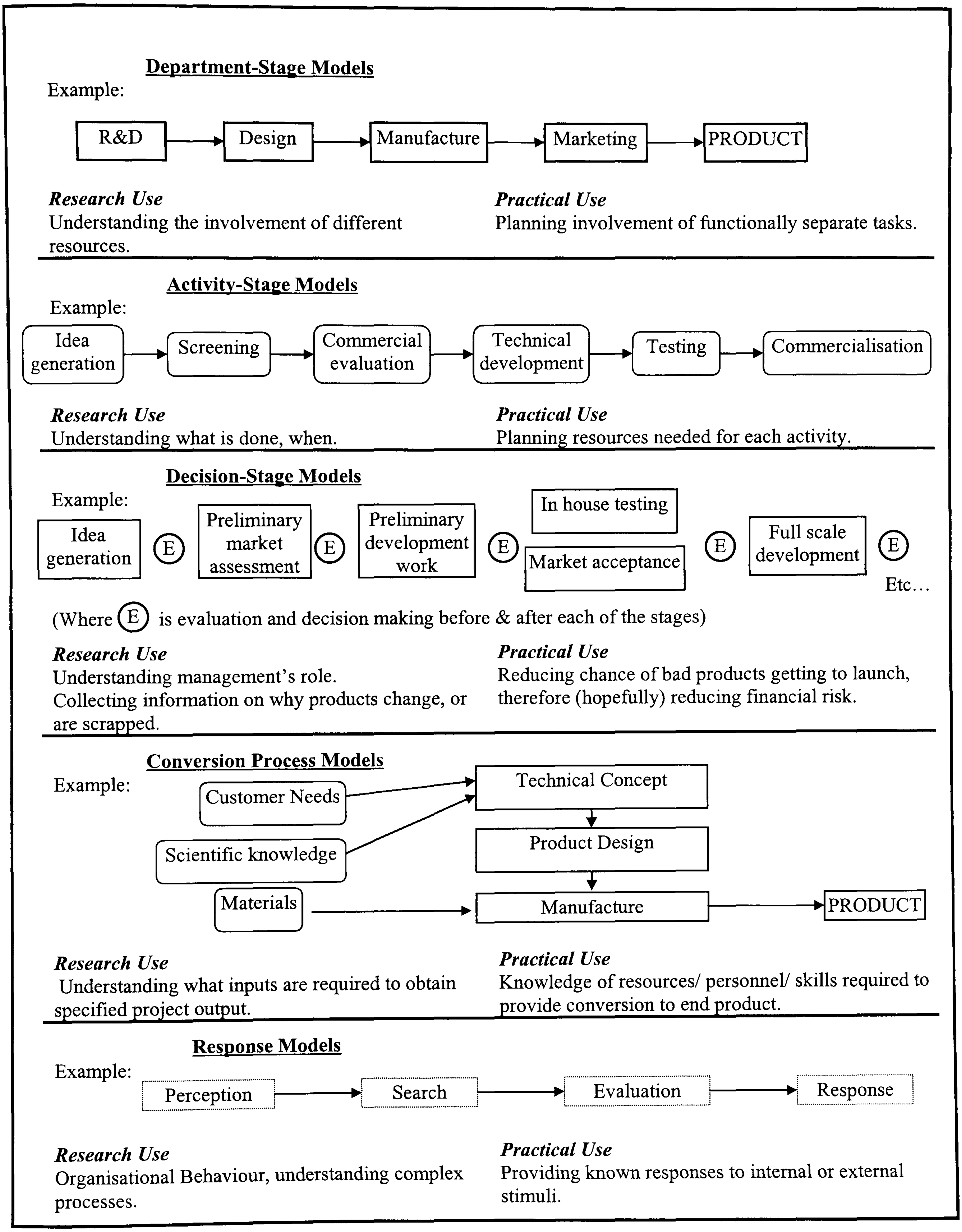


Figure 2.7. Summary of some NPD process models (after Saren, 1984).

A more recent paper from (Jenkins *et al.*, 1997) uses the 1960's phased development model as a starting point for a comparison with some of the product process model ideas which have been progressing from the late nineteen-eighties into the nineties. Jenkins *et al.* cite modern stage/ gate methodologies, product and cycle-time excellence; and total design as the main examples of advancement in processes aimed at improving product success (Jenkins *et al.*, 1997). Since there is a number of different ways to model the NPD process, and each way has associated with it its own specific strengths and weaknesses, this review will cover those which are recurrent in the most recent literature. Therefore, the remainder of this section will briefly outline the origins, uses and limitations with respect to customer needs compliance, of five generalised modelling techniques, which are common and progressive: stage/ gate models; a multiple convergent process; product and cycle-time excellence; total design; and third generation new product processes.

2.3.1.1 The stage/ gate model

The stage/ gate type of model takes the process as an alternate series of activity stages followed by decision gates (see figure 2.8) The decision gate allows or prevents the following activity stage being initiated, depending upon whether it meets the evaluation criteria. At any stage the project may be killed, suspended or rejected for rework or improvement until it can finally pass the gate. It may even have to go back further, to a previous stage. Therefore, the stage/ gate process facilitates iteration, with built-in feedback loops in each stage, and among stages (Zhao *et al.*, 1999). In recent years authors have suggested that successful product development is aided by following a stage/ gate decision process because it encourages activities to be undertaken by a core team of representatives from all functional departments (Towner, 1994; Cooper, 1994). These stage/ gate models may help the reader to understand the management of the process and may also help prevent losses made by revealing early on, and before market launch, the products which will fail in an industrial situation by reducing failure risk in the comprehensive review implemented at the gate of each stage (Zhao *et al.*, 1999).

However, the model does not lead us to a means of ensuring that the product will meet the needs of the customer. This kind of system does have the potential to include "go/ no go" decisions, based on whether the product is being designed to high enough *quality* and will satisfy the customer. On the other hand, without elucidation from someone providing a customer needs compliance emphasis, there is not necessarily any strong incentive to use this as a basis for what the product "must meet" or "should meet" when product management decisions are being made at each of the gates.

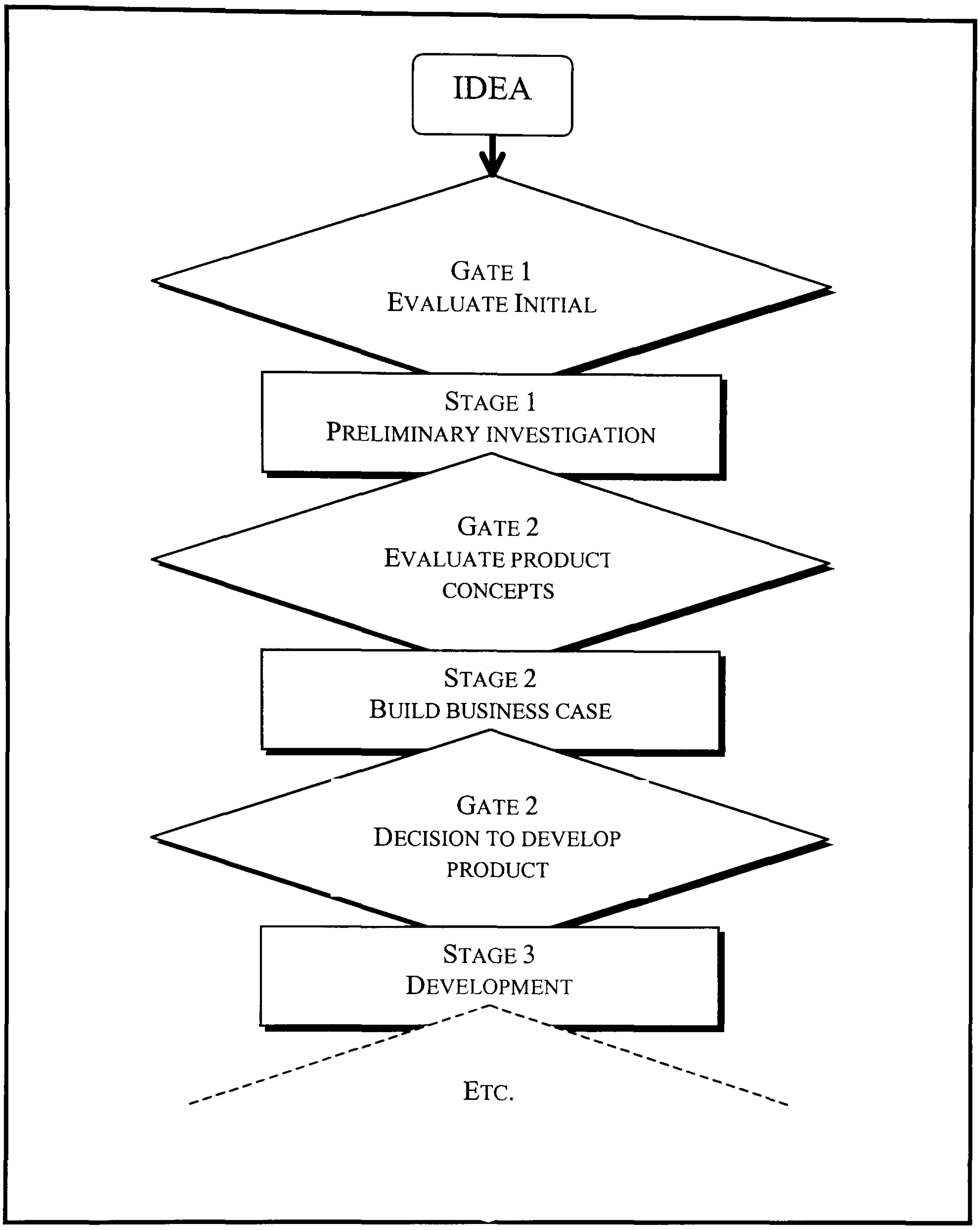


Figure 2.8. An example of a stage/ gate model (after Cooper, 1994)

Although some form of this model can be seen widely in practical use today in some industrial organisations (Rosenau, 1990; Urban and Hauser, 1980) there are some general problems which occur when following a stage/ gate model which are indicated by Cooper (Cooper, 1994). He notes that even though the idea has been taken up in the last decade with positive effect, stage/ gate process models are still not really usable because they are too time consuming, often have too many ways of wasting time, are too bureaucratic and have no provision for focus (Cooper, 1994, p3). Also, one author provides a fairly severe and emotive set of comments in his book *Survival* *of the fittest, New product development during the 90's.* Himmelfarb says that it "creates products that are hard to make, that cost too much, that require too many expensive design changes, and that may or may not meet marketplace needs. It encourages isolation of functional areas and, worst of all, it's very slow." (Himmelfarb, 1992, p10). All to of these observations do not bode well for the extra and important inclusion of customer needs compliance in this particular process model.

2.3.1.2 Multiple convergent model

Problems of the stage/ gate model and other linearly defined process models have been recognised by those who have been researching the interaction of the process and the people involved with them (Snelson and Hart, 1991). The multiple convergent model devised by Hart and fellow researchers aims to directly and explicitly integrate people into the process and overcome the reported shortcomings in other NPD process models (Hart, 1995; Hart and Baker, 1996).

The model takes into account the lessons learned from reports in literature that suggest that success comes from having quality inputs which are valid from multidisciplinary areas. Hart places much importance on the use of networks and the production of a model which breaks down multidiscipline boundaries (Hart and Baker, 1996). The model views NPD as tasks which are tending towards a common conclusion, but are required to come together at a number of different natural and integrative points for evaluation (see figure 2.9). In this way the multiple convergent model is similar to the stage/ gate models. However, where it differs is that the convergent model has multiple points which it recognises as important to an iterative process. The advantages of taking the process as a series of converging points for evaluation, followed by diversion into functional activities are: it accommodates iteration; it allows for iterative communication and evaluation within the functional groups; the framework can accommodate third parties easily; and methods for real integration of work from functional groups can be provided in the convergent points (Hart, 1995).

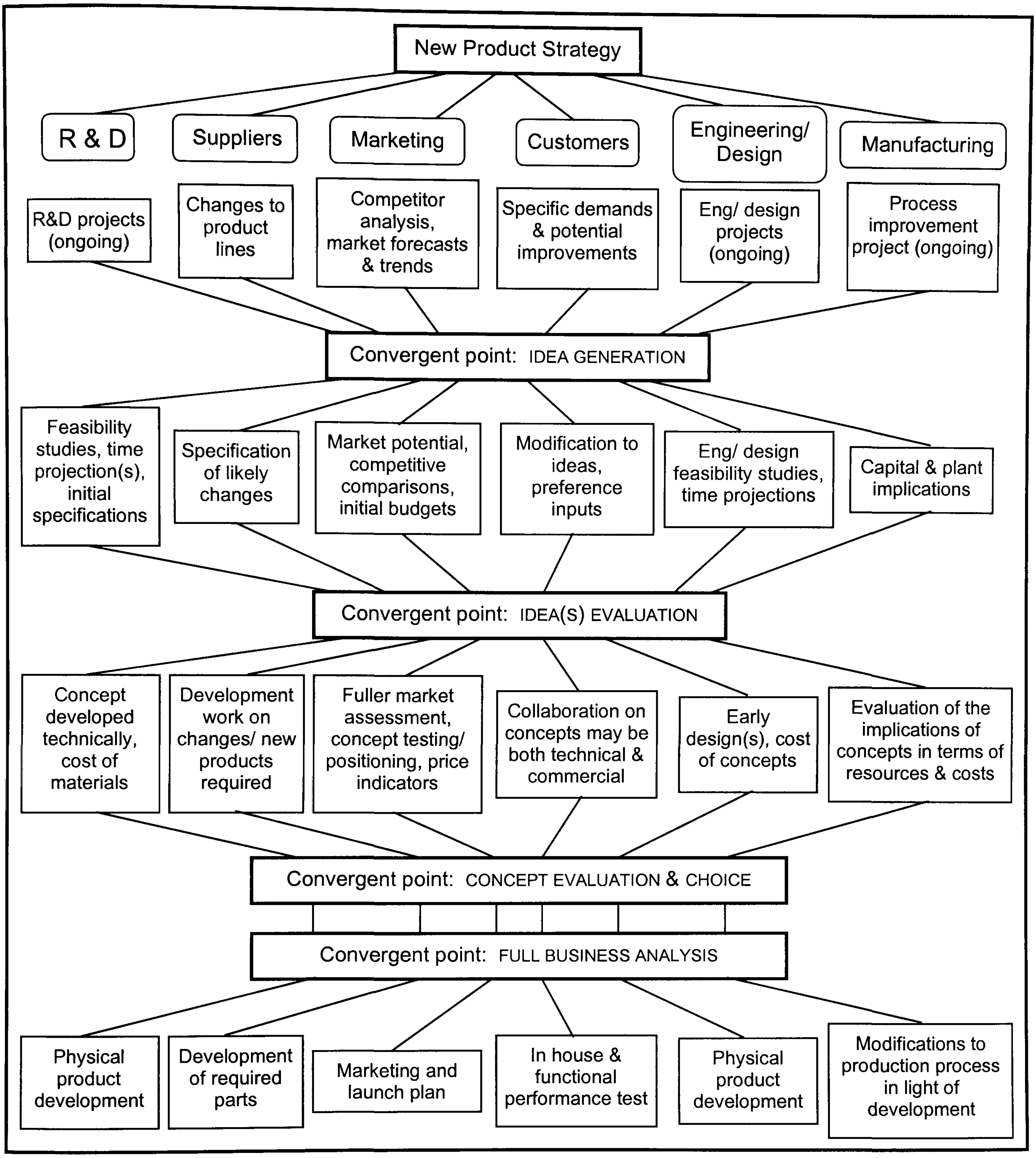


Figure 2.9. The early stages of the multiple convergent model (after Hart, 1995)

Despite the model being driven by converging points, the main disadvantage in practical use appears to be, ironically, that it may be too divergent: it converges for cross functional decisions, but then separates out into each of the different functions to carry out the tasks. The authors describe a key element as the amount of information sharing which is modelled (Hart, 1995), however, horizontal communications, between functional areas, are only modelled as happening during the evaluation or collation points and not during other activities. With so many points of convergence during the process, this model does not appear to be conducive with efficiency and it seems to require a large amount of management effort to keep the process on track.

2.3.1.3 Models which concentrate upon productivity and cycle-time

In contrast to the multiple convergent model, there are models which have been developed which are driven by the need to reduce time to market. These models concentrate on the control of the economics of the design process. One such example is that of the product and cycle-time excellence model developed by Pittiglio Rabin and McGrath (McGrath *et al.*, 1992). This particular model follows a stage/ gate analogy, with 'phase reviews' providing the decision points at which the project should continue to go on, be redirected or killed. However, during phase reviews the decisions are not made by the multidisciplinary core team carrying out the work, as with multiple convergent theory, but a group of four or five senior managers known as the 'Product Approval Committee' (Whiting, 1991). Under product and cycle-time excellence, the process is seen as a funnel taking in lots of ideas and, following the completion of five phases, producing new products (see figure 2.10). In an attempt to reduce the time it takes to develop a new product, the productivity model breaks down each of the five phases in the process into 15 or 20 steps and then each of these steps into 10 to 30 tasks. Database records can be kept on the timing for each of the tasks and thus the total development time can be judged for each new product (Burkart, 1994).

The productivity and cycle-time concepts also pay attention to the management of the process in more holistic ways. Of the seven major elements for this model, four are directly related to overseeing the whole of the product development process in the company: the provision of core teams during development; the use of a product strategy; the review and correct implementation of technology management; and the endorsement of cross project management (Jenkins *et al.*, 1997). The authors of the product and cycle-time excellence model also advocate the use of design techniques and automatic development tools which will help focus and streamline the development of the product (McGrath *et al.*, 1992).

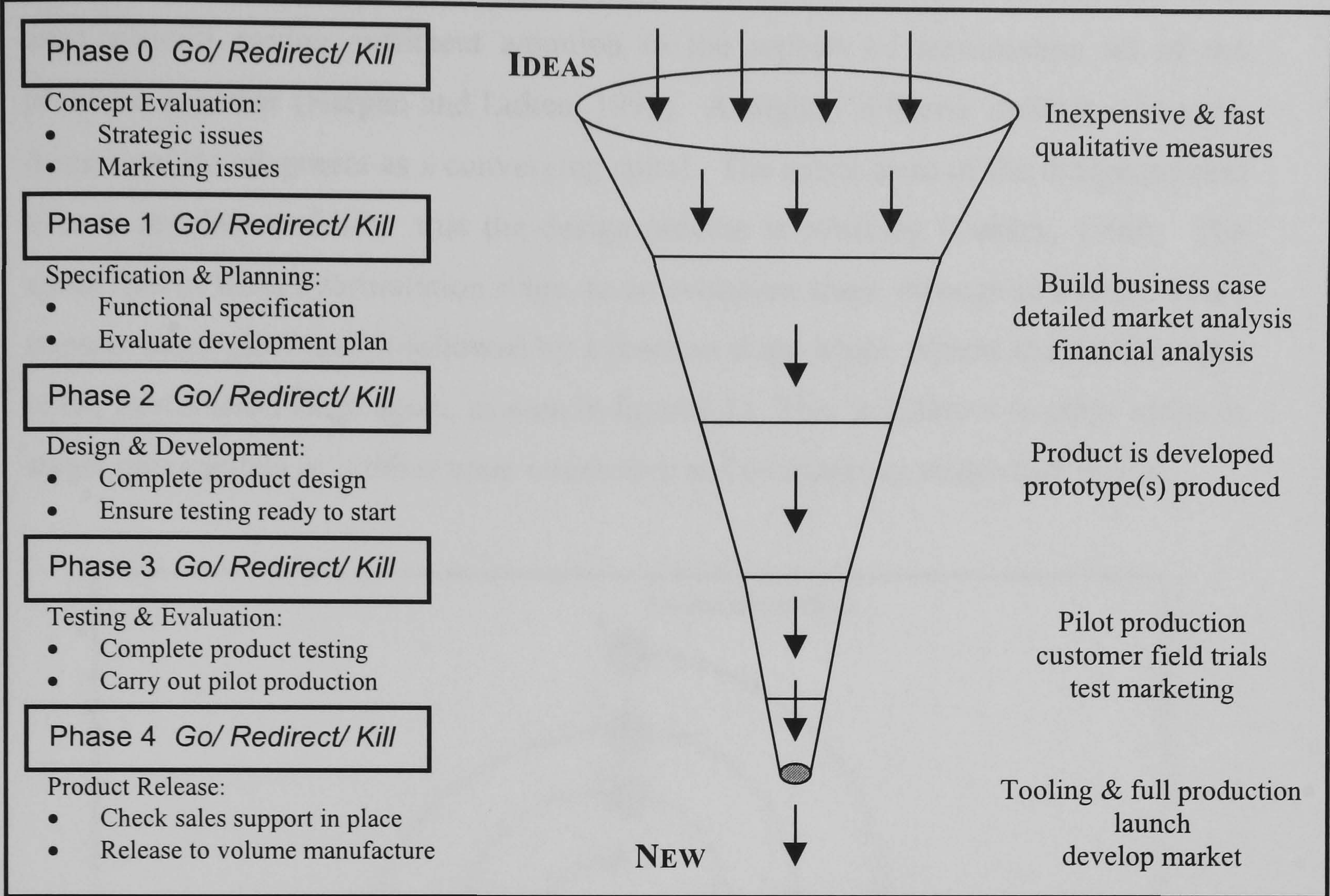


Figure 2.10. The phase review process within PACE (after Jenkins *et al.*, 1997).

The product and cycle-time excellence model is obviously more than just a definition of the development process. It is aimed at efficiently managing the development of new products such that the product is produced on time and in budget, whilst using the correct balance of skills and methods at the right points during the projects' progression. However, these types of model, which are driven by productivity and cycle-time reduction rely upon putting senior management in an overriding position of authority and also upon splitting down the design process to a level so low that it can be timed. As well as the obvious philosophical discussions about specifying exactly the creative nature of design which these issues provoke, both of these ideas seem regressive and are reminiscent of workstudy principles, based on Taylorism, which had its hay-day at the turn of the century.

2.3.1.4 "Total design"

The models described so far revolve around breaking-down the process into manageable chunks by seeing the development process as a series of problems to be solved (Wright, 1998). Authors have criticised the way of focusing on parts of the problem and solving them one-by-one because they have found that they are often used without paying sufficient attention to the aspects of assimilating all of the problems together (Harpen and Luiten, 1993). A slightly different outlook is to view design and development as a converging spiral. The spiral form of the design process tries to emulate real-life: that the design process is evolving (Oakley, 1990). The spiral moves from a formulation stage, to an evolution stage, through to a stage where transfer takes place and is followed by a reaction stage which returns the development to the formulation stage again, as seen in figure2.11. This is different to other series or stage/ gate models as it relies upon interactive and overlapping stages that evolve.

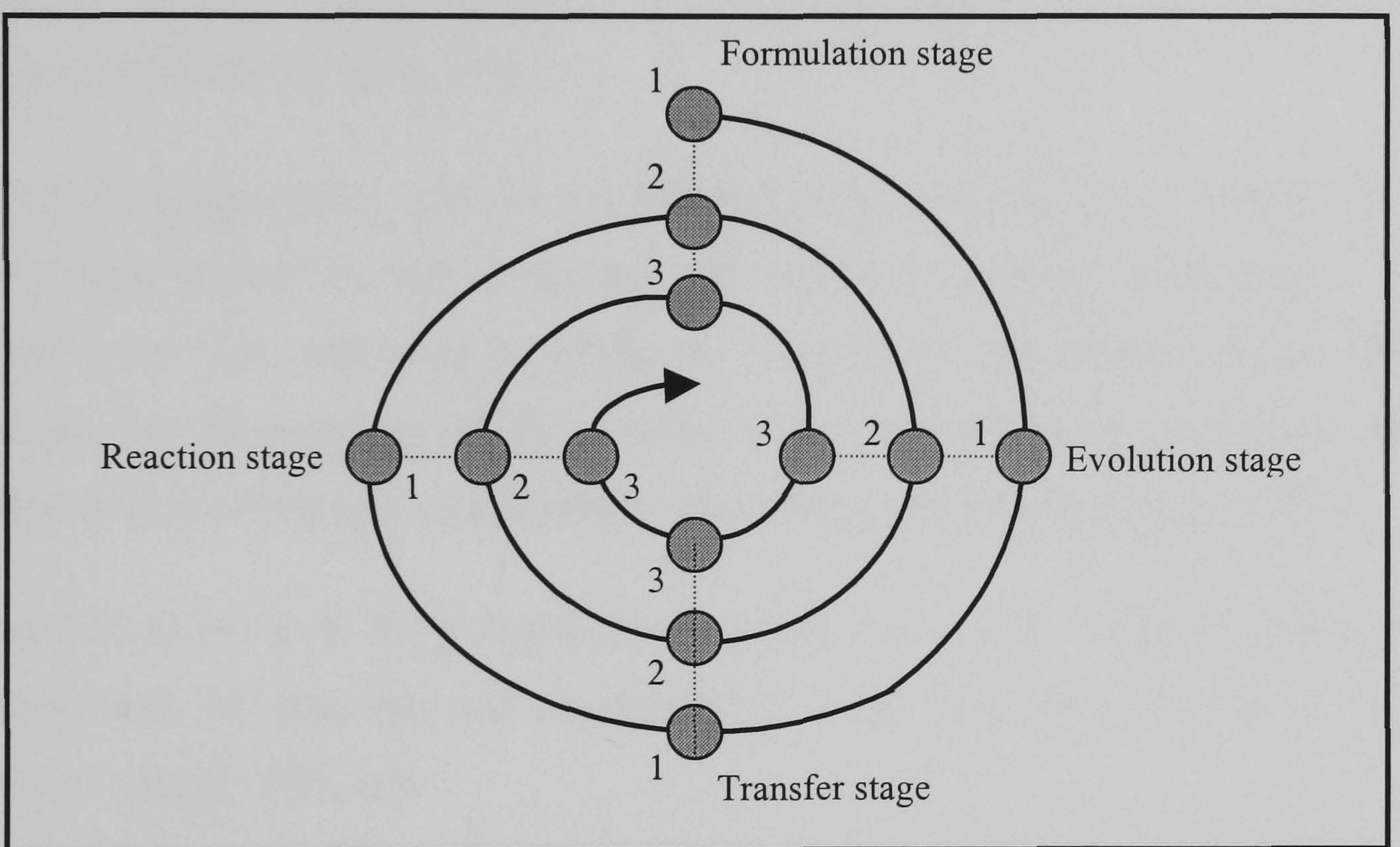


Figure 2.11. A spiral model of the design process (Oakley, 1990, p11)

The spiral form was a depiction used for Acar's triple-helix model of the product development process, that can be cross-sectioned at any point to reveal the interaction between specification, conceptual design and embodiment design (Acar, 1966). In the Total Design model championed by Pugh and his colleagues, the spiral is taken into more depth (Pugh, 1991; Pugh and Morley, 1988; Hollins and Pugh 1990).

> "By total design we mean that design is seen as a broadly based business activity in which specialists collaborate in the investigation of a market, the selection of a project, the conception and manufacture of a product, and in the provision of various kinds of user support"
>
> (Pugh and Morley, 1988, p1)

The development of the Total Design model and subsequent publishing of Pugh have stimulated much discussion within engineering design circles (see Pugh and Morley,1988; Pugh, 1991; Hollins and Pugh, 1990; Hollins and Hollins, 1996; Jenkins *et al.*, 1997). Also, the Total Design philosophy is taught as a useful and useable model of best practice on a number of UK Universities' engineering courses, especially because it emphasises the use of many different discipline-independent tools and methods. (Wright, 1998).

The Total Design model outlines six nominal spirals which try to capture the main undertakings during the design process, all within an iterative environment. These "design cores" are presented by Pugh as: investigation of market/ user needs and demands; the development of the product design specification; conceptual design; detailed (technical) design; manufacture; and selling (marketing) (Pugh, 1991).

Figure 2.12 shows how Pugh visualises the whole package of design activities, within a "framework of planning and organisation.... and how they fit into a business structure" (Pugh 1991, p8).

The Total Design model and its embellishment with detailed information on how to approach each of the "design cores" goes a long way to help engineering designers practically undertake product design systematically. Pugh and his colleagues have devoted books to explaining methods and tools which can be used in conjunction with the total design philosophy (see Pugh, 1991; Pugh & Morley, 1988; Hollins & Pugh 1990; Hollins & Hollins, 1996). The model does acknowledge and capture many of the complexities of NPD and tries to attract a cross discipline audience. It also explicitly acknowledges the place of design within the company's structure and long-term strategy (Service *et al.*, 1989). However, much of the work is essentially a model and text for engineers, and gears itself more towards explaining business requirements to a technical audience, rather than explaining technical issues to a business audience.

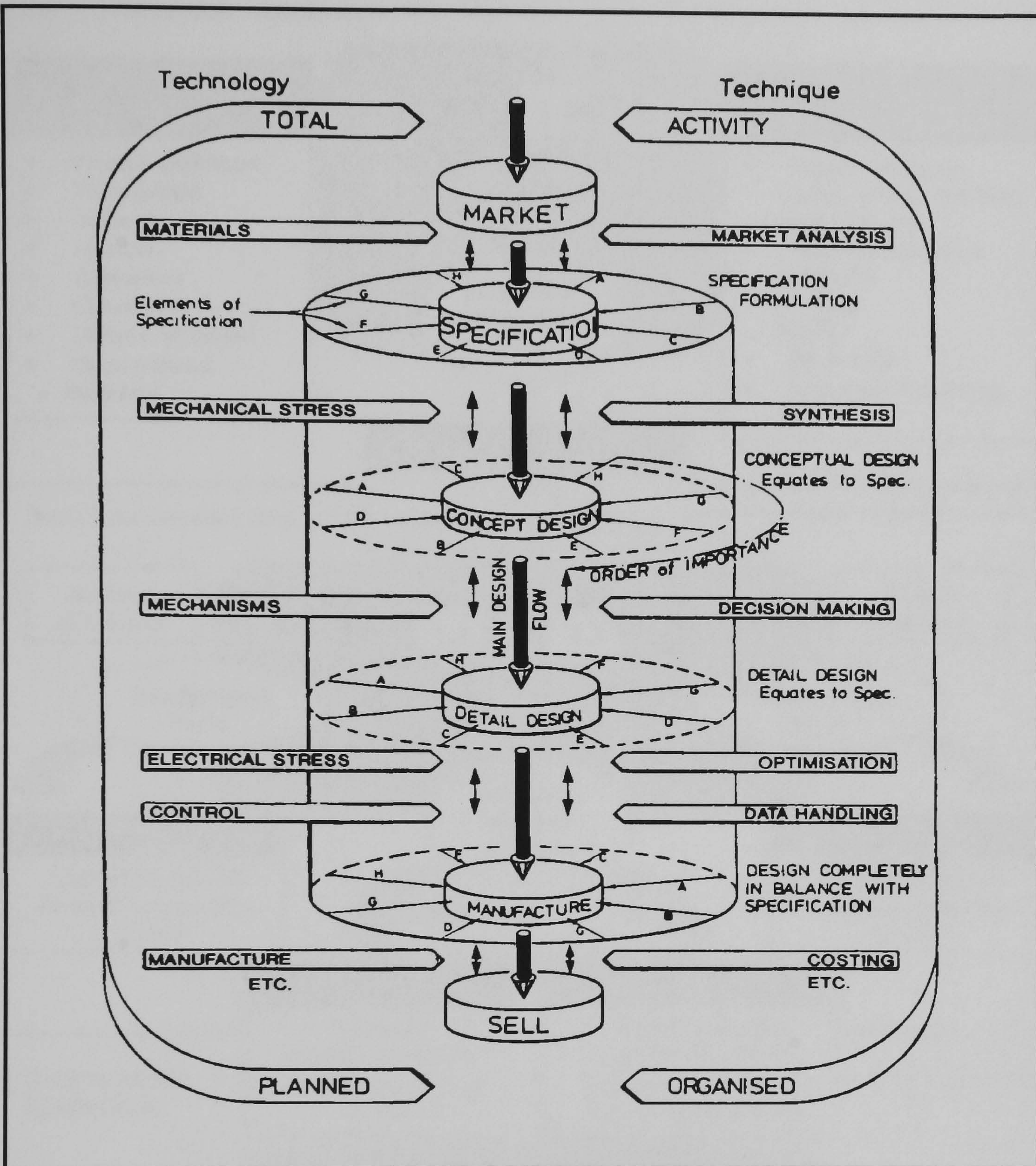


Figure 2.12. The total design activity model (Pugh 1991, p11).

The market and user needs "design core" does not put enough meat on the bones for an inexperienced company or researcher to fully comprehend the importance of meeting customer needs to the success of the product. Having said that, there are many issues that have arisen from studying this approach, such as the strong emphasis on the Product Design Specification (PDS) and the recognition of informal paths of communication within the design team, which have directed some of this particular research and will be discussed in following sections and chapters of this thesis.

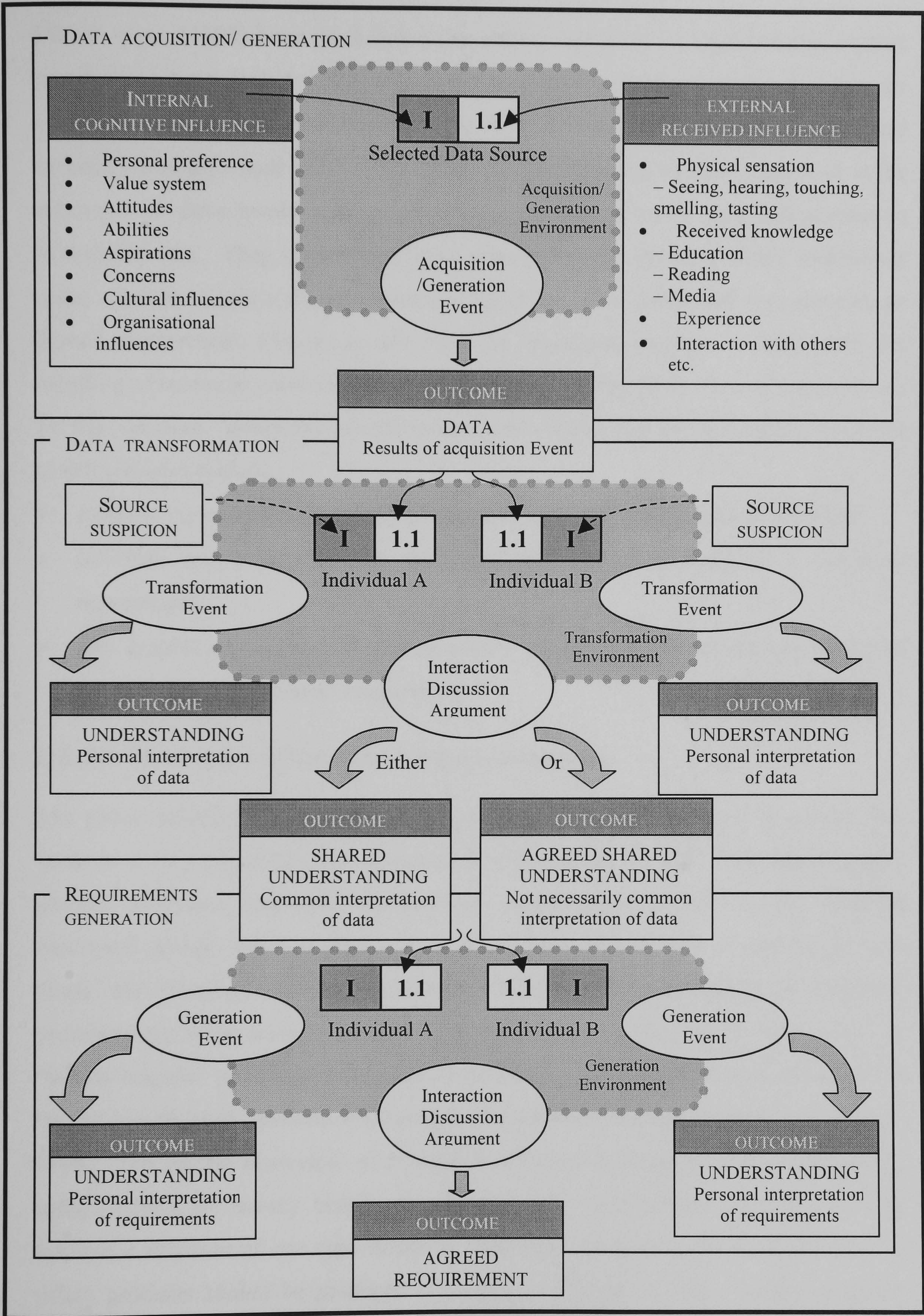


Figure 2.13. Theoretical requirements capture process model (After Cooper *et al.*, 1998, p510)

2.3.1.5 Requirements capture process model

Cooper *et al.* (1998) have produced a theoretical model of the requirements capture process and have included the aspects of individual and group understandings for customer requirements (see figure 2.13). In their work they discuss internal and external variables which influence the personal interpretation of data. They look at the outcomes of three levels: acquisition of data; transformation of data; and generation of requirements. They concentrate upon considering the situation where individuals come together to gain a shared understanding of customer needs and then generate an agreed requirement. Copper *et al*'s work is important, because it deals with the handling of customer information and the definition by the NPD team of requirements for the customer. Issues that are addressed in the model, that are particularly pertinent to this research include:

- different views and understandings (perceptions) of the same data are included;
- activities and events change the understanding (perception) of a customer requirement;
- data acquisition and transformation events are required to gain an agreement on the definition of a product requirement.

2.3.1.6 Third generation new product processes

The phase development models of the nineteen-sixties are referred to as the first generation of defined product processes (Jenkins *et al.,* 1997). The phase review process advocates sequential development stages, each carried out by different functional groups which complete their phase then pass on the results to the next phase and function (Urban and Hauser, 1980). First generation development processes are often referred to euphemistically as "over the wall", "relay race" or "bucket brigade" processes because development is handed onto the next group, when the last has finished, with an obvious lack of interaction between each phase (Gehani, 1996). The second generation of product development processes are the processes of today –which are mainly based around stage/ gate type models involving a cross discipline structure of one type or other. The third generation are the future way in which products *should* be produced according to Cooper (1994). Cooper, suggests these third generation processes are relatively ill-defined because they are still in development and should be organically grown around the specific company. They are driven by the need to efficiently create new products and get them to market as quickly as possible, but with a much greater tolerance for calculated risk taking, which is a conflicting view to that of the previously discussed models driven by cycle-time.

Cooper suggests that there is a distinct need to redress the balance from a restrictive linear process which only moves the product development forward when a decision is made on the outcome of a preceding activity (see figure 2.14). The ideas put forward by these third generation models tie in with the management practices of concurrent and simultaneous engineering.

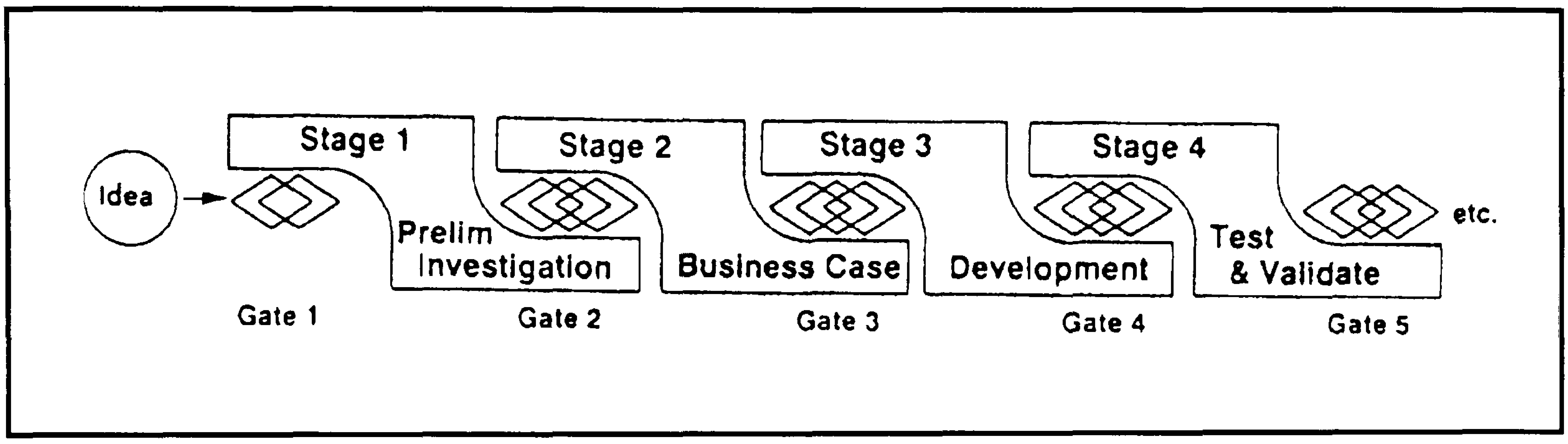


Figure 2.14. Tomorrow's third generation process with overlapping, fluid stages and "fuzzy" or conditional Go decisions at gates (Cooper , 1994)

This model would, inevitably require integration through software, hardware and 'humanware' or team facilitation (Gehani,1996). They will allegedly work from a premise which attempts to maintain discipline, but allow a balance of action thoroughness, complete information and the need to move quickly (Cooper, 1994). To answer problems which may arise from this basis of reasoning, four fundamental '*F*s' have been defined:

- Fluidity - the model is fluid and adaptable, with overlapping and fluid stages for greater speed.
- Fuzzy gates - the model features conditional Go decisions (rather than absolute ones), which are dependant on the situation.
- Focused - the model builds in prioritisation methods that look at the entire portfolio of projects (rather than one at a time) and focuses resources on the "best bets".
- Flexible - the model is not a rigid stage/ gate system, each project is unique and has its own routing through the process.

(Cooper, 1994, pg 9)

The implications from the use of such a model is that everything becomes so much more difficult to define in absolute terms, making devising and understanding the product development process a more daunting task. As a project progresses, decisions which are made will be more complex and sophisticated and may be hard to place into context if the stages overlap too readily. Falling into an ad-hoc or free-for-all system of product development seems a distinct possibility. Cooper has also made some of these observations and suggests that this model will only work within a framework based on the second generation, stage/ gate models. He does not advocate a withdrawal from stages and gates, instead he realises that to make these systems really work, product development must allow much more flexibility. One way of achieving this would be a move towards reducing the authoritative role of senior management and pushing the decision making role of the project team members and leaders.

2.3.1.7 Summary: The usefulness of a product development process model approach

The above dialogue provides a good example of the abundance and variation in the different ways of modelling the product development process. It is by no means exhaustive, but rather reflects the importance of the diversity which exists in this one area alone (for fuller and discipline specific discussions about product development process models see Saren, 1984; Mahajan and Wind, 1996; Gehani, 1996; Cooper, 1994; Jenkins *et al.*, 1994; Oakley, 1990; Urban and Hauser, 1993).

The necessity to examine these different types of models and ways of describing the product development process is that of practicality – if one can somehow capture what it is one's company does and can follow the path which product development process takes, then one can have a better understanding of how to improve the process and can reap tangible benefits. It has been found that positive consequences result from the existence of formal NPD processes (Cooper and Kleinschmidt, 1995a). Also, research has suggested that the lack of understanding and implementation of product development processes in industry can account for poor product development performance (Pugh and Morley, 1988; Gupta and Wilemon, 1988; Hayes *et al.*, 1988; Cooper and Kleinschmidt 1994; Griffin, 1992).

Since many product development authors and practitioners have reported these positive results, it is no wonder that they are driven to try and capture the essence of good product development practices and processes. Therefore, in an effort to make the task of modelling the process more manageable, different authors have tried to summarise their complexities by generalising and minimising differences between companies and products (Saren, 1984). Because of this the models are often only a representation of the process and are regularly produced by individual researchers as tools to investigate specific phenomena that occur during product development. The reality of producing working models is also that there is the consideration of differences which occur between what the literature describes and/ or prescribes and what is actually done in reality because the nuances within each company are so difficult to encapsulate (Cooper and Kleinschmidt, 1986).

Given the plethora of product development models available and reviewed here, it would be reasonable to assume that there would be one which specifically follows customer needs through product development. However, although many pay more than just lip-service to customer needs, none have been found that depict the *whole* of the process for NPD, with explicit emphasis on customer needs compliance. The closest is a descriptive list suggested by Holt *et al.*, 1984. Their list of stages during which different user needs issues are addressed, is shown in figure 2.15. This is a useful list, and does highlight different periods of need recognition, assessment and appraisal. Yet, it does not get to grips with the essence of product development interaction, process, iteration and communications required - issues that are being looked for in this research to be able to understand at least some of the facets of customer needs compliance.

Need identification	*A problem or a user need is perceived, often in a vague form. This is usually the initiation of the product innovation process.*
Need evaluation	*Based on available information, the perceived need is analysed and evaluated, e.g. in connection with preparation of the proposal.*
Need clarification	*This involves a systematic study of the user needs involved. It may be undertaken in connection with a feasibility study in the last part of the idea generation stage.*
Need specification	*Based on assessed needs and their relative strength, relevant need requirements are specified.*
Need up-dating	*As the project moves ahead, the needs specified are up-dated at intervals in connection with development of the technology and planning of the marketing and manufacturing operations.*

Figure 2.15. Model of the need assessment process (Holt *et al.*, 1984, p6).

In summary, various investigators have provided a lot of different methods for depicting the NPD process. Yet none of the methods have been specifically developed for the following of customer needs through the NPD process from idea to launch. However, the representation of the linkages within NPD practice that these models show is a useful starting point for further examination, as long as they are taken within their context and understanding of their limitations. To advance this research, the literature review proceeds with a synopsis of activities which may take place within some of these NPD processes which are advocated by previous authors. Later, management and information provision for customer needs compliance issues will be discussed.

2.3.2 New product development activities

Whether following a formal model of the process or not, it is the *activities* undertaken during NPD that provide the output for the company. Achieving a successful product, which has the right balance of customer *quality* values requires a combination of technical and marketing inputs into product development, sound judgement on behalf of the team, and an effective mix of skills (Bruce *et al.*, 1996). Thus I have reviewed research on activities, methods and techniques hoping to find enlightenment on how to perform activities to best provide for a *quality* product. Unfortunately much work is anecdotal and other work is based inside the boundaries of core disciplines such as sociology, organisational behaviour and marketing. Despite this, there is enough information on innovation and NPD activities to encourage debate and provide a platform upon which more research may be based.

2.3.2.1 Undertaking successful activities

Looking at the models previously discussed in this chapter, many of them have their starting point as customer requirements and their end point as a transaction with the customer handing over money. The bottom line is to make money, so companies need to follow activities from the start of the process to end, to get this kind of success (Wright, 1998). NPD is about generating the right product and the secret of successful NPD is to do the right activities, in the right way, at the right time. Using NPD correctly makes the difference between an interesting idea and a market leader.

Typically, the greatest company and product success is achieved by companies who:

- combine technical excellence with sound marketing;
- are committed to new product design and development;
- have a wide spread of relevant personnel, and certainly design represented at board level;
- provide full-time dedicated teams for new products and have frequent internal (inter-disciplinary) and external (distributors and suppliers) communications.

(Summary from a survey of 369 British companies: Service *et al.*, 1989, p5)

On the other hand, the company that is likely to fail at its NPD programming will:

- Use phased approach
- Develop products that have little bearing on actual marketplace needs
- Have little top management commitment
- Be intolerant of risk and failure and be reactive and defensive in their NPD
- Wait until product line is becoming obsolete
- Have top-down management
- Ship new products before they are ready

(Himmelfarb, 1992, pp.13-14)

Product, project and company success has been discussed by many authors. The two lists above, one of successful NPD, the other of failed companies are typical of the generic findings. As with many issues in NPD, a long list of reviews and papers are available for the topic of NPD success (Johne, 1984; Stagg, 1996; Griffin and Hauser, 1992; Loch *et al.*, 1996; Lilen and Yoon, 1989; Griffin and Page, 1996; Story, 1998). There are many who are looking at this specific area and are necessarily more detailed than this review. Therefore, it is not an intention that this is covered in great depth here, more than to condense some of the findings which are relevant to the discussion of product *quality* and customer needs compliance activities in the NPD process. The next section briefly takes a sojourn through NPD success literature, concentrating upon design and marketing and the need for synergistic customer needs activities.

Technical activities

Developing a product is more than just technologically designing something. The best designer cannot be responsible for defining a product which will be a commercial success, unless the requirements of the customer have been previously established (Wright, 1998). Conversely, "the world's best marketing department cannot successfully sell poorly made products that fail to meet consumer needs" (Kotler *et al.*, 1996, p438). Successful product development is, therefore, about getting the technological expertise of the company to match the needs of the customer. The product should be a coupling between user needs and the technology that can fulfil this need (Holt *et al.*, 1984), see figure 2.16.

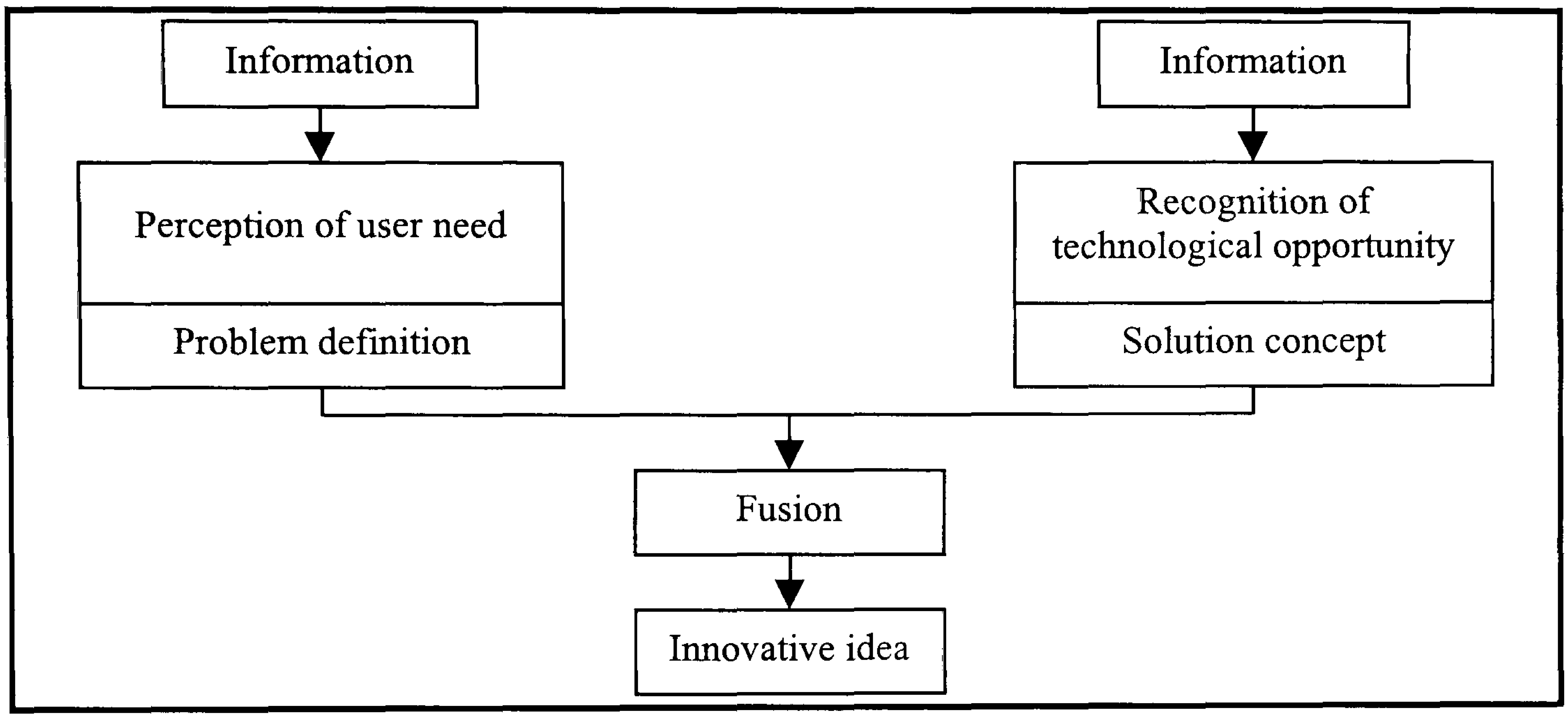


Figure 2.16. An innovative product idea is the fusion of user need and technology to fulfil this need (Holt *et al.*, 1984, p7).

In order to get the product right first time, avoiding repairs and changes once the product is released, companies must learn from customer experience and supply what customers want with what designers and engineers can practically manufacture. Dolan recognises this design issue as "strategic quality management" (Dolan, 1993, p352). Studies provide evidence for this by highlighting that the most successful companies combine technical excellence with sound marketing (Service *et al.*, 1989). Also, that commercial success is correlated with the understanding of the market (Freeman, 1972; Rothwell *et al.*, 1974). Companies which are most likely to fail develop products that have little bearing on actual marketplace needs (Himmelfarb, 1992). Sometimes, failures occur because the customer has not even been asked, their needs have been improperly interpreted, or are even ignored (Holt *et al.*, 1984, p2).

Activities to gain company synergy

Company synergy and co-operation within and between company functional groupings affects the success of products (Service *et al.*, 1989). The innovativeness of the product makes a difference to the proficiency of marketing activities. When innovation is prominent in a company, the company pays a lot of attention to getting things right . Whereas low innovation is easier to provide for because it is closer to home and the understanding of the product within the company is high. It is therefore, interestingly, the moderately innovative products which provide problems for the company because less attention to technical and marketing detail is possible, alongside a complacency and potential misunderstanding. Thus it is a more difficult task to produce a successful product of *quality* in this situation (Kleinschmidt and Cooper, 1991).

A large amount of expended effort in co-operation between R&D and marketing for every single item is, however, not necessary (Hise *et al.*, 1990). Instead, effort should be homed in on the activities which have been recognised as the most important to successful NPD. Cooper and Kleinschmidt direct us towards two main areas: pre-development activities (which include initial screening, market research, market and technical assessments and financial analysis) and evaluation activities (Cooper and Kleinschmidt, 1994; Kleinschmidt and Cooper, 1991).

Market requirement activities

Researchers have found that new products are expected to provide approximately one-third of company profits (Booze, *et al.*, 1982; Service *et al.*, 1989). Therefore, a focus on these new products by deeper concentration on the activities which recognise market demands is required. Mørup, (1993) relates that industry studies show that poor product quality is only seldom caused by the lack of technical expertise. Marquis frankly states this as a 'lesson in successful innovation', that "recognition of demand is a more frequent factor in successful innovation than recognition of technical potential" (Marquis, 1988). This was the finding of one of the most well-known studies in the nineteen-seventies - the SAPPHO project (Freeman, 1973; Rothwell *et al.*, 1974). Their analysis for pairs of successful and unsuccessful innovations found that most product successes were initiated by the 'need pull' of market requirements. It was further found that successful innovators: have a better understanding of user needs; undertake thorough market research or have good knowledge of market requirements; pay more attention to marketing; and (most importantly) the degree with which one tried to satisfy the needs of their potential users. (Holt *et al.*, 1984; Rothwell *et al.*, 1974). Other early research also looked at the necessity of market research. In 1973 Robertson discovered that an important common denominator in projects which failed commercially was that companies paid less attention to the needs of potential product users (Holt *et al.*, 1984).

NPD can be seen as a need fulfilling process (Holt, 1990). However many companies do not include activities in their NPD process which undertake a study of what their customer needs might be (Holt *et al.*, 1984). In their study of 142 firms, Calantone *et al.* found that firms which possess superior marketing skills have a higher chance of being able to provide a product which addresses the real needs of the customer (Calantone *et al.*, 1993). However, many of the companies in their sample did not undertake any marketing research.

Effective marketing effort is that which collects the right information about the right customers and interprets the findings so that the maximum value can be added during product development. Nevertheless, activities of market research are fraught with difficulties. One failing Pugh describes is that questioning of customers during design and development is often random (Pugh, 1991). In European companies information on customer requirements in most cases results more by chance, or from informal approaches and intuition (Holt, 1990) or the past experience of individuals (Pugh, 1991). The practicality of satisfying customer needs during product development is very apparent, even when market research is undertaken:

> "If the results of market research are taken too literally, a company may well end up introducing yesterday's product – two years from now. The aim is to introduce a product which makes the user say: 'This is what I always wanted, but I didn't know I wanted it until I saw it.' Such products rarely, if ever, spring from a market survey. They come from perceiving a real but unidentified need and translating it into a new product."
>
> (Bernsen, 1990, p89)

However, it is arguable that rather than market surveys being ineffectual, it is the way in which surveys are undertaken and interpreted which is inappropriate to find new products. As previously mentioned, customer needs can be expressed or inherent expectations (Kano *et al.*, 1984) e.g. the customer won't tell you that they expect a watch to be rain proof but they do because of the use of the product. This leads us to an understanding of how to elicit the right information about what it is the customer believes they are *actually buying*. Unfortunately, market research can often be "aimless fact gathering that fails to provide help in making decisions except by accident" (Roberts, 1968, p148). If we understand customers as value maximisers, we may have more of a chance. Customers will choose from the market offerings that they are aware of, the one that gives them the most value, within the limits of costs, searching, knowledge, mobility and income (Kotler *et al.*, 1996). Designers need to know these things about their potential customers. However, in some situations, the marketing function tends to work separately and does not provide the right information to R&D or design (Wright, 1998). This not only means that designers do not get the product design right in the original version, but it may also be why companies often take a long period of time to resolve any disparities that arise between products and the real needs of the customer (Pugh, 1991). Even though the marketing concept relies upon doing a better job of meeting and satisfying customer needs (Kotler *et al.*, 1996) many companies still do not practice any more than sales techniques (Hollins and Pugh, 1990) and in this case customer needs compliance is unlikely to occur.

One possible solution is for technical personnel to spend time in the marketplace, gathering customer needs. This will stop them becoming isolated and help ensure that they are able to contribute ideas that meet actual marketplace needs (Himmelfarb, 1992). Another activity which will benefit the needs compliance process and product success is product evaluation (Kleinschmidt and Cooper, 1991) During design evaluation specific research is undertaken to determine if customers perceive real benefits from product concepts, if there is no real benefit, a "no go" decision should be made (Urban & Hauser, 1993). Otherwise there is a danger that the technical characteristics of a product are achieved but the original customer desire is not.

Adding value through company activities

Good design is the essential next step after finding out what it is the customer needs are – adding value by making the product fit-for-purpose and to appeal to the customer (Cooper and Press, 1995). Better commercial performance of a product occurs where both engineering design and aesthetics are represented throughout the process (Service *et al.*, 1989). Value in the artefact is not the only thing being sought by potential customers. Operations management areas such inbound logistics, service, procurement and so on are all processes in Michael Porter's well-known company 'value-chain' (Porter, 1985). In real terms, this affects issues of time to market, speed of delivery, inventory management, customer help services and company flexibility that the customer will see and pass judgement on (Armistead and Grant, 1996). Technical activities, those of R&D, design and manufacture logically add a substantial amount to the finished product, and certainly Calantone *et al.* found support for the proposition that adequate performance of technical activities has a positive effect upon the quality of the launched product (Calantone *et al.*, 1993). However, since this is so logical, the work of Calantone *et al.* and a few others (e.g. Cooper & Keinschmidt, 1994 & Hise *et al.*, 1990) lead the scant empirical field on this topic. This is possibly because research finds that, for many firms, the execution of technical activities is fairly good and is rated higher than for marketing and evaluation or financial actions (Cooper & Keinschmidt, 1994).

2.3.2.2 Techniques and methods

To undertake the individual activities that are part of NPD process, requires separate methods and techniques. This part of the literature review is aimed at providing an overview of the methods which have been found to impact upon customer needs compliance in the NPD process.

Techniques and methods in design and development help provide a game plan (Wright, 1998). They are often claimed to be applicable to improve the product development process and many tools are cited by advocates of Total Quality Management (TQM). However, systematic use of quality methods in NPD are still not widespread, as compared with applications of quality tools in manufacturing processes (Zhao *et al.*, 1999) Such quality tools and techniques are often seen by designers as contributing little to the design process and are even viewed with contempt (Lamb and Dale, 1994). Unfortunately, previous research has shown that techniques are not applied widely in practice (Kohoutek, 1983; Spring *et al.*, 1998).

Despite these negative reports, there are actually lots of methods, techniques and tools available to product developers. In his book on design methods in engineering and product design, Wright determines the benefits of using product development methodology (Wright, 1998). He developed a requirement tree, which produced the following bottom-level advantages of a using good methodologies:

- Generate more ideas
- Meet objectives
- Meet constraints
- Provide a market edge
- Produce patentable ideas
- Provides a common forum
- Externalises ideas
- Encourages dialogue
- Aids evaluation
- Clarifies thoughts
- Aids communication
- Links market to engineering
- Presents the customer's voice
- Facilitates accountability
- Facilitates traceability
- Provides documentation

(Wright, 1998, pp.31-32).

Zhao *et al.* found over one hundred tools and techniques mentioned in the literature, with different toolboxes proposed and used by different authors. Ultimately they rest on forty tools which they believe to be wholly applicable to improving the quality of the product during NPD (Zhao *et al.*, 1999). The research of Zhao *et al.* (1999) provides a framework that can help decide on the use of quality tools during NPD. Figure 2.17. depicts their classification, which is based on reported and perceived usage of quality tools, such that:

- common activities for all the stages and specific activities for each stage are identified.
- common activities exist in every NPD stage and deal with the aspect of the NPD process whereas specific activities are related closely to the physical aspects of new product design that vary from stage to stage.
- quality tools are then categorised into process-related tools and product-related tools on the basis of their roles in improving NPD process and product quality.
- those process-related tools are sub-categorised further according to their roles in improving the five process-related common activities.

(Zhao *et al.*, 1999, p456)

The diagram of the classification appears to be very useful to researchers and practitioners. Unfortunately their 1999 conference paper does not go into great depth, and only provides examples of about a quarter of the tools they have classified.

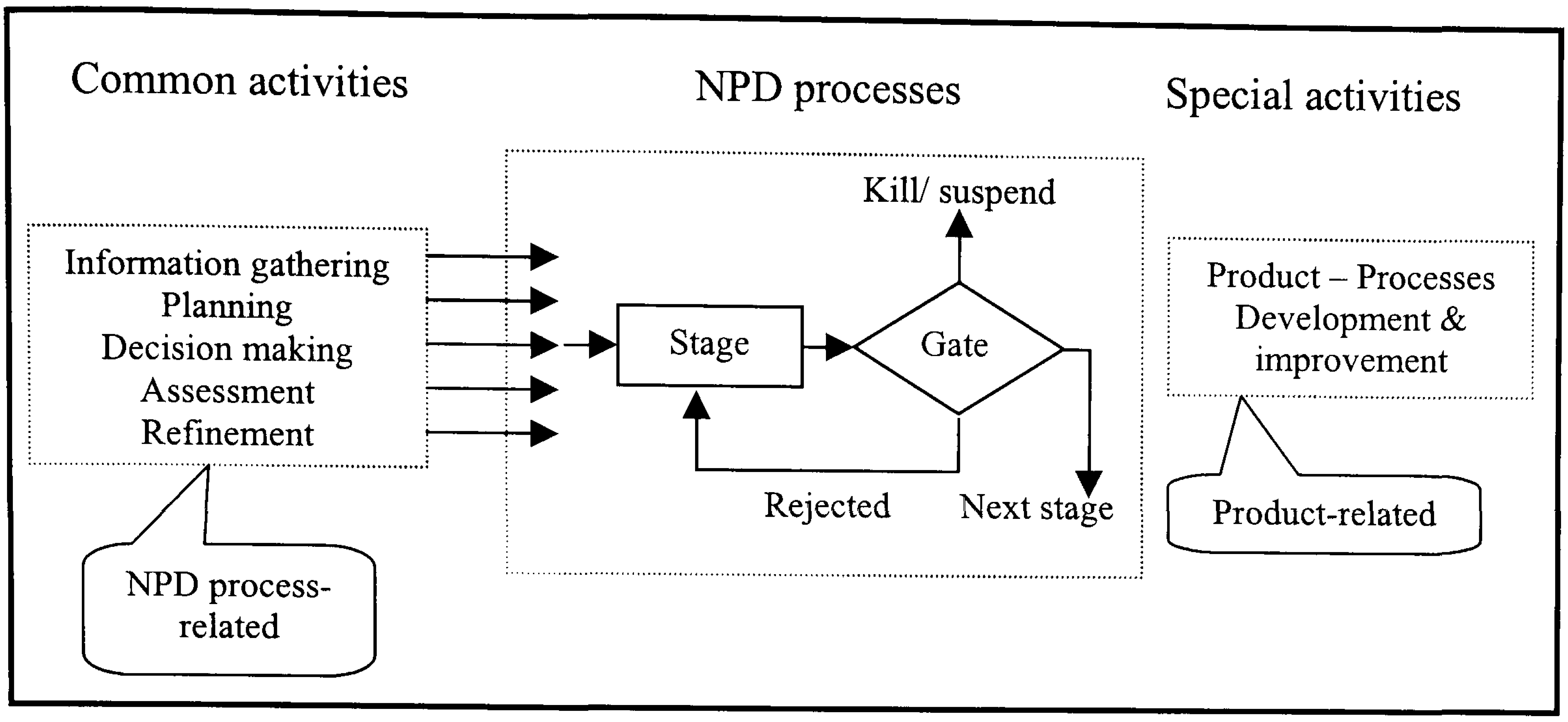


Figure 2.17. Framework for classifying quality techniques (Zhao *et al.*, 1999, p456).

Marketing principles

The field of marketing purports to implement all that we are looking for in terms of producing products which comply with customer needs:

> "Marketing is the management process for identifying, anticipating, and satisfying customer requirements profitably"
>
> (Chartered Institute of Marketing: Wilson *et al.*, 1996, p1).

Methods and techniques for marketers concentrate on the fulfilment of the marketing mix - also known as the 4-Ps: Product; Price; Place; and Promotion. In principle, the marketing mix is a set of four key decision areas that must be managed and well blended to create competitive advantage, whilst matching both the corporate resources and customer needs (Jobber, 1998). It would seem very possible that under the guise of marketing management, this discipline would be able help the product developers through the maze of choices and decisions which determine where the product will end up. Unfortunately, this is just not the case – there are no hard and fast rules which marketers can apply and no recognised tools which *ensure* success. Indeed, product failure rates have changed little over the last couple of decades, (Barclay and Benson, 1990) even though more marketing effort is being put into product development.

Market research collection methods

The activity of market research has already been mentioned, and is one set of tools which is reported to make a difference if it is properly directed (Calantone, 1993; Cooper & Kleinschmidt, 1995a; Service *et al.*, 1989; Rothwell et al., 1974; Holt *et* *al.*, 1984; Hague, 1992). Market research was quickly embraced by many consumer product firms after World War II (Howard, 1968). However, its real worth was not found until the 1970s and '80s when World economies began to slow and competition meant that product sales were hard fought, and the customer demanded value and *quality*, which also affected industrial markets substantially (Hague, 1992). Market research is a method of collection, analysis and interpretation of data to help answer questions and reduce business risk during product development. All of the phases – collection, analysis and interpretation – are absolutely critical to making the right product development decisions. As a technique, careful, exacting market research can lead to the success of new product strategy, recognising customer wants and needs and resulting in superior products (Urban and Hauser, 1980). Conversely, improper research may mean missed opportunities, investment in incorrect directions and the development of products no one wants (Bernsen, 1990).

Many methods of primary and secondary data collection and analysis are available to the market researcher, depending upon the phase of product development and what it is they are trying to uncover (See Churchill 1995; Urban and Hauser 1988, 1996; Wilson *et al.*, 1996; Hague 1992; for background and in depth discussion of applicability and issues surrounding relevance and use of techniques). Methods for investigating attitude scales, interests, opinions, motivations and other psychographic and geographic aspects of customers are available to detect different habits, values, preferences, casual relationships and market factors. Difficulties can arise from the number of alternative ways one can collect, analyse and use the data. It has been reported in the past, that one of the greatest weaknesses in marketing is that the people who use the report seldom participate in the definition of the study (Howard, 1968). This makes much of the information collected useless in the context of those who have to analyse and use the data to produce meaningful customer needs. Indeed, attitude surveys may try to find out what it is customers want, but they are prone to incorrect interpretation before a requirement for the product is developed (Cooper *et al.*, 1998).

Holt *et al.* (1984) suggests that, for finding out customer need attributes, there are 5 distinct phases to research: need identification; need evaluation; need clarification; need specification; need up-dating (see figure 2.15). They suggest that fulfilling needs should be given as much priority as trying to fulfil technical problems (Holt *et al.*, 1984).

Data analysis may also take many forms. Outcomes from the analysis may be a value system (e.g., rating scores, probabilities or rankings), which denote aspects of the customer preference, and may be used to derive judgements of alternatives (Dolan, 1993). Techniques which imply relevance to customer needs compliance may include analytical methods used to produce snake plots, perceptual maps, benefit segmentation and preference analysis (Urban and Hauser, 1980; Churchill, 1995; Dolan, 1993).

Positioning statements and perceptual maps

The analysis of data can produce multi-attribute positioning statements and perceptual maps. A product can be positioned in the minds of the customer in terms of the benefits which the customer is looking for. These positionings look at the customer need attributes including usage occasion, competitor comparisons and product classes as well as specific product features, value and cost (Wright, 1998). Perceptual maps try to depict these customer needs diagrammatically (Urban and Hauser, 1996). The map is developed by rating the two most important differentiating characteristics (Dolan, 1993). The technique places products, customers or companies in a grid, where the axes may be any one of a number of alternatives e.g. speed Vs convenience; effectiveness Vs. mildness; price Vs ease of use etc. These maps should be simple, clear and communicate meaning to all of the design team. However, one drawback with these maps is that they can only place items against two axes at any one time, requiring many different maps to be drawn. To accommodate larger groupings of factors snake plots can be used (Urban and Hauser, 1996). The snake plot places a value against each of the attributes, which produces a line when the ratings are joined up. These do allow for larger groups of ratings, but are complex, sometimes proving too difficult to distinguish what the most important issues are. A further means of mapping customer views is by taking overall similarities of products or attitudes towards ideas. Here, instead of rating each product on a large number of explicit scales (as with factor analysis and conjoint analysis from attribute ratings), pairs are evaluated in terms of how similar or dissimilar the customer views are (Urban and Hauser, 1996).

All of these positioning charts do capture some areas of importance to design teams and marketing managers, as they allow many different customers to be put onto the one chart. However, the means by which these charts are produced is often dubious, in that they place a high burden upon the respondents to result in a reliable map (Dolan, 1993) and they do not go beyond the experience of the users interviewed, i.e. many novel product ideas lie outside the real-world experience of many individuals (Von Hipple, 1988a). The multi-attribute rating techniques used to produce positionings and perceptual mappings also have the inherent problem that there is no means to stimulate users to name all of the possible product attributes that maybe relevant to a product category (Von Hipple, 1988a). With respect to this research, these maps are very difficult to produce, since these scalings tend to explicitly mention a product or brand, to which attributes are assigned to. However, it is not inconceivable that these may be used in a more general sense to provide for customer needs compliance, even though they are not described in this way in the literature.

Segmentation and core benefits

The techniques of segmentation and core benefit analysis are also used to determine what customers may want from the product. Positioning and mapping the customer needs is often done by averaging customer views (Urban and Hauser, 1996). This provides an easy and convenient summary measure, but variation across customers is necessary, if the company is not to court disaster (Dolan, 1993). Segmentation analysis looks at the value systems that different types of customers use when making decisions about the products they buy and use (Wright, 1998). "Benefit segments" can be identified as separate entities, so that each segment can be defined where the benefits sought are the same within a segment, but quite different between them (Dolan, 1993). Core benefits analysis takes this segmentation further by suggesting physical and psychological aspects of benefits which the customer is seeking. The "core benefit proposition" for a product is a statement of the benefits that each type of customer deems to be important (Urban and Hauser, 1996). Von Hipple (1988a) suggests that "lead users" are employed in research of this kind, to discover issues for future designs. These "lead users" are a particular group of customers who can be identified as those who follow the trends in the general marketplace, are at the forefront of these trends and are willing to explore their needs further. The benefits they seek may be found through the use of such methods as the Delphi technique

(Holt *et al.,* 1984) or user focus groups (Krueger, 1988). All of these methods which have grown out of marketing contexts are worthy of investigation for this research. These techniques do attempt to capture customer and user needs and they are well used, in many different versions in practice today. Even so, these techniques are not always widely used to track customer needs as they require continual up-dating and much investment from companies, also they are often kept within the marketing arena (Holt *et al.*, 1984).

Technically driven methods

There are also many design methods which have developed for, and by, technical people. Nevertheless, they suffer from similar problems in terms of capturing customer needs. Requirements analysis, product design specifications, benchmarking, quality function deployment and value analysis and engineering are all very useful and worthy tools advocated and used by engineering designers - they are, however, very transitory. They do help capture, communicate, and regulate the design process activities (Wright, 1998, Hollins and Pugh, 1990) but, they do not map relationships to help make longer term strategic product design or research and development decisions. Requirements analysis and the Product Design Specification (PDS) are more about defining a set of product characteristics from non-technical requests. They lay out customer requirements in as complete a method as possible, after which the design team can commence the innovative activity of proposing product configurations to satisfy customer needs (Wright, 1998). The PDS is a primary means for ensuring compliance during the development process (Cross, 1994). Unfortunately, the items included in these analyses and definitions are often those which can be captured in terms of tolerances, definitive statements and standards to be adhered to, which may miss underlying issues of customer needs. That is not to say that many customer needs can not be captured in such a PDS, but that the company must be aware that many of the issues which may be important to the customer are not written down or tested in such a way. Benchmarking can be used by a company to compare itself against similar organisations (Norman and Peterson, 1999). Unfortunately, it is generally used in the context of critical processes for manufacturing and technical product performance, rather than in the context of success in terms of satisfying the customer.

QFD and Value analysis as NPD methods

The Japanese 'voice of the customer method' also called 'quality function deployment' (QFD) is also a technique which falls into this category in terms of a specific tool (It will also be addressed as a means of quality management in section 2.4.1.3). QFD attempts to look for the sum total of the attributes that the customer values (Wright, 1998). QFD, like many of the other methods, look promising for customer needs compliance. However, there is a short fall in all of these methods - they only attempt to be a practical means of following customer need parameters through the design of a *nominal* product. Figure 2.18 identifies this - the customer requirement is quickly made operational by a design requirement for that particular product, losing the generic nature of the original wish and narrowing the potential for future use of resources, process capabilities or other competencies because the link is always via part characteristics. This is not a problem for their prescribed application, but it does not wholly fit the needs of providing us with a model for understanding longer term customer needs compliance decisions at a higher level. Value analysis and value engineering are methods which are also deemed to help design products that will fit with the values a customer might perceive from products (Wright, 1998). Yet again, however, this method only reflects the changes in the "value" of component parts, having designed the product. As with QFD, it makes characteristics operational, rather than understanding general customer needs and complying with them.

CUSTOMER REQUIREMENTS	DESIGN REQUIREMENTS	PART CHARACTERISTICS	MANUFACTURING OPERATIONS	PRODUCTION REQUIREMENTS
"Years of durability"	No visible exterior rust in 3 years	Paint wt: 2-2.5 gm/m^2 Crystal size: 3 maximum	Dip tank 3 coats	Time: 2.0 minutes minimum Acidity: 15-20 Temperature: 48 - 55°C

Figure 2.18. Making customer needs operational (Adapted from Eureka, 1986)

Prediction techniques

Varied conditions from stage to stage in the design process necessitate the use of varied applications of design methods and techniques. Assessment tools are used in specification development and refinement tools are helpful to make the product and process robust (Zhao *et al.*, 1999). Yet, in spite of all the potential of these techniques, few are useful in anything but explicit form. In other words, most of these methods require the customer to provide perceptual measurements of exact items – either those which the researcher has put forward, or, those which are prompted to come to mind. Thus, if the techniques are correctly administered, they are particularly good at capturing what the customer thinks now, permitting prediction of the choice that the consumer would make if confronted with a set of products in the marketplace (Dolan, 1993). They are, however, less good at determining what the future may hold, as they do not offer a means of going beyond the experience of the particular respondents (Von Hippel, 1988a).

According to Holt *et al.* (1984) the most important formalised methods for future needs assessment are inspecting government information, scenario writing, system analysis and Delphi polls. Looking at trends in available government information and systems analysis relies upon a rational, progressive future, whereas writing scenarios of alternative futures can help stimulate ideas for product development in a more flexible way. The Delphi method involves experts contemplating the future needs in a particular product area, through a succession of iterative statements. Need assessment results in a list of identified problems and needs which require transformation into a generic need specifications, that include information on what the problems are, how they are being solved today and can the need be satisfied by technical solutions, regulations or behaviour. (Holt *et al.*, 1984).

Zhao *et al.*'s work summarises that there are over 40 separate and useful techniques available for process-related and product-related quality conformance during all phases of NPD. However, their main conclusion is that there are relatively few empirical cases reported and that there is much work to be done in the area of understanding the application of quality techniques in NPD.

2.4 Compliance during product development

So far, this review has described who the customer might be and what they might want from a product. It has provided a discussion of how the design and development of new products may take place, by describing NPD models and activities, methods and techniques.

> "Design is a complex activity often involving the manipulation of large quantities of information which is frequently compounded by the chaotic interaction of large project teams of designers and supporting departments. This process is constrained by limited resource, finance and time."
>
> (Edwards and Murdoch, 1993, p1676).

The job of the design team is an onerous one, in reality. They must pin-down the right needs and qualities and act on them, providing compliance during product development. In respect of this task, it is worth researching the management of the process and the information required. Therefore, this section provides further depth to compliance action during NPD.

2.4.1 The management of the product development process

Closely related to the development of models of the NPD process and the activities undertaken during product innovation is the need for NPD management. This is exemplified by the European Commission identifying the need for producing a Green Paper in the form of a "European Guide to Industrial Innovation" (Norman and Peterson, 1999).

The European Commission identified two distinct skill sets for the innovative firm:

> **strategic skills:** *long term view; ability to identify and even anticipate market trends; ability to collect, process and assimilate technological and economic information.*
>
> **organisational skills:** *taste for and mastery of risk; internal co-operation between the various operational departments and external co-operation with public research, consultancies, customers and suppliers; involvement of the whole of the firm in the process of change, and investment in human resources.*
>
> (Norman and Peterson, 1999, p66).

Here follows a summary of the investigation into such management requirements in the context of the effective and efficient planning, organising and controlling of NPD. This section discusses the possible effects of management roles, NPD strategy, quality management and organisational structures upon customer needs compliance during NPD.

2.4.1.1 The role of management in NPD

A common element in the literature is the influence that management personnel have upon product success. If top management reinforce positively the place of design and development, and this position is reflected throughout the organisation, then there is a positive effect on performance (Rothwell 1977; Maidique and Zirger, 1984; Peters and Waterman, 1982; Walsh and Roy (1997) , year; Kotler and Rath, 1984). One study reported that performance in terms of percentage turnover accounted for by new products was influenced by what staff were present at the highest level in the company. Performance was found to increase in firms where there was representation at board level of research and development, sales and *both* engineering design and aesthetic design (Service *et al.*, 1989). Nevertheless, an alternative study found less proof that management influence had an effect on performance (Cooper & Kleinschmidt, 1987a). Others have recounted that although management is needed, too much contact could be undesirable and seen as interfering by design staff and cause delays and changes to the product development (Urban & Hauser, 1980; Maidique & Zirger 1984).

In order for the business to adopt progressive standpoints managers must support, and often initiate, the use of relevant customer needs methods during innovation (Holt *et al.*, 1984). A revealing survey of managers reported by Oakley recounts the orientations and aims of managers with respect to designing for customer needs (Walker, 1990). The *Fortune* magazine survey showed that the six most important objectives cited by chief executives for product development were: [1] to improve profits earnings (36.7%); [2] growth (21.9%); [3] improve return for shareholders (11.1%); [4] employee development (8.8%); [5] long-term planning strategy (6.4%); [6] control costs, improve productivity (4.5%). Less than 4% of top managers offered the objective of improving product/ service quality (3.9%) and designing a better product was not specifically mentioned at all (Walker, 1990).

The 1990 report of Service, Hart and Baker presents a deeper analysis of top management alternative attitudes towards NPD. They identified seven different NPD orientations. Results provided evidence that these different orientations influenced product performance. Table 2.3 summarises the characteristics of each new product design and development orientation and the areas of performance which they were found to affect.

Table 2.3. Comparison of top management NPD orientation. (Summary of results from Service *et al.*, 1989, pp15-18).

Orientation	Characteristics	Associated with better performance in
Incremental	Continually researching & designing. Invests in market research. Cautious.	• industry comparison • new product's contribution to sales volume
Radical	Not bound by current, extant market needs or available technologies. Cost not much of an issue.	• industry comparison
Balanced	Innovates Also recognises marketing input required into NPD.	• percentage sales growth. • compared with major competitors • industry comparison
Added-Value	Emphasises the notion that product design influences market tastes (particularly in exclusive segments).	• compared with major competitors • industry comparison • new product's contribution to sales volume
Fashion	Emphasises speed & aesthetics. Effort into changing features & trimmings easily. Divorces marketing from design & development.	• new product's contribution to sales volume
Independence	Redesigns products on own terms.	
Design	Commitment to developing design expertise, but not market research.	• percentage sales growth. • industry comparison • new product's contribution to sales volume

The same study found that the management of product development had to be a team effort, as well as the undertaking of the development itself – "delegating responsibility for the task of new product design and development to one solitary manager is less effective" (Service *et al.*, 1989). This may actually be a reflection of the change in attitude towards management *per se*. Employee involvement and empowerment is becoming more wide spread as structures become flatter, thus more individuals are on the same "tier" and cannot pull rank (Huczynski and Buchanan, 1991). The traditional manger may feel slightly more vulnerable, but in practice it indicates the onus on *changing* their skills and abilities, rather than removing them (Weaver, 1995). The balance is tipping towards the acknowledge of design making an important contribution to the company profits (Cooper and Press, 1995).

Himmelfarb candidly states that

> "the best managers are those who don't feel intimidated by creative people. They spur creative people on to greater performance levels than they ever thought possible... Good managers are willing to take calculated risks, and they encourage their subordinates to do the same." (Himmelfarb, 1992, p179).

He suggests practically a catch-all list of some things senior management can do to help promote fast and effective NPD:

1. Developing and communicating the vision;
2. Preaching the importance of speed;
3. Identifying and overcoming barriers to fast product development;
4. Finding the right people for fast product development;
5. Staying informed;
6. Empowering the teams;
7. Emphasising training;
8. Minimising bureaucracy;
9. Seeking ideas;
10. Identifying the marketplace needs;
11. Establishing formal criteria for selecting projects;
12. Prioritising projects and matching the project load to available resources;
13. Providing resources;
14. Making risk and failure acceptable;
15. Insisting on quality;
16. Being a cheerleader. (Himmelfarb, 1992, p36).

This list is very typical of the kind of advice provided by many authors. Management should provide sustained support for innovative activities so as to maintain the aptitude, knowledge, expertise and personal interactions of its professional technical staff (Marquis, 1988).

2.4.1.2 New product development strategies

In the recent past it has become more recognised in design management that the development process for new products must be understood at both a strategic and operational level in order to meet customers' needs and stay in the running (Crawford, 1997; Service *et al.*, 1989; Cooper, 1984, 1985). Product development strategy was therefore, identified in the literature as a significant management issue in terms of product quality and company success. As a matter of fact, Cooper and Kleinschmidt found that one of the most important factors affecting product success was "a clear and well-communicated new product strategy for the company" (Cooper and Kleinschmidt, 1995a, p384). In explanation, the reason why strategy is so important is because it directs long-term competitive advantage and impacts upon plans, company flexibility and product directions in the face of changing market environments (Cooper and Press, 1995). Booz, Allen and Hamilton modified their original NPD process to specifically identify NPD strategy as the first step of product development, placed before product idea generation (Booz *et al.*, 1982). Put this way, strategy is an essential principle, because it impinges on what products the company should produce, by helping identify, and give direction to, all of the important company synergies which may influence product success or failure (Kleinschmidt and Cooper, 1991; Calantone, 1993; Service *et al.*, 1989; Griffin and Page, 1996; Rothwell, 1977; Cooper 1984, 1985).

Company strategies

It is essential to note that firms operate under different strategies, and that different strategies produce different levels of dependence upon NPD. The survey of Hart *et al.*, (1989) which researched UK companies, found that companies adopted one of four general new product strategies to achieve their long term organisational goals. The top performer's in their research used strategies which have a marketing orientation and approve of continuous improvement and product diversification. In rank order of importance, they list the new product strategies which companies use to achieve long term objectives as:

1. developing new products to satisfy existing markets
2. increasing sales of present products in existing markets
3. developing products with a higher value added to serve new markets and,
4. developing new markets for existing products.

(Hart *et al.*, 1989)

Other authors have offered means of delineating strategy types. Booz, Allen & Hamilton, (1982) divide strategies between internally and externally driven factors for new product management. The work of Cooper (1984 and 1985) concludes that company performance and new product strategies are related. He offers a set of scenarios which indicate how much the strategy is market-facing, technology-lead, and under budgetary control. The way in which an organisation reacts to the competition is the basis for the 'business strategy typology' developed by Miles and Snow (1978). They place emphasis upon the speed with which an organisation responds to the changing environment and believe a company will come under one of four general categories:

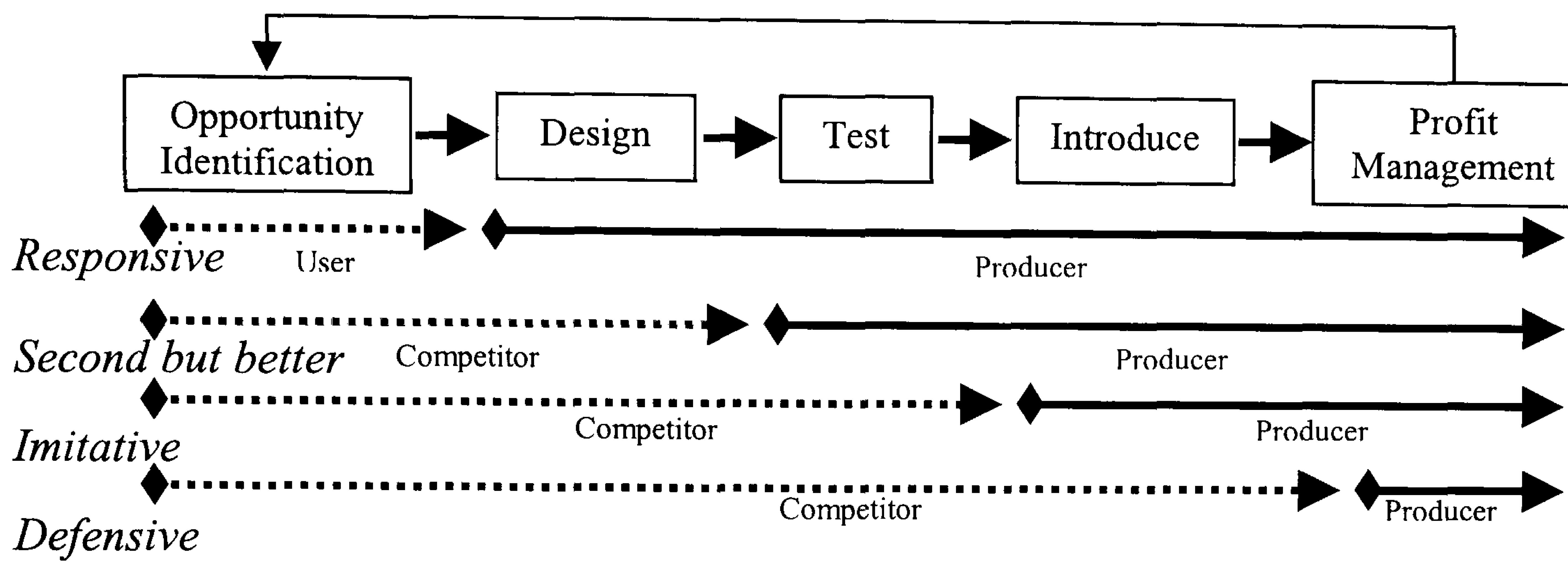
> ***Prospectors.*** Respond rapidly to early signals for opportunity and value being first, even though not all efforts are profitable.
>
> ***Analysers.*** Seldom first to market, but can frequently be a fast follower, bringing cost-efficient or innovative product into the market area quickly.
>
> ***Defenders.*** Attempt to locate and maintain a secure niche. They protect by offering higher quality, superior service or lower prices. They ignore industry change that have no direct influence on current operations.
>
> ***Reactors.*** Respond only when strong external factors. Are not as aggressive in maintaining established products and markets as their competitors.
>
> Miles & Snow (1978)

Proactive and reactive strategies

A fundamental organisational choice is whether to have reactive or proactive strategy (Hart *et al.*, 1989). Urban and Hauser (1993) review issues surrounding these two managerial perspectives of NPD strategy. They indicate that a firm should concentrate their effort on marketing, design and development activities to differing extents, depending upon the basic strategy for each product. Figure 2.19. summarises some of their discussions in their book "Design and marketing of new products" (Urban and Hauser, 1980 and 1996).

If an organisation chooses to be more proactive, than reactive, it may also choose whether to maintain a traditional perspective on NPD strategy, for the product through its market life-cycle. This is where the manufacturer assumes responsibility for the management of the entire sequence of activities leading up to the production and beyond launch of the innovation - Von Hipple (1978) called this the 'manufacturer-active paradigm' (MAP). The MAP situation is one of the customer only responding when asked, thus it is only possible to gain answers to particular questions. Von Hipple suggests that this is detrimental to real innovation, because underlying ideas and issues cannot be extracted. He proposes that customers could provide not only need information, but also solution data, within a 'customer-active paradigm' (CAP) (Foxall and Johnston, 1994).

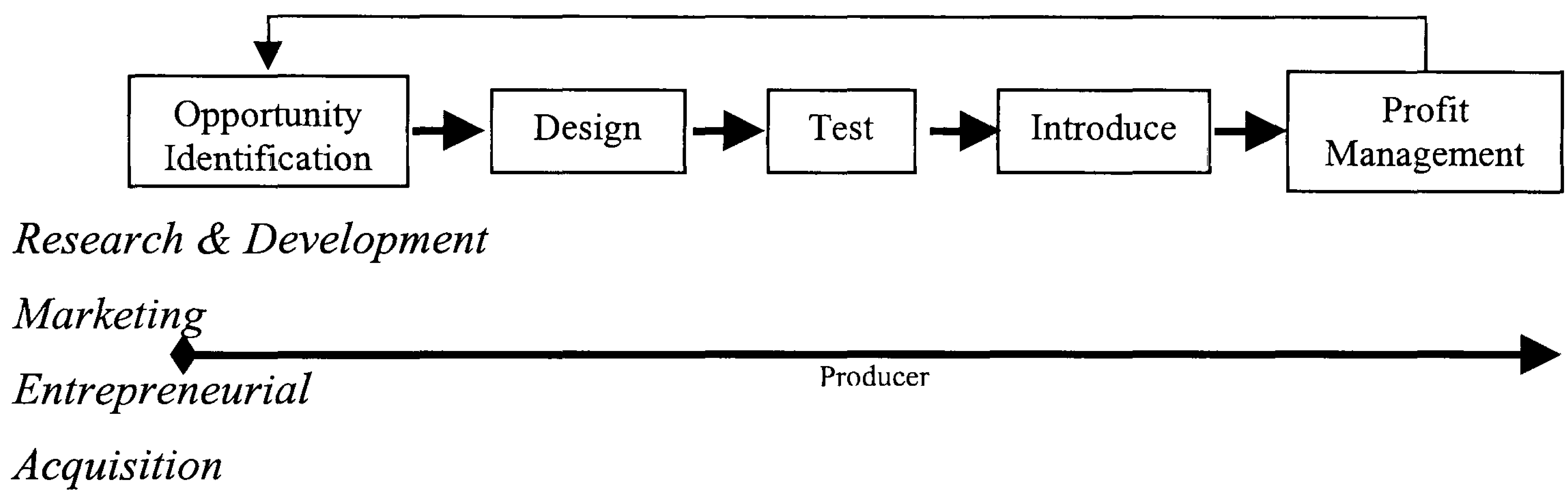
NPD reactive strategies



In general, reactive strategies are best when:

- the organisation sees its strength in managing existing products,
- markets are too small to recover development costs,
- little protection is available for innovation in the market, &
- the organisation has insufficient resources to conduct development.

NPD proactive strategies



In general, proactive strategies are appropriate when the firm:

- has an aggressive policy towards growth,
- is willing to introduce new products & enter new markets,
- can protect its innovation by patents or market position,
- is targeting towards high volume or high margin markets,
- has the financial resources, staff & time required, &
- can prevent its innovation from being overwhelmed by competition.

Figure 2.19. Company strategies for reactive and proactive NPD (After Urban Hauser, 1988)

The hypothesis is that CAP offers a better fit to proactive industrial product idea generation, than does MAP. Unfortunately, CAP can only be successfully applied in situations where would-be customers are overtly aware of their new product needs. On the other hand, MAP is still used more readily, because is more easily used when customer needs are overt or latent and the manufacturer may require the opportunity prompt to get to the deeper issues, using market research and user focus group techniques (Von Hippel, 1988a).

Product strategies

In each of these differing approaches, design has to work in conjunction with the overall strategy of the company (Cooper and Press, 1995). At project level each NPD may follow a slightly different strategy which may be judged along a sliding scale of innovation (Kleinschmidt and Cooper, 1991). Kleinschmidt and Cooper grouped factors into three groups of high, moderate and low innovative products for their study on product innovation and performance. They concluded that the type of project was highly correlated with product advantage and that a 'balanced strategy' where new products are innovative, but are also strongly focused upon the fit in the marketplace, provided by far the strongest performance (Kleinschmidt and Cooper, 1991; Cooper 1984 and 1985). The emphasis is on getting the design right - high innovation is rewarded if it offers products which are of higher *quality*, with unique customer benefits so that they are superior in the eyes of the customer and solve the customer problem. Design has to be integrated into the strategy for each of the projects or products (Griffin and Page, 1996) and at each and every one of the distinct levels of the company strategy (Clipson, 1990). The strategic role of design at project development level is illustrated in Table 2.4. by providing accounts of projects in diverse industrial situations Cooper & Press (1995). This demonstrates how the management and planning of the product development direction and of design resources can play a significant role in realising the goals of the company. Additionally, the list of challenges shows that if the design effort is inappropriate and ineffective, problems can be created for the company and the customer, and may produce negative effects of dissatisfaction, customer confusion, delays and even accidents, legal complications and loss of profits to the company (Clipson, 1990).

Table 2.4. The different strategic roles of design (Adapted from Cooper & Press, 1995, p112)

Challenge	Strategic goal	Role of Design
Small firm in consumer electronics market.	Secure distinctive international niche.	Provide niche through unique styling, identity and product innovation.
Survival in a mature industry with keen price competition.	Concentrate on added value markets or processes.	Add value through fashion orientation.
Trans-national manufacturer with diverse world markets.	Coherent identity and appropriate exploitation of scale economies.	Corporate identity and co-ordination of design resources to target global markets.
Japanese companies in competitive Western markets.	Quickly develop products appropriate to diverse lifestyles.	Integrate innovation process and humanisation of product.
Service supplier in newly competitive market.	Develop distinct identity.	Corporate identity and environmental design.

The understanding of different strategies at company and project level may lead to a better informed judgements on how to undertake NPD in certain markets. Griffin and Page (1996) also recommend that, as part of their strategy, customer satisfaction should be used as a measure of success, alongside any financial measures an organisation may use. However, they point out that using any framework and post-hoc measure only leads to an understanding of what has gone before (Griffin and Page, 1996). Therefore, it does not forecast the strategy which will ensure design for customer needs compliance in the future.

2.4.1.3 Quality management and deployment

This research is looking at product *quality* and customer needs compliance. Therefore, of direct relevance is the emergence of Total Quality Management (TQM) and Quality Function Deployment (QFD). As their titles suggest: TQM is a set of management philosophies; and QFD offers a means to exploit *quality* issues during product development.

Total Quality Management and ISO9000

TQM has many advocates and a similar number of definitions. However, they are all in agreement that TQM requires elements of: clearly defined organisation purpose that is consistently deployed; strong customer focus; process orientation; empowerment of people; continual improvement of all aspects of the organisation involving everyone in team efforts (Norman and Peterson, 1999). TQM is an attempted shift in paradigm, from inspection and statistical control of quality in the product, to the strategic use of quality, that top management exercises strong leadership (Garvin, 1988). Quality gurus have moved from *inspecting in* and *controlling in* quality to *building in*. Now TQM accentuates the role of goal setting and exploiting competitive opportunities by *managing in* quality (Mørup, 1993). Thus, TQM should include activities which stretch across the whole of the company. For that reason, the word 'total' is used to try and emphasise the broader impact of the quality management (Mørup, 1993).

The International Standard Organisation (ISO) set requirements for companies to attain in order to be accredited with *ISO9000*. An empirical study of 700 UK businesses in the North East of England revealed that successful ISO 9000 accreditation and further TQM enhancements do result in improved competitiveness (Prabhu *et al.*, 1999). Prabhu *et al.*'s 1999 study resulted in significant association between TQM activities and competitiveness: companies systematically adopting best practice achieved significantly higher performance.

For many who work in the quality arena, ISO9000 is a minimal quality management standard - they believe that companies need to address many more issues to achieve world-class standards in TQM (Norman and Peterson, 1999). ISO 9000 does not ensure that the company produces a product which is of *quality* and meets the needs of the user. Rather, it ensures that the company has a quality management system which can be audited and products can be traced – it makes sure that the company produces what it says it will produce, but this does not necessarily mean that it will meet the customer's needs. Surveys show that the ISO 9000 certification exercise is regularly used to comply with contractual requirements, rather than arising from any real concern for *quality* issues (Chan and Fan, 1999). ISO 9000 has become an end in itself, and has been promoted as a "new and competitive approach to quality", which it is not (Norman and Peterson, 1999). It is interesting to note that the UK study of Prabhu *et al.*, (1999) showed a difference between simple ISO 9000 accreditation more progressive TQM companies: 74% of TQM companies, whereas 28% of ISO companies achieved (what they class as) 'World class' or 'potential winners' status. This has been recognised, and as such a new European guide "Excellence in innovation" has been produced to aid companies and provide a set of practical tools to enable real quality management in organisations (Norman and Peterson, 1999).

Further still, TQM is often believed to be an all-encompassing technique which will ensure that the design of the product will meet the needs of the customer (Juran, 1992). Managing *quality* is a much deeper concept than this (Chong, 1999). Mørup, (1993) dedicates much discussion to shortcomings of TQM and the way the TQM fraternity fail to embrace the real essence of design. He lists six issues that need to be addressed by TQM in order for it to move forward and help provide product *quality* through design:

- TQM overrates specifications and planning
- TQM overlooks the fact that quality is the outcomes of a design synthesis process
- TQM focuses on problem solving only
- TQM implementation risks bureaucracy
- TQM is often blind to the linkages between activities performed elsewhere.

(Mørup, 1993, pp58-68)

These issues are very relevant to this research and are still very pertinent as obstacles to product *quality* from the customers point of view. Thus, even if TQM is adopted by companies, there is still a need for research into the concerns of how companies produce products which meet the needs of the customer at an operational level.

QFD as a management technique

One technique which is purported to fill such an obligation is Quality Function Deployment (QFD), a method which has been advocated by Japanese companies for over two decades. It was developed to provide a 'voice for the customer' in the product development process. It tries to ensure that the product is driven by features which are of benefit to the customer (Wright, 1998). QFD seeks to translate customer needs perceptions into design parameters that can then be deployed horizontally through product planning, engineering, manufacturing, assembly, and service (Sullivan, 1986a). The origins of QFD are with the Japanese Kobe shipyard, where they employed 'quality tables' from 1972 onwards. These were then taken up and transformed into the recognisable 'house of quality' by the Toyota car company (Himmelfarb, 1992). Following the great benefits reported by Toyota, they required all of their world-wide organisations to follow similar practices so exposing the value of the QFD methodology to the wider society (Dolan, 1993; Sullivan, 1986a)

Advocates believe the revolutionary thing about QFD is that it stresses the views of the customer, as opposed to the views of the engineers and product planners (Himmelfarb, 1992). The technique starts by asking "what does the customer want and need?". A customer need is a description of the benefit to be fulfilled by the product or service and is not a solution (Griffin and Hauser, 1993). The phrases that the customer uses to describe product and product characteristics which they perceive to be their requirements are called customer attributes (Wright, 1998). Experienced users of the house of quality try to preserve customers' phrases and even clichés (Dolan, 1993). These customer requirements (*what* they want) are then translated into design requirements (*how* to achieve them). In turn, the design requirements can be viewed as *what* is required, so that lower level part characteristics can be developed to provide a means of *how* to achieve them the design requirements (Eureka, 1986). Quality function deployment can produce four or more separate 'houses' (Hauser and Clausing, 1988). Each of these have specific relevance to the development of the product and require attention to the process steps required to generate the matrices (Clausing, 1986; King, 1987; Akoa, 1999).

There have been a lot of positive reports of the use of QFD. Toyota gives testimony to the cut in pre-production and start-up costs (Sullivan, 1986a, 1986b) as well as the reduction in engineering changes required during and after product development (Hauser and Clausing, 1988; Wright, 1998) and the practical removal of warrantee problems related to rust (Eureka, 1986). QFD facilitates multifunctional team working (Dolan, 1993) and is valuable as a change agent by moving the company toward higher levels of cross-functional integration because it enhances communication (Griffin and Hauser, 1992). Researchers also describe how QFD delivers process related benefits by effectively gathering data in one place; communicating plans between management and design team; easily and quickly highlighting areas where the development team must concentrate; and storing decisions and records why these decisions were made (Daetz, 1990). Abbie Griffin (Griffin, 1992) suggests that project related results indicate the necessity of QFD in a strategic sense. In 29 out of the 35 projects in the study (over 82%) companies reported that using QFD provided definite strategic benefits of structuring decision-making processes across functional groups; building an organised, highly motivated team; and moving information efficiently from its origin to the ultimate user.

Despite the potential, and even observed, advantages of using QFD, this method is used infrequently in practice (Araujo *et al.*, 1995). This may be due to its complexity and the time required for completion. For example, if a customer states that they want a piece of equipment to be "easy to use" or "quiet in operation", how can these be interpreted? Sales people, engineering, manufacturing staff and product planners all have to agree that what design has produced really *does* reflect the customer's actual views. There is a danger that designers' interpretations can mislead teams into dealing with problems which the customer deems less valuable (Dolan, 1993). The study of Griffin (1992), mentioned previously, also reported that the use of QFD did not deliver the improvements promised by Japanese users. The study conveyed that certain types of projects (clean sheet, complex and strictly process-oriented) have little chance of success under QFD. Also, although possibly beneficial to those involved, the use of the technique actually lengthens development time if personnel are not accustomed to the method or working together (Griffin, 1992). A simplified version of QFD is often encouraged by other authors of design process texts because there is the need for significant investment in time and money before the rewards of QFD are returned (Griffin and Hauser, 1992). The important aspects of multifunction team communication, customer involvement and marketplace-aware product design decisions are aspects that are fostered by what the authors think are these "easier to understand" approaches (Jenkins *et al.*, 1997; and Himmelfarb, 1992; Barlow, 1999).

The QFD method has been used in conjunction with other tools and techniques to provide enhancement in particular circumstances. Different applications are those in service industries (Lloyd-Walker and Cheung, 1999) system development projects (Tam and Lee, 1999); and the design and analysis of questionnaires (Chan and Fan, 1999).

In conclusion, TQM and QFD have desirable goals of continuous improvement in terms of ensuring efficiency and excellence in processes and outputs. They are extremely important as philosophies for customer needs compliance research. In practice, both total quality management and quality function deployment have provided evidence of their benefits. However, they have been found to require long term company and top management commitment and, unfortunately they are often not used with as much sincerity as their advocates would like.

2.4.1.4 Structural linking mechanisms

Wright notes that there is a kind of serendipity, that can produce an outcome which is greater than the capability of each individual alone – this being due to the synergistic effect of working together (Wright, 1998). Working together requires structural linking mechanisms which are both formal and informal. Of all the ways to illustrate or express the linking of the 'organisation', the simplest might be to draw a pyramid style chart, of some fashion or other, depicting formal structures and critical control relationships. This does not provide enough information to understand the behaviour of individuals and leadership style, nor does it show any informal relationships or communications which are required to develop products.

Organisation structures

Nadler and Tushman believe that a picture of organisational structure is a very limited perspective, which is narrow and static. Such a model only captures a small part of what goes on in organisations (Nadler and Tushman, 1988b). Organisational structure is of interest to this review because it intrinsically affects product development issues. It is the basis of corporate identity and therefore must have an impact upon customer needs compliance and product *quality*. With respect to customer needs and the production of *quality* products the main aspects influencing product development found tend towards the composition of the organisation. Organisational structure literature especially discusses the integration of marketing and technical groups and differing ways of working with the multifunctional needs of product development. Ulrich and Eppinger, describe the three simplest formal organisational structures a company can adopt.

> "The most appropriate choice of organisational structure depends on which organisational performance factors are most critical to success. ***Functional organisations*** tend to breed specialisation and deep expertise in the functional areas. ***Project organisations*** tend to enable rapid and effective co-ordination among diverse functions. ***Matrix organisations***, being hybrid, have potential to exhibit some of each of these characteristics."
>
> (Ulrich and Eppinger, 1995, p27)

However, there are certainly quite a number of complex alternatives possible, and each will have strengths and weaknesses. No one form will serve all needs. Therefore, companies have to rely upon judgement, anecdotal evidence and past experience when selecting a structure for the firm (Urban & Hauser, 1980). Often, the right structure for the product development process will be one which provides efficient multi-channel communication in an environment with a low degree of certainty, what Lawrence and Lorsch (1969) calls 'low-structure'. Empirical studies which have looked at the role of organisational structure tend to favour multifunctional team working (Maidique and Zirger, 1984; Pinto and Pinto 1990). Hart *et al.* (1989) report that they found a positive correlation between teams and dedicated product departments and better company performances in the marketplace. Conversely, they found a negative relationship between product performance and companies that have either a new product manager or where the technical department alone is responsible for new product design and development.

Multidisciplinary approaches

Interdisciplinary inputs are a very important aspect leading to product success, separating the highly successful firms from those with the lowest success rates for new products and the lowest percentage of sales by new products (Cooper and Kleinschmidt, 1995a). Processes should be put in place to ensure multifunctional teams work well and effectively together, because during NPD may be the only time individuals meet (Hart, 1995). A multidisciplinary approach to NPD can reduce the time it takes to get from idea to launch (Takeuchi and Nonaka, 1986; Dolan, 1993; Himmelfarb, 1992). Yet, there are problems with team working. There is evidence that teams which have been together for a long period of time (over 5 years, for mean group tenure period) have lower success rates with projects, than those which are more dynamic and are together for shorter time periods (between 2 and 4 years) (Katz and Allen, 1982). If a team is together for too long they may form a negative mind-set (Huczynski & Buchanan, 1991) and may even fall foul of the "not invented here syndrome" (Katz & Allen, 1982) which dogged function-based phased development projects (Himmelfarb, 1992). Forming a team which consists of different disciplines is not enough to succeed. A regime is required which encourages relationships which work for the good of the product development process tasks. A good rugby team has been used as an analogy for the many interactions and the effort that is essential to accomplishing a common goal (Cooper and Press, 1995). Urban and Hauser, 1980 and 1996 and Eales-White, 1995 are some of the many authors who describe the various informal roles which need to be assumed by the individuals which make up the team in order for it to achieve.

Informal structures

It has been found that informal mechanisms are essential to transfer ideas and information, as well as other resources, during idea generation, problem solving and field testing phases of the innovation process. Indeed, research by Conway, indicates the mobilisation of informal boundary-spanning and contacts and networks may often be an important, and sometimes critical, factor in successful innovation (Conway, 1995). Nadler and Tushman also suggests that differing types of strategic links, which are made to cope with the capacity of information and resources produces a high reliability upon informal communications (Nadler and Tushman, 1988a). Unfortunately informal communications not only provide for supply and acquisition of information know-how, but they can have detrimental affects upon the project and company. Firstly they can result in information leakage - the trading and sharing of information by employees may be guided by purely personal objectives or even misguided, due to the insufficient availability of managerial information to enable well-informal decisions to be made. A second concern is that, given the importance of these activities to the innovation process and the reliance of the innovator on a small number of specific individuals acting as boundary-spanners, the organisation is vulnerable. Thirdly, the unpredictable nature of the interaction patterns within informal networks are difficult to evaluate and manage (Conway, 1995).

Flexibility in organisations

Development projects which require innovation need flexibility and organic structures (Cooper and Press, 1995). Calantone *et al.*, 1993 empirically investigated the role of organisational structure, marketing skills/ activities and technical skills/ activities in NPD and whether the adoption of an organic, flexible structure by a firm serves to encourage successful innovation indirectly. The results, from 142 firms, showed that flexibility in organisational structure was related to higher levels of skills and resources in both marketing and technical areas. Through its impact on marketing and technical skill, organisational structure was shown indirectly to affect the performance of marketing and technical and marketing activities, and ultimately product quality and NPD success rates (Calantone *et al.*, 1993). Also important, is the study by

Kleinschmidt and Cooper (1991). They noted that products with moderate innovation and low product advantage (meeting less of the customers' needs) were also a relatively poor fit to the firm's resources – both technically and for marketing (Kleinschmidt and Cooper, 1991).

Discussion on the various frameworks continues and many new issues are being highlighted as important to the success of product development. Nadler and Tushman (1988b) suggest that a company should undertake a problem analysis process to understand organisational development. This is often necessary because the conditions organisations face change frequently (Quinn, 1986). Nadler and Tushman's 'congruence model' and the problem analysis process that goes with it are tools offered to help managers create, maintain and develop effective organisations by structuring and dealing with the complex reality of organisations (Nadler and Tushman, 1988b). Sharpe and Goodwin (1993) believe that multidisciplinary product interactions can be modelled by using a model called a 'causal lattice'. They do show the integration of different groups, and their relationships with product quality issues. Unfortunately for this research, they concentrate upon lower level technical sections e.g. component level requirements of force, temperature, velocity etc. rather than the overall customer benefits being sought.

In a different piece of work, Nadler and Tushman, (1988a) collate and reviews information on different communications and organisational structures. They compare the information-processing capacity with cost and dependence on the informal organisation for each of the basic structural linking devices. Figure 2.20 provides a summary of their work. This helps in the understanding of the impact which management and structural linking mechanisms have upon the product development. This can also be tied to the duration of a project and the rate of change of knowledge in any given product development (Allen, 1977). A long project duration and rapidly changing technologies and knowledge bases, rely more upon the functional aspects of organisations, whereas short duration projects, or where knowledge or technologies are slower to change, then project organisations provide better success. (Urban and Hauser, 1996).

Linking device	Description	Cost	Dependence on informal organisation	Information processing capacity
		Low	*Low*	*Low*
HIERARCHY	Use a formal distribution of power & authority. It is limited because of inherent cognitive & information processing capacity. Managers & other individuals can become overloaded.			
LIAISON	Rely upon intense problem solving between two liaison individuals, who serve as sources of information & expertise. They can enhance information flows, but rarely have the authority to back up their positions.			
CROSS-UNIT GROUPS	Use task relevant representatives to focus on problems/ products/ markets. The groups can be temporary, permanent or ad-hoc. The objective is to ensure the correct expertise comes together. They provide a more extensive form of information transfer than liaison individuals, but rely on more informal mechanisms for this.			
INTEGRATOR ROLES/ DEPARTMENTS	Are used if problem solving requirements increase and more decisions affect multiple groups. The roles are responsible for co-ordinating cross-functional groups. Integrators do not have formal authority for all personnel and must rely on expertise, interpersonal competence, team and conflict resolution skills.			
MATRIX ORGANISATION	Whenever strategy requires simultaneous maximisation of several different dimensions, including information processing the matrix structurally improves co-ordination by balancing power with 2 chains of command. The individual reports to both functional and project manager which makes the management very complex, requiring dual controls and rewards.			
		High	*High*	*High*

Figure 2.20. The consequences of different structural linking mechanisms (after Nadler & Tushman, 1988a, p482)

Future organisational structures

The future for NPD structures may be as discussed by Osterlund, 1997. He disagrees that the way forward is through multifunctional teams who physically group together. He suggests that the usual way to assign specialists of different professions into interdisciplinary project teams endangers core competencies necessary for corporate success by removing the individual from the source of the competence. Thus Osterlund dissects traditional ideas (such as Nadler and Tushman's,) and involves the ever-improving Information Technology to make communications more appropriate to a competence based approach and the establishment of virtual teams for project work. He describes replacing face-to-face personal contacts with technologically-driven medium such as electronic mail and full media video communications (Osterlund, 1997).

If it is to work in the future, however, these product design and development 'teams' (whatever form they take) must have a focal point – customer needs compliance. Management is important, so that these groups do not become dis-located from the process, or fail to co-operate because of functional territory and authority issues which have forced a reluctance to operate quickly in the past (Himmelfarb, 1992).

2.4.2 Production and use of information during NPD

The development of a product can be seen as a series of information cycles carried out to increase the level of detail and evolve a set of work objects that contain complex and well organised information (Bailetti and Litva, 1995). Information is the base currency in the NPD process (Hart, 1995). Unfortunately, much of the literature assumes that designers are mere recipients of information on customer needs and requirements. It sees marketing and product management functions as the providers, and the role of design is limited to performing technical tasks, regarding this information (Bailetti and Litva, 1995).

It is true to say that all of those involved in the design and development of new products rely on information which has been created internally or is provided by an external source. However, what is produced or delivered to the managers, marketers, designers and other engineers is only worthwhile collecting and disseminating if it is really meaningful information – that is "it must add to the (person's) store of knowledge, to be meaningful, the increase in knowledge must be relevant to the (person's) decision-making activities" (Bentley, 1990). Therefore, to generate and develop the concepts and embodiment of the design which are oriented towards the customer, what is required is clear information about the target market and their needs (Bruce *et al.*, 1995a).

The tasks of information collection, transformation and interpretation are key to the undertaking of design and development. Put frankly, the product development process can be seen as:

> "a progression of activities complicated by the presence of repeated iterations in the search for the best solution to a series of design problems.... To facilitate this approach, the designer needs continuous access to information and the knowledge, skills and opinions of many people. Recognising the need for information, being able to identify the sources from which it is available, and ensuring that it is taken into account during the product development process is essential for good design. For this reason, information management is one of the most important activities of an accomplished designer."
>
> (Wright, 1998, p17).

When placed under scrutiny, these comments can be born out in reality. Information accumulates and grows massively throughout the development process (Wright and Swain, 1995). Previous research has found that that designers can spend between twenty and thirty percent of their time searching for, and handling information (Cave and Noble, 1986) and that, on average, 18% of a designer's time is spent searching for information (Court *et al.*, 1993). Thus, the systematic management of vital information and knowledge to aid customer needs compliance requires discussion. Recent work of Cooper *et al.* (1998) relate a theoretical framework of data acquisition/ generation; data transformation; and requirements capture which make up the front-end product development activities of requirements capture. They believe that one way of ensuring *the right product for the right market at the price* is by paying attention to requirements capture, and inherent in this is the management of the production and use information (Cooper *et al.*, 1998). Therefore, attitudes, problems and activities associated with the processes of creating, collecting, organising, disseminating, and exploiting customer needs information are looked at further in this section.

2.4.2.1 Information gathering and generation

Data gathering and the generation of information are important because the decisions taken about requirements later on are only as sound as the data they are based on (Cooper *et al.*, 1998). Building up a strong competence in the capture of information will affect the competitive performance of the company (Bruce *et al.*, 1996). Poor information collection leads to poor decision making and non-conformance of products (Angus and Murdoch, 1993). Relevant information about the market, competitive products, strategies and consumer tastes, wants and needs can be used by the firm to make better marketing decisions (such as how much promotional or distribution support to render) and also better technical decision (such as what product concepts to bring to prototype or what features to build into the final product). Thus adequate performance of market intelligence activities should improve performance of certain technical activities as well as other marketing activities (Calantone *et al.*, 1993).

Data and information gathering

To provide the right information, it is crucial to know what the requirements of the information users will be. The way people think determines what information they require. Marketing and design executives will spend time thinking about the customers of their products. The way they think about them determines the information they want about them (Howard, 1968). Also, the design team will want to pull together a specification or design brief for the product, which may require information on as many as 30 customer needs areas (Pugh, 1991). The front-end design activities of requirements capture, idea generation, concept development and feasibility testing all demand knowledge to make informed decisions (Wright, 1998). Information is used to solve individual, complex and multiple problems during product development (Court *et al.*, 1993). Essential marketing information needs are those of knowing the market, knowing trends, knowing what is being sold to whom, where and what for and knowing how well the company and competitor products are meeting market needs (Bentley, 1990). Information is also essential to help reduce risk. However, all the information to make a decision with 100% certainty will never be provided, therefore it is just as important to know what information is not available, so that the risks being taken can be assessed (Drucker, 1968). The individuals' needs for information will differ a great deal. One of the most important factors for making decisions about how much information is required is personal experience. Bentley (1990) found that the more the experience a manager had in a particular job, the more they relied on accumulated (internal) knowledge and the less they requested more information.

Data sources

It has been found that commercially successful firms employ more, deeper and formal forms of information sources (Bruce *et al.*, 1995b). Excellent companies are characterised by user orientation: they stay close to their customers and understand their requirements (Holt, 1990). The requirements for a new product can be grouped into product requirements, market requirements and financial requirements (Cooper *et al.*, 1998). In order to produce requirements which will anticipate and satisfy customer needs, information must be collected from appropriate sources, in the right manner. Cooper *et al.* (1998) think of different data sources as 'vessels' which contain or possess data. These 'vessels' (e.g. individuals, groups, objects, written material) give up information which is the outcome of two separate factors: their *internal cognitive influences* and their external *received influences* (Cooper *et al.*, 1998). These influences may be meaningful to this research because of the many different ways that a designer can acquire what they consider as customer needs information. Product developers may use a particular source, such as a catalogue, to gain different types of information such as an overview, hard product data, soft product data or commercial information (Court *et al.*, 1993). However, it is important to bear in mind that the source may not be appropriate to the application. The "careful selection of research technique and control of the acquisition/ generation environment, which form part of a data source's external influences, are necessary to ensure useful data is acquired..... (so that) only those data sources whose internal and external influences are appropriate are approached during data acquisition." (Cooper *et al.* 1998, p506).

Holt *et al.* (1984) describe the use of three main types of data source which may be appropriate for customer needs information:

Secondary data sources which make use of existing information. These are a relatively cheap way of obtaining information about users. The major problems with secondary information relate to finding the location of the most important sources, and then to foster a company culture which emphasises the utilisation of relevant data.

Primary data sources, where the company generates new information. This is a more expensive means and requires greater effort to assess the needs of customers. However rewards are that the information is generally more complete and reliable.

Other sources which provide information. These include informal approaches and indirect methods of product safety tests and ecological analysis.

(Holt et al., 1984).

One study by Araujo *et al.* (1995) found that the main information gathering activities for customer needs utilised methods of interview, customer specification, observation and questionnaire. Other empirical studies relate that many people rely upon their own data stores and do not use external information gathering (Bentley, 1981). However, Hart notes that much research is still warranted into how information is generated and what contingencies might affect information gathering activities (Hart, 1995).

Information and knowledge generation

There are problems hindering knowledge generation. Information generation is, by no means, straight forward. Resources may be insufficient, the information captured may be presented in a way that is difficult for others to access, or poor communications between functions may mean that information is discarded (Bruce *et al.*, 1996). Collection of information is expensive and time consuming, as is its transformation into something useable (Hague, 1992). There is also limited time for the recipients to read and assess the contents of reports, diagrams and charts when they are presented (Wright, 1998). Additionally, those who receive the information can be very critical. Formal information produced may be judged with suspicion and given little regard. There is often a higher awareness of the inaccuracies contained within it, rather than beneficial aspects of it (Bentley, 1990). It is the focus on the customer and their needs which is of prime importance to the designer. This role fundamentally relies upon the supply of a breadth of information to enable informed decisions to take place. However, the collection, capture and management of such information is often not as effective or efficient as the recipients would like (Bruce *et al.*, 1995a). In spite of this, at the end of the day, the design team has to make do with whatever information they can obtain, since they have to progress the project and carry out their function, no matter what is available (Bentley, 1981).

2.4.2.2 Information transformation and dissemination

Having collected customer needs information it is important that this is then passed between marketing and R&D and other disciplines involved in the design of the product. The information needs to be realistic, well analysed, well presented, consistent and useful (Gupta and Wilemon, 1988). However, there is often "no shortage of information in most organisations; the trouble is that it is often the wrong kind of information, excessive, irrelevant and incompatible, apart from being outdated" (Chisnall, 1977, p91). Unfortunately there is often significant dissatisfaction from design and marketing teams with the type of information supplied about customer requirements, the quality and the format in which it is delivered (Bruce *et al.*, 1995a). This may be because the increasing complexity of products places increasing strain upon information systems and those who use them (Angus and Murdoch, 1993). Acar's (1966) triple-helix design model examines this in that everywhere in the process of developing a product he suggests that there is a requirement for a circular interaction of information passing between specification, conceptual and embodiment design. Therefore, it is understandable that empirical studies show when attention is paid to meaningful improvement to communications and an integrated approach, there is better product performance (Service *et al.*, 1989).

Information flows

To enable a company to operate, there is a network of information flows (Howard, 1968). However, information may not be free-flowing in many firms. It has often been mentioned that information and knowledge are a form of power. More information equates with more power and that is why, in practice, many managers are reluctant to forfeit the information they have managed to accumulate (Bentley, 1990). Other researchers report that access to information varies widely amongst firms (Cooper *et al.*, 1998) and transfer of information and knowledge may even affect the successfulness of innovation (Gilbert and CordeyHayes, 1996).

Even when information is available, it may not actually aid the product development team in making design decisions. Three reasons suggested by researchers are:

Information presented may be viewed with suspicion. Empirical studies reported that information given to mangers was regularly not taken seriously (Bently, 1981). Cooper *et al.*, 1998, describe how "source suspicion" affects the individual's interpretation of data. A designer may take more or less notice of the information depending on how they rate the data and state that "ideally, this rating would depend on the perceived expertise of the data source in relation to the data provided... alternatively, it may be based on the perceived importance of the data source to the development project... in addition, however, source suspicion often may be the result of an individual's prejudice against certain types of data sources" (Cooper *et al.*, 1998, p507)

Formal systems contain data from dubious sources. Unfortunately, one of the reasons why the former point is true, is because things get reported 'as fact', when they are not. The Bentley research also provides evidence of this. He reports that "a great deal of the information in formal systems, whilst appearing accurate, is often based on highly suspect raw data." (Bently, 1990, p.56).

There is the potential to misinterpret the data. "For the design function to respond effectively to this information, it must be prepared in a way that enables the designer to interpret it in an appropriate way. In many cases, the marketing information needs to be analysed and re-formatted by the designer. In the case of an engineering designer, unquantified customer perceptions of requirement may have to be interpreted to quantified performance descriptions. Such re-formatting carries the potential danger of misinterpretation, leading to a final product that does not meet market requirements" (Wright, 1998, p54).

These issues provide another set of explanations as to why a *quality* gap can occur during product development – inappropriate information transformation and dissemination. Wright (1998) admits escaping such problems is not really achievable as long as human beings are involved in the system. Cooper *et al.* (1998) suggest that although complete avoidance may not be possible, using methods such as formal weighting and QFD to provide a more objective view should be encouraged.

Information processing

As stated previously, the reason why data collection and its subsequent dissemination is so vital to product development is because data are at the bottom of a processing hierarchy: by choosing and analysing raw data, information can be produced; by selecting and combining information, knowledge can be generated; from this decisions can be made; actions are then taken and recorded (Webb, 1998).

The decision making cycles required to develop a design model needs all sorts of different types of data, information and knowledge. Specific to customer needs compliance, the development team will need customer requirement knowledge and in particular, customer requirement knowledge developed both externally and internally

(Bailetti and Litva, 1995). In their discussions of design model evolution, Bailetti and Litva describe the basic building blocks for the product development design cycle as:

A design model that is an input to the cycle (Design Model M_i). This embodies the input to the design cycle and includes constraints of the formal system model.

A design model that is the output from the design cycle (Design Model M_{i+1}). The output from the design cycle, includes constraints of the evolved system model.

The designer. Important here are the attributes of the designer, such as age, education, salary, experience etc. They decide upon design plan and then apply knowledge to derive Design Model M_{i+1} from Design Model M_i.

The customer requirement information endorsed by marketing and product management. Such as the goals and intentions formally included in development plan. These establish formal constraints for the design cycle$_{i+1}$.

The customer requirement information produced and used locally by the designer's work group. Including goals and intentions shared by designers in a work group. They establish informal constraints for the design cycle$_{i+1}$.

A formal proof that establishes that Design Models M_i and M_{i+1} are equivalent. This establishes the equivalence between Design Models M_i and Design Model M_{i+1}. This must include the attributes of the method used by the designer.

(Bailetti and Litva, 1995)

Their work is important to design development and customer needs compliance because they carry out research in companies looking at how exactly designers make decisions and how they use customer-related knowledge to evolve the design. Figure 2.21 shows the evolution of a system design model and the role of different types of customer requirements information and knowledge, studied and tested by Bailetti and Litva (1995). They determine that design teams create much local knowledge which is used to develop products. Because of this, organisations must ensure that "the formal definitions of customer requirements, the information about customers created by design groups locally and the customer-related knowledge actually applied by the designers to evolve the design are internally consistent" (Bailetti and Litva, 1995, p14). They fail, however, to explain exactly how to maintain congruence with the real customer requirements, which is one aspect important to this particular research.

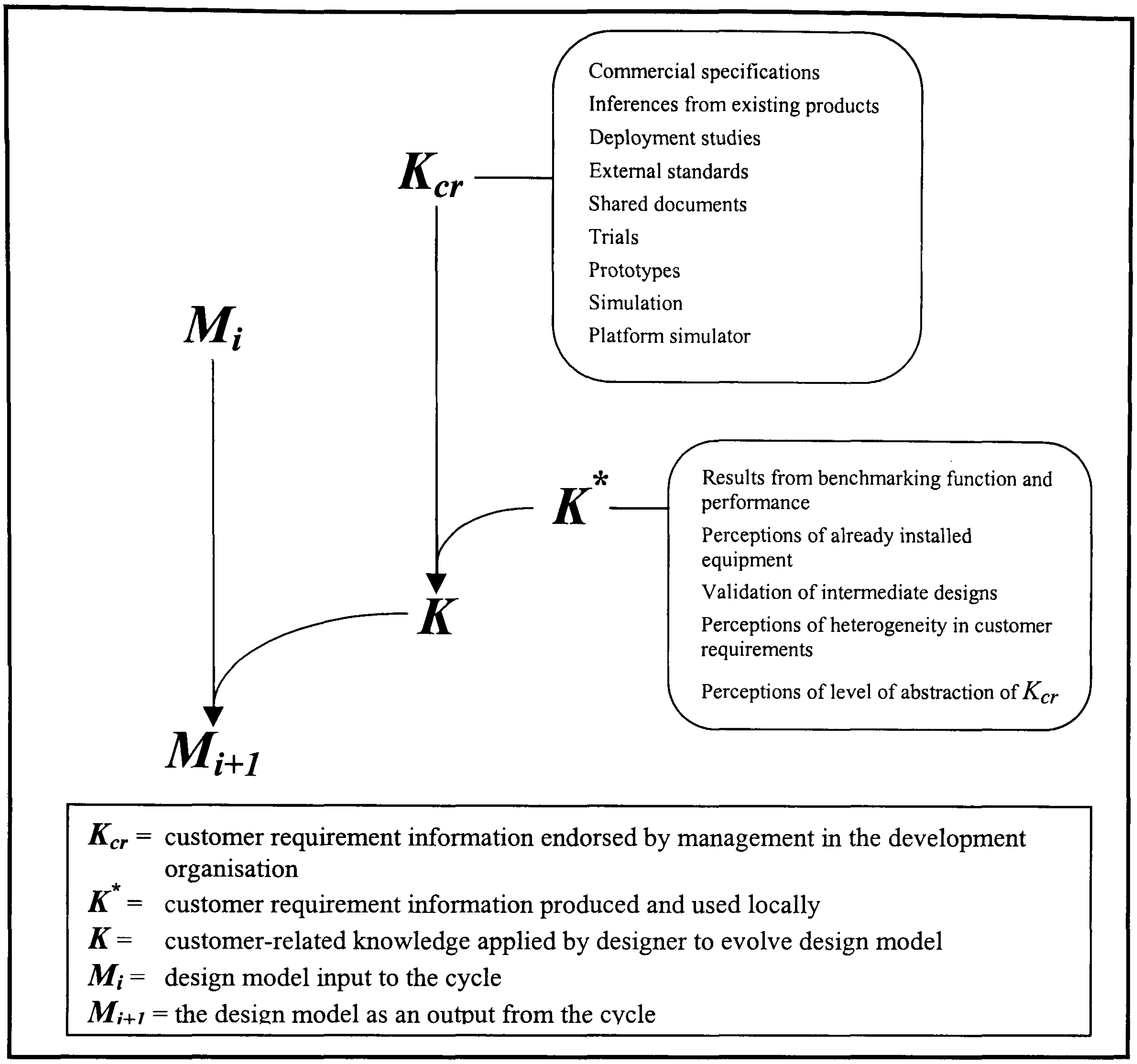


Figure 2.21. Sources of customer requirements information used by designers to evolve design model (After Bailetti and Litva, 1995, p13)

Information transformation

The use of information and knowledge to capture requirements has also been examined recently by Cooper *et al.* (1998). They too, discuss internal and external influences upon the designer as they develop product requirements. Interestingly, they produce a model which has different, but equally important information cycle elements, to those of Bailetti and Litva. It is noteworthy to mention their deliberations about data transformation. They expand the transformation task stating that transformation of data occurs twice: firstly, as each individual interprets and understands the data themselves; and secondly, when the data are examined when a formal understanding is reached through the interaction, discussion and even argument of the individuals involved in the design team (Cooper *et al.*, 1998). If these ideas are then followed through, they will obviously impact upon an individual's perception of customer needs. Which may, or may not be the same as those shared by colleagues (Cooper *et al.*, 1998).

Involvement in information processing

Interdisciplinary group synergies and structural linking mechanisms have already been mentioned in section 2.4.1.4. However, it is worth mentioning a few specific issues which directly impact upon information dissemination here. It is agreed that the majority of NPD requires many different skills and knowledge bases. It is also no secret that functionally based organisations often find it difficult to communicate (Wright, 1998). In order to be an innovative company, effective communications of customer needs and wants must be facilitated between specialist groups (Marquis, 1988). Information exchange problems occur because of the different backgrounds in education, training, terminology and responsibility between people on the team. These are what Lawrence and Lorsch have called "differentiations", that influence the thinking of people, so that different impressions result from the same data (Bergen, 1990). Therefore, a common language is necessary between team members, but this is often not easy to establish (Sharpe and Goodwin, 1993). One way of breaking down the product into the different subsets of information which are seen by team members is that of viewpoints or perspectives. Erens *et al.* (1993) provide five examples of possible viewpoints of a product family, in their paper which reviews current design

frameworks:

- The commercial specifications of a product family (sales and marketing view);
- The functional decomposition of a product family (product engineering view);
- The physical decomposition of a product family (assembly engineering view);
- The technical realisation of a product family (manufacturing, logistics and service view);
- The project management of a product family (design management view).

(Erens *et al.*, 1993, p1281)

When the product development starts, customer requirements are going to be generated. Different individuals will see the market, customer and product requirements differently because of the way they each transform, interpret and view the same customer-related information. Cooper *et al.* (1998) therefore also suggest that the choice of those who are to be involved in the interpretation of data and the subsequent generation of requirements is important. They offer advice that those involved must be able to work together effectively and be able to look at issues and concepts subjectively, with the ability to stop products early in the development process if they are likely to be unsuccessful. The integration of the different viewpoints within the group will be aided by co-location (where appropriate) and frequent interaction and meetings (Himmelfarb, 1992). Indeed, the results of study work has provided evidence that the frequency of meetings (at least weekly) has a positive relationship with the percentage of turnover accounted for by new products (Service *et al.*, 1989). With informal information sharing within these forums being essential to the successful implementation of projects (Pinto and Pinto, 1990).

Facilitation of data and information transfer

There are various other formal methods of information transfer and ensuring customer needs compliance. The results from a survey by Araujo *et al.* (1995) indicate that the most popular way is by carrying out a design review. An important starting point for this is the use of a design brief, which needs to be unambiguous, providing the development group with a focus. The brief should help keep aspects such as design costs and programmes on track, but it's main task is to avoid producing a compromise solution which has insufficient *quality* and does not meet market or customer requirements (Besford, 1987).

Information sharing through formal and informal means should aid the design team in making the right decisions about customer-related knowledge. The work on data transformation and interpretation, together with viewpoints offers an appreciation of the different ways the product can be thought of. However, facilitation is generally needed in order to supply understanding between the different perspectives and to agree on a common goal. At the moment, this task is mainly down to design and development or product marketing managers to perform (along with all the other tasks which we have discussed in previous sections).

Information systems (computerised or paper based) still lag behind what is really needed in terms of workable design support, mainly because it is difficult to capture the dynamic nature of the developing product and requirements information (Macleod *et al.*, 1994; Angus and Murdoch, (1993); Harpen and Luiten, 1993). One such example in terms of the design team, is that the drawing is still considered as a central carrier of information between departments and discipline (Harpen and Luiten, 1993). Computer Aided Engineering (CAE) and Computer Integrated Manufacture (CIM) use tools and techniques such as computer-aided drafting, drawing, manufacture and component analysis as information carrying support (Yeomans *et al.*, 1985). However, surveys carried out indicate that often no more value is added to the information than would be conveyed in a paper-based drawing, and automation tools fall short of expectations (Harpen and Luiten, 1993). In another study, Angus and Murdoch, (1993) offer a practical example for the use of a computerised Interactive Knowledge Source (IKS) to reduce non-conformance, through improved information delivery. Again, although this paper provides an illustration of the practical appraisal of design-assistance packages, the description is more about engineering characteristics than customer requirements. This is typical of the design literature accounts: that real success in integrated customer-needs knowledge systems are uncommon.

Customer needs information

As can be seen by these discussions, there are many prominent issues relating to the production and use of information in the NPD process. Discussions on the creation of knowledge through the use of information and data sources is an expanding area of research. However, it is notable that few studies discuss customer needs information. Court (1998) reviews some of the empirical studies and simulation studies of information and knowledge access in engineering design. In particular, he identifies some pertinent issues that will need to be considered in order for information and knowledge to be successfully integrated into future product development. Issues identified, that are relevant to this study include:

1. An appropriate format for information and knowledge presentation to be shared between users should be agreed.
2. Research is still needed to determine a clearer understanding of the means by which knowledge used in NPD is represented.
3. Research is required to establish new methods of physically locating knowledge so that it is more beneficial to the whole company.
4. New systems must be developed that can treat knowledge in a manner that accurately reflects the current design situation.

5. It is important that these systems can record and subsequently distribute individual knowledge and company experience.
6. Research is needed to develop techniques for "best" design of computing tools that aid rather than impede the flow of information and knowledge to the engineer.
7. Methods and tools are required for determining the accuracy of an individual's (and company's) knowledge entering a system and to evaluate the quality of the knowledge used in NPD.

(Court, 1998, pp.497-499)

2.5 Summary: Implications of previous research

The objective of this literature section has been to bring to the fore the state of the art in the area of NPD and customer needs compliance. It has explained some of the principles involved and concepts which are generally referred to in the field of NPD and marketing. This review has concentrated upon findings and discussions of previous researchers and has sought to define the context in which the research described in subsequent chapters took place. It has examined the areas of customers, product definition, NPD process modelling and activities, together with a discussion of management issues and matters of information production and use during product design.

The literature has revealed that there is much anecdotal evidence, postulation and idea generation around the area of NPD processes and designing new products. Yet it also indicates the lack of research which has been specifically carried out, that looks at customer needs during NPD. In particular, the requirement for further study is evident in a number of particular areas.

- Customer needs literature is mainly restricted to marketing and marketing research literature. There is little research in engineering and design which acknowledges the importance of the customer as the end recipient of the product's *quality*.
- There is much NPD literature which concentrates upon general NPD and, in particular, the success and failure of products, broad NPD processes and the overall management of new product ideas. However, specific attention to the customer during success and failure, NPD process, or management of design is minimal.

- There are no apparent NPD modelling methods which have been specifically designed to capture and show the development of new products to meet customer needs requirements. Those models which are available may be used as a basis, but definition of how and what should be modelled to capture information on these aspects is required.
- It has been discussed that the most successful companies undertake both marketing and technical activities well. It has also been noted that good market research is a key to achievement, together with practical application of quality techniques. However, little empirical case work has been carried out to discover the affect these issues may have upon customer needs compliance and customer satisfaction.
- The strategy and structural linking mechanisms adopted at company and project level have been discussed in the management literature, but still little empirical studies in design research acknowledges links between strategically valuable NPD processes and customer needs.
- The production, transfer and use of information on customer needs has been included by a number of authors. However, Hart (1995) notes that much research is still warranted into how information is generated and what contingencies might affect information gathering activities. Also, Court (1998) identifies that there are still many areas worth researching with respect to information and knowledge presentation within the design process.
- A *quality gap* has been recognised and discussed by previous researchers. However, there is certainly a requirement for more empirical research to investigate the role of the perceptions that the design have of the product's *quality* during NPD.

The literature has revealed that there are many gaps in current NPD research, and therefore, potentially a large number of definitive areas for research in the field of customer needs compliance, product *quality* and NPD. However, much of the work carried out by previous authors *can* be used as a basis to start a novel project. Chapter 3 in this thesis details the exploratory work undertaken after the literature review to determine a more precise direction for the concentration of research effort. After this literature review and exploratory work, Chapter 4 then presents conceptual work and the development of the research problem into hypotheses.

Chapter 3
Exploratory investigation

This chapter describes the exploratory investigation undertaken after the literature survey. This was carried out in order to determine the most appropriate direction for the construction of research questions and to establish the context and realistic limits for further research in practical industrial circumstances. The investigative study uses experience surveys and analysis of selected cases. Their research designs, analysis and findings are discussed in this chapter.

3.1 Objectives of investigative work.

Since the literature has indicated that there is little which is specifically known about the problem of customer needs compliance during NPD, exploratory investigation is particularly appropriate as the foundation for directing the main research study (Churchill, 1995).

The basic aim of exploratory research is to provide ideas and insights (Selltiz *et al.*, 1976). For this research, the main objectives of the exploratory investigation can be summarised as:

- gain deeper knowledge and familiarity with the research area and formulate the problem further;
- establish priorities for the research;
- help develop research questions and hypotheses;
- gain information on the practicalities of undertaking the main study.
- The exploratory investigation endeavours to progress the research towards a situation where the problem can be conceptualised, ready to produce research questions and hypotheses that can be more accurately considered in the main study.

3.2 Investigative study design.

There are a number of different methods that could be employed to gain insights and ideas to progress the research. For this investigation two forms of study are particularly useful: (1) experience surveys and (2) analysis of selected cases. A semi-structured-undisguised approach was taken during all of the exploratory investigation work (Malhotra, 1996). At no stage were the objectives of the study hidden from the interviewees. Also common to both designs is the need for flexibility, and hence the lack of formal design for example, detailed questionnaires and probability samples are rarely used (Boyd *et al.*, 1989). Thus, neither of the two exploratory methods used questionnaires, but rather, a flexible and more accommodating semi-structured interview technique. Also, both used a purposive sample: individuals were chosen from a willing collaborative company, who produce medical devices for UK and overseas markets. Only one company was used for reasons of time and cost – the risk of this being unrepresentative was accepted, as it was expected that the study would be sufficiently productive for the specific purposes of the exploratory investigation (Green and Tull, 1978).

3.2.1 Experience surveys

The purpose of experience surveys (also known as "key informant surveys") is to collate knowledge and experience that is relevant to the general research subject (Churchill, 1995). For this research, selected individuals at one company were used in order to gain expert opinions on the subject of customer needs and compliance during NPD. There are many people who are familiar with the general subject of product development and could class themselves as knowledgeable. However, this research chose to view "experts" as those who were involved in the day to day development of new industrial goods and, in particular, also had experience of the customer.

The interviews for each case in the experience survey took between 1 and 3 hours, depending upon the amount of time that could be provided by the expert. It is important to include people with points of view that differ (Churchill, 1995). Therefore, three different experts were consulted, one each from the marketing function, the design function, and the research and development (R&D) function. After these three interviews, the information collected was reviewed and it was deemed that it was satisfactory for the purpose of evolving the research.

Experience surveys give the researcher the opportunity to provide a feel for what research hypotheses would be most productive (Churchill, 1995). Therefore, these key informant surveys were used to ask interviewees what they felt to be the most likely influences upon customer needs compliance, in their experience (Selltiz *et al.*, 1976). Interviewees were asked to elaborate on their answers, and to include their own opinions about what could be done to improve customer needs compliance during NPD.

3.2.2 Analysis of selected cases

Analysis of selected cases were also used as part of the exploratory investigation, after the experience survey had taken place. This research method involves intensively studying particular cases of the phenomenon that is being researched, and is also sometimes called "insight-stimulating examples" (Churchill, 1995, p161). Analysing selected cases can help produce hypotheses by studying cases that are in some ways generally representative of the expected main study sample, but are also in some ways in stark contrast to one another, to intensify any important differences that may be found. As such, the selection of cases (individual people) was determined by a number of factors:

- all cases were people involved heavily in the NPD process;
- cases reflected differences in experience of the customer (with extremes of many days spent with the customer, to no involvement at all);
- cases reflected the differences that the interviewees in the duration they had worked at the company, and differences in product knowledge;

Six cases (individual people) were used for this stage of the investigative study. Again, following information collection, there was a review which established that after these six interviews little new data was being found – an indication that this was an acceptable sample (Mahoney *et al.*, 1995). The sample included two of the experts who were used previously and four others from the R&D and design functions.

The aim of this part of the exploratory investigation was to gain insights from the company that could provide focus for the main study. The interviewees were asked questions about particular areas that the literature survey and experience surveys had revealed as possibly impinging on customer needs compliance. These areas included:

- the products, markets and customers of the company;
- what the interviewee deems to be important customer needs;
- who is the competition and also who is involved in the supply chain;
- what externally influences there are on company;

- what they use as performance measures;
- the product development strategies of the company and who they saw to be the stakeholders involved in the NPD process;
- how the company provides communications of customer needs and other important information during NPD.

3.2.3 Exploratory instruments

The investigation used specific methods for collecting data which were appropriate for qualitative exploratory research (Miles and Huberman, 1994). In each case the instrument was an interview script, which was very loosely defined for the experience surveys, but more tightly controlled for the selected case interviews.

The nature of the aims for the experience surveys meant that their structure was particularly flexible. This allowed the interviewer to ask questions that probed further into the importance and meaningfulness of previous answers given (Tull and Hawkins, 1993). The interview script for the experience surveys, that was used as a general guide to the interviewer, is listed in Appendix A.

The interviews for the analysis of selected cases took the form of semi-structured interviews, using a set of comprehensive questions in a tabular format, which required the interviewer to fill in the appropriate sections. An example of the tabular layout of the questionnaire, which sought to provide some structure for the questioning, is provided in Appendix B. The interviewer attempted to address all of the general sections for each interviewee, however, when it was found that the interviewee was not aware of any information on that subject, the next section was then dealt with. In addition to an interview script, one question required the interviewee to read and mark up a list of customer needs. This form of instrumentation was used because there was a long list of potential customer needs that required comment and discussion. This list is displayed in Appendix C.

For all of the interviews the main source of data collection was the hand written notes provided by the interviewer. Answers noted during the sessions were then written-up by the interviewer soon after the interviews, this adds back some of the information that are missed in raw field notes (Miles and Huberman, 1994). All of the interviews were also audio taped. These recordings were used to provide the interviewer with a reference for answers and meanings given by the interviewees. As the work was exploratory, it was not deemed necessary to fully transcribe the tapes.

3.3 Analysis of exploratory investigation

Qualitative data analysis often implies the requirement of time consuming and costly methods, used mainly on large volumes of unstructured, in-depth data. However, with this applied exploratory investigation it was necessary to take a more standardised approach that allowed the main issues to be unearthed, whilst acknowledging the value of other, indirect, material (Easterby-Smith *et al.*, 1991).

The methods of data reduction and analysis adopted here are those suggested by Miles and Huberman (1994). They introduce a set of tools which aid early analysis, followed by the use of matrices and tables of "data displays". These displays provide a "visual format that presents information systematically, so the user can draw valid conclusions" (Miles and Huberman, 1994, p91). However, before data displays were produced, preliminary analysis of the experience surveys and the selected cases was necessary.

The write-ups from the experience surveys were ordered and analysed using QRS NUD*IST qualitative data analysis software. The software package helped analyse the data by content analysis – allowing the assignment of codes to particular sections of the write-ups. These codes were then used to help delineate and order the areas of interest. Summary sheets for each of the three informants in the experience surveys were drawn up from the content analysis (Miles and Huberman, 1994). These were then used to develop an overall data display of the findings from this section of the exploratory analysis.

Case summaries were produced for each of the interviewees for the analysis of selected cases. These summaries were in a similar tabular form to those used as prompts during the interview. These were then further examined and condensed under general sub-headings. Main issues that were useful to developing the study were then extracted by the use of data displays.

3.4 Accuracy of exploratory investigation

Any research should stand up to outside scrutiny, as such it should be able to answer questions of validity, reliability and how well they can be generalised (Easterby-Smith *et al.*, 1991). Issues of accuracy for qualitative research have their origins in quantitative social science (Easterby-Smith *et al.*, 1991) but researchers find it very difficult to define the quality of qualitative research (Miles and Huberman, 1994).

Despite the altercations that exist around this subject, there is still the need to provide some credibility to the way the research has been undertaken and some defence of the conclusions drawn from it. In general, therefore, it is necessary to provide answers to the kinds of questions posed in figure 3.1.

Internal validity/ credibility

Has the researcher gained full access to the knowledge and meaning of informants?

Does an instrument measure what it is supposed to measure?

Do the findings make sense?

Are the findings credible to the people in the study and to other researchers?

Are the findings an authentic portrait of what is being looked at?

Are the findings internally coherent?

External validity/ generalisability/ transferability

Are the conclusions of the study transferable to other contexts?

Do they "fit" and can they be generalised?

Are findings congruent with, connected to, or confirmatory of prior theory?

Reliability/ dependability

Is the process of the study consistent and reasonably stable over time and across researchers and methods?

Will similar results be found by different researchers and/ or on different occasions?

External reliability/ objectivity

Is the study relatively neutral and reasonably free from unacknowledged researcher bias?

Is the research free from bias produced by subjects and conditions of the inquiry?

Figure 3.1. Some questions of the accuracy of qualitative research (After Easterby-Smith *et al.*, 1991 and Miles and Huberman, 1994).

As far as is possible, the researcher has tried to control the validity and reliability of the research, including the instrument. To help maintain internal validity, time was taken by the researcher to understand the interviewees; the interviewees were assured of their anonymity (Moser and Kalton, 1992); and experts (from academia and the company) were asked to review the findings from the surveys. External validity is something which cannot so easily be assured (Miles and Huberman, 1994). Also, the aim of the exploratory investigation was to gain an insight into the area of NPD and customer needs compliance in industrial product companies, to help develop hypotheses and to discover the practicalities of the main study. Unfortunately, having a study that is both based in practice, but that can also be generalised and applied to many different situations presents the researcher with a real research dilemma – that these two are opposing positions (McGrath, 1982). To claim as much reliability as possible between the selected cases, the researcher used a consistent set of questions and recorded answers in a consistent fashion. It is difficult to say if the same results could be repeated after a time lapse, as all companies and peoples' view points change – one obvious factor being that the interviewee does not remain untouched by the process of research, and their views may change after the fact (Green and Tull, 1978). It is expected that similar views would be recorded by different researchers, as the interviewees were assured of anonymity and spoke freely for several minutes on any one topic, but this again is probably subject to temporal changes. The objectivity of the research is mainly based upon whether the researcher is aware of their assumptions, bias and consistency in the application of methods to all of the data (Miles and Huberman, 1994). Uniformity and fairness in accepting information to form the ideas and develop issues was attempted by the researcher and by the research methods employed. Possible alternatives and opposing hypotheses were also considered by the researcher during the analysis and prior to the acceptance of any stated reality.

3.5 Findings of exploratory investigation

The exploratory work took the form of two different means of examination: experience surveys and analysis of selected cases. These two methods produced two sets of results, but the general findings of them were very similar for both. As such, the findings discussed here will include information gained from the exploratory investigation in total, rather than splitting the two up.

The exploratory investigation produced four main areas of relevance to the study: (1) knowledge and involvement of the customer during NPD; (2) participation of different company groups in NPD; (3) intra-company communications about customer needs; (4) other external and internal influences. These will now be discussed together with the practicalities of undertaking such a study.

3.5.1 Knowledge and involvement of the customer during NPD

The informants in the experience surveys initially drew attention to the fact that customer needs compliance is likely to be influenced by the customer themselves, together with the ability of the individuals who interact with the customer on behalf of the company. Although it may seem obvious that customer needs compliance is affected by the customer, the interviewees in the selected cases found it difficult to agree on who actually was the customer of their products. This is a reflection of the real life anomalies that are indicated in the literature (see chapter 2, section 2.2.1). In this study, each interviewee offered up to 5 different types of "customer": with a total of 7 different "customers" being identified between them, only two of which all respondents agreed were important. The development of a product which complies with the customer is therefore, not only affected by whether a customer is asked about their preferences, but also by which customers are asked. These results indicate the importance of the identification of customers, and that the work of Webster and Wind (1972), Bonoma *et al.* (1977) and Owen and Hills (1996) should be used to help review and understand the results of any findings in the main study.

The experience surveys also revealed that the customer could be involved with the development of a new product, to varying degrees. Some customers were highly involved – they were invited into the company to look at prototypes and simulations, or were involved in user panels, which discussed new ideas and problems the customer may be having with the existing products. The customers' information could be collected at different times and could therefore change the ideas of the company during the NPD process. However, some interviewees believed that a customer may be unable to make comments on what they really want, except when using a proposed design as a frame of reference. Also found to be important was the level of involvement different people within the company had with the customer. The analysis of selected cases found that some company personnel attended regular trade shows and went to the customers' places of work and observed the products being used. Others had a small amount of customer contact, some job positions within the NPD team allowed no interaction with the customer at all. There was a general belief that personal experience and design expertise within the NPD team, in place of asking the customer, is perfectly reasonable for making decisions on what the customer would like or need.

These findings emphasise that customer needs compliance is influenced by the methods of customer needs capture and also who is involved in these activities. It also suggests that, if customer needs compliance is to be studied in any depth, there is a need for capturing the temporal nature of the information.

3.5.2 Participation of different groups in NPD

The selected cases were asked about what they thought were the most important customer needs. On initial inspection, the views of what are important are very different, even within the same function. However, there does appear to be a tentative link between the job position held and the views given, that is those at the "bottom" (often the ones doing the detail design) have similar views to one another, but opposing views to those higher up the chain of command. This is an important observation for the research, because the main study may find more prominent groupings other than function.

The development of new products follow similar paths. Each project is set up in its own right and a team appointed to produce project work before full scale product development. The team provides information on requirements, time scales, costs, sourcing of materials and development labour, together with supply and warehousing issues. A senior engineer takes control of the project and has a multidisciplinary team working for them. Project timings range from a couple of months for customisations to a number of years for a whole product range. The teams are put together for this amount of time and then disbanded. Also most of the team are part-time members, working on a number of different projects at any one time. All of those interviewed were part of an NPD team, but had very different backgrounds and different knowledge of the customer. This is typical of current NPD practice (see chapter 2, section 2.4.1.4) and highlights the need to understand the discipline or functional background of those involved in the NPD team.

3.5.3 Intra-company communications

Every informant in the experience surveys implied that the major influence on customer needs compliance came from internal company communications and there was a general consensus that the practical processes put in place for communication did affect the quality of the final product. In the selected case analyses, all R&D personnel, including those at a higher grade, felt that they would like more customer needs information fed to them. They expected that, apart from their first-hand knowledge, there is likely to be much more information residing within the company that could help them design a better quality product if only they knew how to access it. Many spoke of the requirement for more of the informal type of information to be passed on from those who see customers more regularly. Also, the lower grade engineers involved in NPD voiced annoyance at not being able to get hold of people in other departments, especially marketing. Some said that when they got no feedback from marketing, they made the design decision themselves.

There were vast differences in opinion about the various methods of collecting and disseminating information. It was noted that one (management) respondent had a low and almost dismissive view of a design review process (which included specialist customer representatives). However, this was highly thought of, as a decision making body, by many others (especially in R&D) who were interviewed. Others said that they collected a lot of information that was not used by anyone but themselves and that there were few processes in place to share information about customer needs. All of these incidents show the importance of knowing who is involved in the production and use of information, if gaps in the process are to be understood.

Communications within the company were cited as the most important single issue that could be addressed to improve customer needs compliance. This observation implies that genuine consideration should be given to the role of communications in the NPD process, when conceptualising and developing the main study.

3.5.4 External and internal influences

There were many other issues that were introduced as possibly influencing customer needs compliance during NPD. These are summarised below.

- The company involved in this exploratory investigation produces products that are sold to hospitals. They are used by doctors, nurses, and physiotherapists, with the end user being the patient. The types of product that this company is mainly involved in developing change incrementally over a long period of time – the essence of some designs have been around for over 15 years. This situation is due to the controls placed upon it by external authorities. The driver for product development was thought to be a mixture of technology and commercial reasons. Despite being in an effectual "closed" market, there is a necessity to provide the customer with easy to use, reliable products which the customer can put their professional belief in. The difficulties of a "new to the world" type of product in this industry include an extensive trial programme and restrictive legal registration.
- Knowledge of strategic decisions did not appear to be penetrating into the company and lower level designers and engineers admitted to knowing little of the overall direction of the company. However, senior members of the interviewee sample believed that they knew what would be developed and changed within their own product areas.
- External product operation statistics are very important to the company, with certain reviews being particularly so. When these reviews had been worse than expected the company does try to find out why. But it was believed that a number of poor exposures had been due to some inappropriate means of testing the product, and hidden political agendas of those publishing the data. The company interviewees generally did not accept that their products were poor competitors. However, the success of products is not highly analysed by this company. Margins, sales and market share are collected and monitored to a degree, but is infrequently acted upon directly. The company generally did not identify between products that had been a "success", and those that had "failed" in the marketplace. No one accepted responsibility, or could even name a responsible third party for any "failures" that had happened. Informants gave the impression that there was more than a tolerance of mistakes, and rather a mind set which implied little

thought of financial matters. Thus, inappropriately designed or marketed products were not seen as completely unacceptable to the NPD team and this made customer needs compliance less of an issue.

- Company structure and cultural issues relating to the lack of promotional opportunities and (ineffective) appraisal systems produced dissatisfaction which seemed to impinge on the communications within the NPD team. Although obviously indirectly related to NPD, these and other issues were noted, as the development of products is not carried out in isolation from the rest of the company environment.
- It can be seen that there were many issues which could affect customer needs compliance in the NPD process and it would be impossible to list all of the nuances that respondents came up with. However, this exploratory investigation revealed that there were some major issues that should be investigated further and some minor issues that should be controlled as much as possible when undertaking a larger study between more than one company.

3.5.5 The practicalities of the study

As has been discussed by previous authors, undertaking this type of exploratory investigation opens up the researcher to be a sounding-board for the interviewees (Easterby-Smith *et al.*, 1991; Miles and Huberman, 1994; Green and Tull, 1978). As such, many topics other than those of customer needs compliance were brought up because issues of politics and culture in a company cannot easily be detached from the every-day working of the NPD process – listening to these issues enabled the interviewer to gain the confidence of the respondents, but also allowed some of the underlying issues to be included in the research. Therefore the researcher needs to be aware that any interactive interview will provide this kind of scenario, which needs to be managed well in the main study, especially as it is expected to be much larger that this exploratory investigation.

Factors relating to the size, turnover and products were available through company accounts and public databases (Financial Access Made Easy – FAME database). The company's standing with respect to market share, market size, market growth and their biggest competitors was found through an independent international report on the company's type of business. Ideally this sort of public domain information will be available for all companies and can therefore help comparisons between companies in the main study.

This exploratory investigation found that it was easy to gain insights that had no "right" or "wrong" answers – opinions of how the company operated, who the customer was and what the customer might need were easily accessible. Most respondents were very happy to provide details of information on how these needs were collected and disseminated within the company. Information that was harder to gather was that which was factual, or involved. Everybody had information that they did not know off hand and that needed a follow-up. Also aspects of culture, performance and success were more sensitive and difficult to get respondents to talk about.

There is a huge amount of information potentially available: freely given opinions and perceptions; views on sensitive subjects; known facts; and facts which need to be found out. In the main study, there will be a need to gain a fuller understanding of a few areas and be consistent, rather than to have an overview which is too general, where no conclusions can be made adequately. There will be some aspects that will require condensing, at the expense of others.

3.6 Summary

The literature review showed the large number of potential issues impinging on the area of customer needs compliance. Therefore, an exploratory investigation was undertaken to gain a deeper knowledge of the research area in practice and to gain information on the practicalities of carrying out a major study.

The two methods of experience surveys and analysis of selected cases were used to develop general findings of relevance to the research. According to these industry based studies, the major influences on customer needs compliance revolved around company and customer communications. Many different issues were raised, but there will be practicalities that will prevent all of these being investigated in further research. The conceptualisation chapter will develop the areas that will be included in the main study, in light of the literature survey and this exploratory investigation.

Chapter 4
The research problem: Conceptual work and development of research questions

Chapter four considers the theoretical basis for this research. The literature survey has provided evidence that there are many areas which warrant research with respect to customer needs and the NPD process. Also, that few empirical studies have been undertaken. In particular, there exists a need for work in the areas of information provision and use for NPD and customer needs compliance (see Chapter 2, section 2.4.2). This was also highlighted by the findings of the exploratory investigations. This research is therefore aimed at one particular area: understanding the role of customer needs and the definition of *quality* during NPD, through empirical study. Thus the general research problem for this research can be stated as:

> *How do companies define what the customer wants and what is the role of information management in ensuring customer needs compliance during NPD?*

The objective of this chapter is to define how this empirical research will undertake to provide an answer to this problem. To do this it conceptualises the problem domain in a model. Also, the chapter takes qualitative ideas that are difficult to evaluate, and breaks them down into terms that can be evaluated as constructs in the model. The chapter will then focus the problem through research questions and hypotheses that will guide the main study.

4.1 The conceptual research problem.

Further theoretical examination is required to advance this research before the formulation of research questions and hypotheses can take place. This examination uses the development of a conceptual model to illustrate linkages between aspects which affect the definition of *quality* during new product development. The conceptual model will help define who and what will and will not be studied and also it assumes the relationships that can then be used to compose the research questions (Miles and Huberman, 1994).

4.1.1 A framework of product quality

Fundamental to the development of a conceptual framework is how the artefact and its associated *quality* is viewed. The satisfaction of the customer (overall *quality* of the actual product) is determined by the customer (Drucker, 1968). Hence, the *quality* of the product, the actual product offering itself, and the customer needs can be considered as three separate entities that are inter-related. 'Product *quality*' is a synonym of customer needs compliance. It is a comparison of how well the customer needs are met by the product – thus the product alone possesses no specific *quality*, rather a combination of *quality* attributes ready to be assessed by potential customers, who determine for themselves the overall *quality* of the product. This interpretation relates positively to the ISO8402 definition, which establishes *quality* as the ability of a product, in totality, to satisfy the needs of the customer (Rothery, 1991). Figure 4.1 shows the relationship between product *quality*, the artefact and customer needs.

Also, included in the framework in figure 4.1 is how the product is viewed during its development. Just as different customers will have different perceptions of the product and the *quality* attributes they require, so too will those who are involved in the development of the product (Mørup, 1993). As the design evolves, the development is driven by many different people – whether they be marketers, designers, researchers, managers, ergonomists, industrial designers or production experts. The way the product should look, what it should do, how it should do it, who will want it and why, are all perceptions of those who will shape and form it into its final incarnation. Thus, the product requirements and the expected artefact itself may change and evolve before the completion of the development process (Ulrich and Eppinger, 1995). This is illustrated in the framework by showing the actual product which is offered to the customer as being the outcome of (and being possibly different to) that which is perceived as the product during its development. This simple framework illustrates that the product is only perceived by the development team until it becomes a reality.

A fuller model of the perceived product is required so that aspects of the NPD process are included in the research. This is now constructed and discussed.

Figure 4.1. **A framework of a product's *quality*.**

4.1.2 A model of NPD and customer needs compliance.

A conceptual framework explains the main things to be studied: be they events, settings, processes or theoretical constructs (Miles and Huberman, 1994). Presented here is a conceptual model which shows possible relationships between variables which may affect customer needs compliance (product *quality*). Figure 4.2 illustrates the model, developed from the literature review, exploratory work and theorising.

Issues that may affect customer needs compliance during the development of a product are revealed and discussed in the literature survey and were looked at further in the exploratory investigations. The evolution of the conceptual model in figure 4.2 has been achieved by developing three main areas which are considered to be of primary importance in the context of this research: (1) the roles that perceptions play; (2) the provision of customer data and information to the company; (3) other internal company influences. The basis for their inclusion is discussed in the sections that follow.

4.1.2.1 The role of perceptions

The perceptions of the groups of individuals involved during NPD may have consequences for the product's outcome. The lack of synergy between a team's perception of the customers' needs and the reality of those customers' needs may be detrimental to product development. For example, it may mean that even if a company has large resources, they could be directed or used unwisely, thus concentrating on aspects which need little attention, rather than providing important competitive advantages (Calantone *et al.*, 1995). Therefore, company perceptions are included in the model for this research (shown in yellow on figure 4.2).

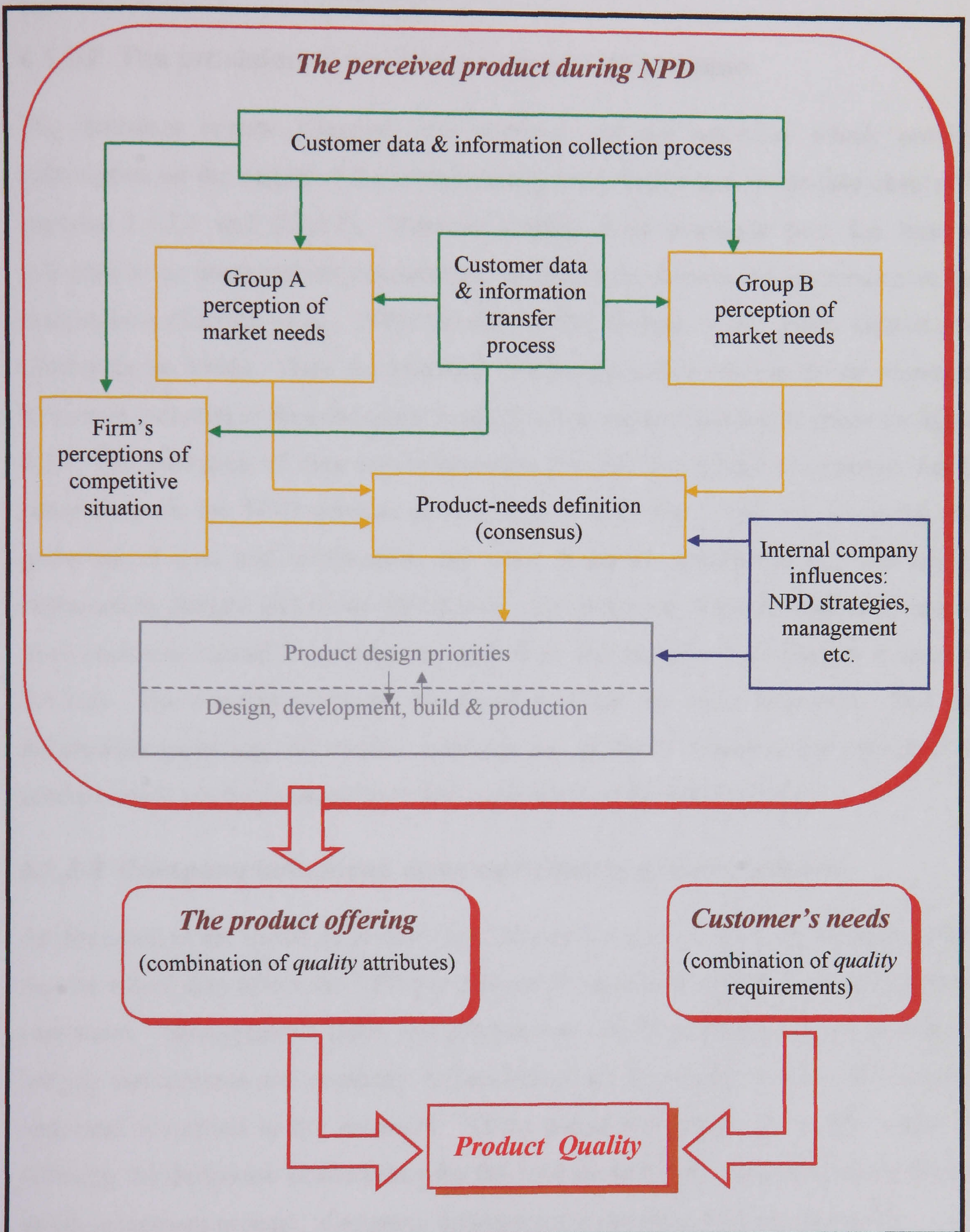


Figure 4.2. A model of NPD and customer needs compliance

From the work of Cooper *et al.*, 1998, it can be expected that each individual in the company will have their own perceptions. Through discussion and interaction with other members of a particular group, these perceptions may change to ideas held as a group perception. The groups may be those of nominal functions within the company (i.e. marketing, sales or R&D) or they may be management groups or grouped by the level of interaction with the customer.

4.1.2.2 The provision of customer data and information

The literature review discusses the relevance of the activities which provide information on the nature of the customer and their desires and wants (see chapter 2, sections 2.4.2.1 and 2.4.2.2). Previous studies have discussed how the lack of information or inappropriate information can affect the success of the product in the marketplace (Service *et al.*, 1989; Bentley, 1990; Cooper *et al.*, 1998; Gilbert and CordeyHayes, 1996). Thus, the provision of data and information to the development process is included in the conceptual model for this research (shown in green on figure 4.2). The provision of data and information fits into the model of customer needs compliance in the NPD process as two sets of activities. One set involving the gathering of data and information, the other about the transfer of it. The model explained by Bailetti and Litva (1995) shows the evolution of the product as an output from customer-related knowledge as applied by the designer (see chapter 2, section 2.4.2.2). The conceptual model developed here has the same inference – that the information gathering and transfer activities are indirectly linked to the definition of product needs via the interpretation and application of the NPD groups.

4.1.2.3 Company influences upon customer needs compliance

As discussed in the literature review (see Chapter 2, section 2.4), there are many other aspects which may affect the NPD process and the ability to comply with the needs of customers. Management skills and orientations, NPD strategies, TQM, structural linking mechanisms and company infrastructure are discussed as some of the most important identified in the literature. These issues are recognised in the model as affecting the definition of the needs for the product and throughout the whole design and development process. Company influences are shown in blue on figure 4.2.

Unfortunately, this research project has not the time nor scope to be able to look at everything which may be a possible factor affecting customer needs compliance. As such, these issues are recognised in the model, but will not be investigated in great depth. However, these issues will not be ignored in the empirical work, but will be monitored to help avoid confounding variables.

4.2 Conceptual definitions

Having explained the basis for the conceptual framework, it still remains to develop descriptions of how the theoretical relationships it presents can be measured. The first step in doing this is to provide constitutional or conceptual definitions of the constructs in the model (Churchill, 1995). A concept or construct is "an invented name for a property of an object, person, state or event" (Tull and Hawkins, 1993 p300). Therefore, the conceptual definition conveys the central idea of a construct by defining it in terms of other constructs which are known.

As detailed above, the conceptual work has concentrated upon three main areas: (1) the roles that perceptions play; (2) the provision of customer data and information to the company; and (3) other internal company influences. Theorising and empirical exploratory research has helped evolve these areas into the conceptual model seen in figure 4.2. However, producing a conceptual model is incremental and is obviously shaped by the research agenda (Miles and Huberman, 1994). Also, some of the constructs included in the model are, in fact, parts of higher level constructs. Therefore, some explanation of how the eventual conceptual were produced (through the use of the three main areas listed above) are included in figure 4.3. It also lists intermediary constructs as well as those constructs that are included in the model.

Conceptual definitions should be used as a basis for the development of operational definitions that will determine the data collected in the main study (Tull and Hawkins, 1993). Detailing conceptual definitions at this stage is also useful for the formulation of research questions, the task to which this chapter now turns.

4.3 Development of research questions and hypotheses

Formulating research questions follows the conceptualisation and modelling of the research area. Research questions make theoretical assumptions even more explicit and focus the direction of data collection. Good research questions will "represent the facets of an empirical domain that the researcher most wants to explore" (Miles and Huberman, 1994, p23). Additional convergence of the research relies upon the use

Main construct	Meaning	New constructs to be defined
Product Quality (ABSTRACT)	How well a product meets the needs of the target customers.	Abstract product; abstract needs; abstract target customer.

But abstract product *quality* cannot be measured, therefore it is taken that there are four forms which product *quality* takes in reality because of **the role of perceptions.**

Customer perception of product Quality	How well a *product offering* is perceived by the *customer* to fit into the *competitive situation* by meeting the *customer's needs.*	product offering; customer competitive situation; customer's needs; customer.
Group perception of product Quality	How well a *product offering* is perceived by the *group* to fit into the *competitive situation* by meeting the particular *market needs.*	product offering; group; competitive situation; market needs.
Product needs definition for product quality	The consensus on between *group perception of product quality.*	Group perception of product quality.
Product design priorities set during NPD	The consensus as it changes during the NPD process.	NONE

Important for this study, are the activities of the NPD process which affect the perceptions of product *quality*, in particular: **the provision of customer data and information to the company.**

Customer information management	The management of *customer data and information collection* and *transfer processes.*	Customer data and information collection process; customer data and information transfer process.

Aspects which may affect product *quality*, but can only be included in the study as controlled confounding variables are **other internal company influences.**

Internal company influences	Other company influences that may affect the NPD process.	NONE

Each of the new constructs introduced above require a conceptual definition:

customer	Some *customer type* who is involved with the product offering.	Customer type, product offering.
Customer type	Who is the customer? And how important are they?	NONE
Product offering	Defined by product variables.	NONE
Competitive situation	How does a *product offering* compare with other offerings in the marketplace.	Product offering.
Customer's needs	Importance given to particular *product attributes* by the customer.	Product attributes.
Product attributes	Separate definable product characteristics	NONE
Group	Type of group affiliation eg. functional, involvement, or management group.	NONE
Market needs	What the *customer's needs* are for the particular *customer*, in a *type of market.*	Customer's needs, customer, type of market
Type of market	Mass or niche products.	NONE
Customer data and information collection process	What information is collected on *product attributes*, how and when	Product attributes.
Customer data and information transfer process	What information is transferred on *product attributes*, how and when.	Product attributes.

Figure 4.3. Conceptual definitions of constructs

of research hypotheses. Hypotheses are educated guesses at the outcome of empirical work which has been designed to answer a research question (Tull and Hawkins, 1993). However, the research hypotheses presented here are not of the kind that are statistically tested:

> "A research hypothesis is a fairly general statement about the assumed nature of the world that gets translated into an experiment..... Typically, but not always, a research hypothesis asserts that the treatments *will* produce an effect..... Statistical hypotheses consist of a set of precise hypotheses about the parameters of different treatment populations. Two statistical hypotheses are usually stated, and these are mutually exclusive or incompatible statements about the treatment parameters..... The statistical hypothesis that will be *tested* is called the **null hypothesis**"
>
> (Keppel, 1982, p25 – emphasis in the original).

The research to be undertaken in this study is descriptive in nature, that is it will only describe the extent of the association between variables (Green and Tull, 1978). It does not aim to test or establish casual relationships, therefore only research questions and research hypotheses will be developed, not statistical hypotheses.

The general research problem for this research has been stated previously as:

> *How do companies define what the customer wants and what is the role of information management in ensuring customer needs compliance during NPD?*

This was necessarily vague at the outset of the research, but now it can be broken down into major (general) research questions, each of which have (specific) sub-questions for clarity and distinctiveness (Miles and Huberman, 1994). Figure 4.4 now presents the list of major research questions and their associated sub-questions for this research. Constructs are highlighted in italics (see figure 4.3. for definitions). This set of research questions will be used to prepare for this research study by employing the conceptual definitions provided earlier. The description of this is contained in the methodology for the research (Chapter 5).

HOW DO COMPANIES DEFINE WHAT THE *CUSTOMER* WANTS?

What does the company think the *customer* wants?

1. - What are the different company (*group*) *perceptions of product quality*?
2. - Can these perceptions be put into *groups*? (e.g. functional groupings, or by the amount of involvement with customers by people in the company?)

WHAT IS THE ROLE OF *CUSTOMER DATA AND INFORMATION MANAGEMENT* IN ENSURING CUSTOMER NEEDS COMPLIANCE DURING NPD?

How does the *customer data and information collection process* work?

3. - Are different *groups* involved in data and information collection?
4. - When is the data collected? (e.g. during beginning, middle or end of NPD process)
5. - Are different methods of data and information collection used for different *product attributes*?

How does the *customer data and information transfer process* work?

6. - Are different methods of data and information transfer used for different *product attributes*?
7. - Which *groups* are the recipients of the information?
8. - When is the data used after dissemination? (e.g. during the beginning, middle or end of NPD process)

Figure 4.4. General and specific research questions for customer needs compliance during NPD study.

These research questions are wide-ranging, therefore the role of a research hypothesis is to represent formal theoretical explanations of what is being studied (Keppel, 1982). Thus, with this research, driving the eight specific research questions listed in figure 4.4, there are 3 primary research hypotheses:

- To provide product *quality*, each different product offering will aim at a different set of customer's needs. Therefore the importance given to the product's attributes will be different for each product.
- There will be differences in the perception of product *quality* between different company groups.
- The customer data and information collection and transfer process in the company will affect customer needs compliance.

These three research hypotheses form the proposed rationale for whatever results are obtained through answering the research questions. These hypotheses are also the underlying inference in the model presented in figure 4.2. Therefore, the results of this research study will be discussed in relation to these hypotheses.

4.4 Summary

This chapter has reviewed the theoretical setting of this research study. In this chapter, an understanding of customer needs compliance and information provision during NPD has been conceptualised through the generation and discussion of a model. Direction for the research has been provided by the explanation of conceptual definitions and the production of research questions. The three underlying research hypotheses for this work have also been introduced. The following chapter describes the methodology for the data collection and analysis.

Chapter 5
Methodology

All research involves employing techniques to inquire, appraise and make assumptions. This section discusses the choices for the methodology of this particular research. Firstly, it introduces the entire research process and explains reasons for the course of action taken. It then details the decisions made whilst designing the main study. The interviewer-administered questionnaire, which was used as the research instrument, is then covered in some length. The relationship of constructs and the variables used to measure them are also considered. The sample chosen is justified and finally, there is an explanation of the way in which the data were analysed.

5.1 The research process

Following a process of decision-making steps should help the researcher undertake effective and worthwhile research. Figure 5.1 shows an overview of the research process adopted for this research. It draws upon the descriptions, diagrams and statements offered by prominent marketing and management research authors: Churchill, 1995; Easterby-Smith *et al.*, 1991; Tull and Hawkins, 1993; Green and Tull, 1978; Jobber, 1998; Moser and Kalton (1992); and Robson (1993).

The diagram shows that a logical progression was used for this research and included planned exploratory work. The preliminary steps were important because the research problem was not clear enough to start with, and required further investigation and theorising. It is unwise to take the next steps in the research until the objectives and hypotheses to be tested have been well developed (Churchill, 1995). The two qualitative methods of experience surveys and analysis of selected cases were suitable because of the flexibility they offer the researcher in both sample decisions and structuring the interviews (these issues are discussed in more detail in Chapter 3).

Once the research questions and hypotheses had been produced (see Chapter 4), work on the main study was started. The main study included descriptive research, the results of this were analysed and interpreted, and their value will be discussed in Chapters 6 and 7. Finally, the research process finishes with an appraisal of the methodology used for the research, and its impact upon the research in its entirety.

The chapters in this thesis follow the same order as the steps in the process as seen in figure 5.1.

Outline general research area/ problem (see Chapter 1).

PRELIMINARY STUDY

Exploratory research (see Chapter 2).

Data collection method: Qualitative research using secondary sources via literature review.

Analyse and interpret data: using keywords.

Exploratory research (see Chapter 3).

Data collection methods: Qualitative explorative investigation using primary sources via experience surveys and analysis of selected cases.

Analyse and interpret data: using keywords and comparisons.

Define research problem and develop research questions and hypotheses (see Chapter 4).

MAIN STUDY

Descriptive research (see Chapters 5 & 6).

Data collection methods: Quantitative research using primary sources via questionnaire surveys.

Analyse and interpret data: using "SPSS".

Discuss and interpret value of new information found during the research (see Chapter 7).

Analyse the methodology and consider further work (see Chapter 8).

Figure 5.1. **Stages in the research process for this work.**

5.2 Design and type of research study

There are, fundamentally, three types of research design. These are separated on the basis of the purpose for the investigation: exploratory, descriptive or causal (Churchill, 1995; Green and Tull, 1978). The research approach within the design can either use qualitative or quantitative data collection (or possibly, a combination). The following two sections discuss reasons for the choices made in the design and type of research study for this particular piece of work.

5.2.1 Research design

The strategy for choosing a research design is led by the researcher understanding the *purpose* of the research (Robson, 1993). According to the research problem, questions and hypotheses presented in section 4.3 of Chapter 4, the purpose of the main study within this research is to report how companies view customer needs and what role there is for information collection and transfer to ensure customer needs compliance during NPD.

Exploratory research, as described and applied in Chapter 3, is used to gain insights and ideas. It is generally used by researchers to help form hypotheses and explore the nature of a phenomenon. An exploratory design was therefore a very suitable approach for the initial investigations within this research, before the research questions were formulated. However, it is not the best design for this main study as the research aims to answer specific questions, for which exploratory research is not less applicable.

A causal (or explanatory) research design is very different to exploratory research. It is concerned with the possible cause-and-effect relationships there may be within the subject under scrutiny (Churchill, 1995). Causal hypotheses are used to guide the research by forecasting under what conditions particular things will occur. Causal research tries to predict the reasons why things take place, and may be summarised by the use of deterministic causation (one item is a function of another) or probabilistic causation (a generalised relationship is assumed from knowing a number of variables, thus explaining a further variable) (Green and Tull, 1978). A causal study is not appropriate for this research. The research does not seek to find reasons for relationships, or *try to explain why* companies capture certain types of customer needs information. This is because the area of customer needs compliance is immature and there are areas that require deeper exploration and understanding of *how* and *what*, before *why* and *wherefore* are involved.

Descriptive research can be used to investigate areas of interest, with an aim of adding weight, or challenging an argument. It is used to provide a description of the situation, for example, by capturing how frequently things occur (Churchill, 1995). Typically, like causal research, descriptive research is also guided by hypotheses. However, they differ because these are descriptive in nature – hypothesising what *sort of trends* are expected in the research findings. These trends may also be used to infer possible relationships between variables, and therefore to formulate hypotheses that can be tested via a causal investigation. The research questions posed in Chapter 4 (figure 4.5), require a descriptive research design approach. Using such an approach, the reality of the hypotheses in section 4.3 can best be explored.

5.2.2 Qualitative Vs quantitative types of research

To decide whether to use quantitative or qualitative data collection, the context of this research was considered, as there are advantages and disadvantages in both approaches. Essentially, research can be quantitative (concerned with measurement and analysis of relationships between variables, rather than processes) or qualitative (examining the content and context of processes and meanings in a exploratory fashion). In general, qualitative researchers prefer narratives and accounts of the way they have interpreted the world, whereas quantitative researchers use mathematical models and statistical tables to relate the research in impersonal terms (Denzin and Lincoln, 1994). However, it has to be noted that there are some disagreements over the separation of qualitative and quantitative research as many researchers use overlapping techniques, such as questionnaires, where responses may be of both qualitative or quantitative nature.

Both approaches have important advantages and disadvantages. A qualitative approach offers the researcher the opportunity to probe and follow different lines of enquiry because they are generally more flexible than quantitative techniques - which typically require answers in particular times and in specific ways. This means that qualitative methods often allow for new questions and answers, but quantitative techniques require pilot studies to exhaust all possible relevant questions and possible responses as they are not flexible when being administered. Qualitative research can put answers into context by questioning and searching for constraints and reasons, whereas the rigors of quantitative methods do not allow for anything that has not been previously anticipated. In contrast, quantitative types of research offer techniques to collect more pieces of specific data in a short space of time (qualitative techniques may mean wasted time pursuing unrelated issues, and need strict administration in order not to miss items). Quantitative research can generally be collected with minimum bias and with regular responses that can be easily compared – things that are more difficult to achieve with qualitative techniques.

To assess the suitability to use qualitative or quantitative methods for this research, the type of information being sought was examined, in light of the pros and cons described above. From the discussion in the previous section, it was decided that the research should seek to describe trends in the views of customer needs, and also trends in information management. Both qualitative and quantitative data collection techniques can deliver information that can be analysed for trends. By the nature of the subject matter, perceptions and qualities may lend themselves best to qualitative approaches. However, data analysis for trends can be assimilated more easily through quantitative, statistical techniques. Qualitative data collection can be used to produce items for quantitative analysis, but this requires the data to go through a layer of processing between collection and analysis. The time taken to process data, and the initial time and possible ambiguity of qualitative methods was considered as a major problem to the research programme. As such, quantitative methods were chosen for both data collection and analysis. The disadvantages of quantitative research, described above, were monitored and reduced by spending a lot of time developing scales that would capture appropriate items for the research and through the use of pilot questionnaires.

5.3 Research method

There are many types of research methods available to the researcher, but only some are applicable in particular circumstances (Churchill, 1995). The decisions made in the two sections above have narrowed down the research methods that can be used in the research: only methods suitable for descriptive research design, with quantitative data collection and analysis techniques are now potentially usable.

Generally, there is a choice between a longitudinal or cross-sectional study for a descriptive research design (Churchill, 1995). A longitudinal study was dismissed as unnecessary, because the time period was not a factor being investigated. Longitudinal studies also require a lot of time to be invested, and results (or mistakes) are not obvious immediately. A cross-sectional study was chosen to provide a snapshot of variables at one point in time.

At a lower level, the method chosen for descriptive research can be one of the following: (1) use of secondary sources; (2) primary data from respondents; (3) primary data from natural experiments; (4) primary data from controlled experiments; or (5) primary data from simulations (Green and Tull, 1978). Experiments and simulations were discounted from being useful choices for the study, as the research aims to look at "real-life" perceptions and find out opinions. Secondary sources were deemed inappropriate for this stage in the research. It was thought unlikely that secondary evidence would be available for all types of customer needs information, and that interviewing people would be inevitable. Therefore, as the most suitable method of data collection for this research was primary data collection from respondents via quantitative questionnaire surveys.

5.4 Questionnaire and interview design

Limited availability of companies and individual respondents meant that there was pressure to focus the research design. Questionnaires are a widely used form of capturing large amounts of information, in a short space of contact time, structuring the data collection process (Frey and Mertens Oishi, 1995). However, to be well-guided, effective and relevant to the research, much front-end questionnaire and administration design is required (Tull and Hawkins, 1993). This section details this design process, although the ordering of sections in some cases is arbitrary, as aspects are interrelated and iterative (Churchill, 1995). The outcome of the process was a questionnaire and interview procedure used for the main study. The pre-test and final versions of the questionnaire can be found in Appendices D and F).

5.4.1 Questionnaire and interview aims

The aims of the questionnaire used in this research are to facilitate accurate information collection from the respondent, to help structure the interview, to record the data collected and to aid the analysis and processing of the data (Hague, 1992). All of these aims require the researcher to specify what information is being sought during the data collection and analysis process (Churchill, 1995).

The information that was required for collection and analysis was determined by taking into account the research questions and hypotheses (see Chapter 4, section 4.3). Table 5.1 considers each of the research questions and lists the information requirements for this study.

Table 5.1. Information requirements of the research

Research question (see Chapter 4, section 4.3)	**Information required**
1. What are the different company (*group*) *perceptions of product quality*?	Importance of product attributes to customers. Current competitive standing of products.
2. Can these perceptions be put into *groups*?	Group characteristics.
3. Are different *groups* involved in data and information collection?	Who collects product attributes information. Who collects customer information and when.
4. When is the data collected?	When product attribute information is collected.
5. Are different methods of data and information collection used for different *product attributes*?	How information on product attributes is collected.
6. Are different methods of data and information transfer used for different *product attributes*?	How information on product attributes is transferred/ communicated.
7. Which *groups* are the recipients of the information?	Who uses product attribute information.
8. When is the data used after dissemination?	Who uses customer information and when. When product attribute information is used.
Other information sought (see Chapter 4, section 4.1.2.3)	
Internal company influences	Product characteristics. Company characteristics. NPD characteristics.

Further sections will develop these information requirements into the individual question content (section 5.4.3) and scaling format (section 5.4.5) used in the final questionnaire.

5.4.2 Type of questionnaire and method of administration

The type of questionnaire used and the method of administering it are interrelated (Churchill, 1995). Decisions about one affect the other. In this case, it was already known that the participating companies were willing to allow interviews. Thus, it was possible to carry out the most appropriate method of administration: an interviewer administered questionnaire via a person interview (Moser and Kalton, 1992). A questionnaire was the most appropriate method for this research because it has the advantages of versatility (many different types of information, including complex information, were sought), speed (a lot of data were collected in a relatively short space of time) and cost (generally proportional to the amount of time spent in the interviews, the actual production of the questionnaire had low costs) (Churchill, 1995). Also, a questionnaire administered directly by the interviewer helped ensure control and consistency in the information that was collected, and how it was presented and described to the respondent. As with the exploratory research, an undisguised approach was taken during all of the research (Malhotra, 1996). At no stage were the objectives of the study hidden from the interviewees.

5.4.2.1 Type of questionnaire and interview

The type of questionnaire or interview can be characterised by the degree of structure and directness (or disguise) (Tull and Hawkins, 1993). Structure is the amount of conformity or freedom the interviewer has when asking questions. Directness is associated with how much the respondent knows about the underlying reasons for asking the questions, that is why it is often refereed to as the amount of "disguise" in the questionnaire design (Churchill, 1995). The questionnaire was directed by the interviewer, but the respondent themselves filled it in. This was deemed the best compromise for consistency in administration and ensuring interest from the respondent.

In this research, the questions themselves were structured in their wording and possible responses, and this individual question wording structure was strictly adhered to. The questions were also given an order - although the interviewer was not completely restricted to this exact schedule and only had to ensure that preliminary questions, and some other specific questions, followed a prescribed order. It was found to be easier to carry out the preliminary questions first, putting the respondent at ease by introducing the configuration of the questions. However, some of the questions did offer the opportunity to be completed in a different order, because some respondents could understand what they were being asked more readily by using a different format and question order. The order to the questions was mainly determined by ease of use (see section 5.4.4) and therefore it was felt that having some flexibility in the structure would not affect the responses given.

The questionnaire and interview technique was direct and undisguised. It was not necessary to hide the reasons for the research and in fact, explaining the benefits of the research was useful encourage the interviewees to participate in a full and uninhibited way. The full extent of the research was not described to the respondents as this was not necessary, although introductory discussion and general reasons for the investment of the company's resources was required to motivate the interviewees. During the 2 hours it took to administer the questionnaire, additional information about specific questions was also given, to try and ensure a high level of interest from the respondent.

The majority of interviews were also recorded on audio tape (on a few occasions it was not possible to have a tape recorder present). The tapes were used only to check reasons for answers and were not transcribed. The use of the tape recorder was explained to all participants and after a few minutes most were relaxed and uninhibited in their answers to questions.

5.4.2.2 Interview procedure

The questionnaire was administered as though it were an interview. The manner in which the interviews were conducted tried to ensure that the most information was collected. The interview procedure aimed to take into account the following issues:

The aspects of confidentiality. Confidentiality agreements were made with the companies. Individual and company responses were collected using anonymous coding. Responses were reported in statistical terms, both in this thesis and to the companies. Respondents were made aware that this would be the case.

The inconvenience that may be experienced by the respondent. Appointments were made. The research and interview process was explained to the interviewees. Interviews were conducted at the respondents' normal place of work.

The motivation and possible boredom of the respondent. The interviewer was given the freedom to change the order of the questions asked (see section 5.4.2.1, above). The interviewer introduced questions in small groups: manageable enough not to appear daunting; but with enough questions together to offer a path and direction for the respondent. The questionnaire used tick-boxes that required a response every time, rather than using open-ended questions that involve the respondent having to constantly think of items. Some questions were different to present some stimulation, whilst others maintained a consistency, to improve ease-of-use for the respondent. The interviewer tried to take an interest in the particular interviewee, asking them appropriate questions and adjusting to suit the unique circumstances of each interviewee (Hague, 1992).

The accessibility of data to the respondent. Some interviewees were not aware of the information that was being asked. This was because they never knew the information; they once knew, but have now forgotten it; or they could not think of answers at the time they were asked (Moser and Kalton, 1992). The interviewer tried to make sure that the interviewee was not answering questions because they felt they should, by reminding interviewees not to be worried about using the "don't know" responses.

The cognition and understanding of the respondent. Questions were worded as simply as possible. The interviewer explained instructions, as well as them being on the page. Pre-testing was used to find ambiguous questions.

The affect of interviewer bias. The interviewer tried to remain neutral and not interject expectations or opinions during the questioning (Frey and Mertens Oishi, 1995). Some interviewer bias must be expected in the responses collected, although the type of information being sought is not typically prone to people offering socially acceptable answers.

5.4.3 Question content

Once it had been established what information was sought from the questionnaire, the content for individual questions was considered (Churchill, 1995). Table 5.2 concentrates upon the content of the questionnaire, by taking the relevant information required and then framing the questions (Frey and Mertens Oishi, 1995). The order of the list in table 5.2 is the same as the "information required" listed in table 5.1 (see section 5.4.1). The sequence of the questions in the final questionnaire was different and, on some occasions, grouped items together. These decisions are discussed in section 5.4.4. The exact wording of the questions is also reviewed in section 5.4.4.

Table 5.2. Explanation of content for questions

Information required (question number on questionnaire)	**Question content explanation**
Importance of product attributes to customers. (C1/2/3)	Questions in this set try to find out what the respondent thinks are important product attributes to customers. The question must first ask who are the customers anyway? And how important are they to the company? The first question needs to be open-ended (but prompted) as no information is available on customers before the interviews. Each respondent then needs to evaluate each product attribute for each customer.
Current competitive standing of products. (B5)	Because product quality is relative, a comparison of products against one another is wanted. An opinion is required on how well a specific product compares with the market as a whole.
Group characteristics. (X1/2/3/4)	It is important to find out what kinds of groupings there are within the company, as these may be found to influence the responses during data analysis. Function, level of management, involvement with customers and number of years at the company are applicable to this research.
Who collects product attributes information. (E2)	An opinion is required from each respondent as to what groups collect customer needs information for each of the product attributes. It is only possible to know about functions as groups, because respondents will not be aware of how many years other people have been at the company, or their involvement with customers etc.

Continued....

...Table 5.2 continued from previous page.

Information required	Question content explanation
Who collects customer information and when. (E1)	An opinion is required from each respondent on what groups (functional only) collect information during the different stages of the NPD process.
When product attribute information is collected. (E3)	To complement the two queries above, an opinion is required on what types of product attribute information is collected during the different stages of the NPD process.
How information on product attributes is collected. (G1)	This question gains an overview of the different tools that the respondent knows are used to collect customer needs information.
How information on product attributes is transferred/ communicated. (G2/ H1)	This question gains an overview of the different tools and communications methods that the respondent knows are used to transfer customer needs information.
Who uses product attribute information. (F2)	The respondent should offer an opinion on which groups use customer needs information for each of the product attributes.
Who uses customer information and when. (F1)	An opinion is required from each respondent on which groups (functional only) use information during the different stages of the NPD process.
When product attribute information is used. (F3)	An opinion is required on what types of product attribute information is used during the different stages of the NPD process.
Product characteristics. (B1/2/3)	To gain background for the study, the respondent should be asked about the particular product that they are offering opinions on (what it is, how long the company has been producing it and the market it is aimed at).
Company characteristics. (A1/2/ Y1/2/3)	Opinions on the company position and simple company qualifiers should be collected. Only suitable respondents will be asked for some information, as they are facts known by higher management only.
NPD characteristics. (A3/ D1/ Y4)	Sources of new product ideas, NPD activities undertaken by the company and R&D budget are enough information to gain a general idea of NPD.

The following are the decisions that affected the content of the questions (Churchill, 1995; Tull and Hawkins, 1993; Moser and Kalton, 1992):

Was the question necessary? Only questions related to the information required, as detailed in table 5.2 were included in the questionnaire.

How many questions were required to gain the information? In most cases there was one main question to gain the information, but multiple responses were required.

Were respondents capable of answering the questions? Respondents were chosen because of their knowledge of the subject area, the questions were temporally independent, so no recall was required, and the interview technique was used to help the respondents to answer.

5.4.4 Question wording and sequence

Some attention was paid to the way questions were worded in the questionnaire (Churchill, 1995; Moser and Kalton, 1992). Questions were worded using direct and specific language, with a conversational tone (Frey and Mertens Oishi, 1995). Responses were mutually exclusive where only one tick was required. Wherever appropriate, "none", "other", "N/A" and "don't know" response options were offered in a consistent order. The questions were written at the same time as scale development, so that consequence of items and responses on the question could be included. Questions and scales were also pre-tested (see section 5.4.7).

In most cases questions included the phrase "do you think", or similar. This made it clear to the interviewee and interviewer that an opinion, or personal understanding of the situation was sought. This was in line with the survey objective of being about perceptions and was also reflected in the analysis of the data. There was a reliance upon the interviewer to emphasise the importance of opinion and knowledge, to ask the respondents if they understood the concepts, and to encourage the respondent to answer "don't know" wherever applicable (see section 5.4.2 and 5.4.3). Unfortunately, not all questions fulfilled the criteria of being (a) comprehensive to all of the respondents; (b)of the interviewer experiencing no difficulty in administering the question; or (c) of not requiring the question to be rephrased by the interviewer (Frey and Mertens Oishi, 1995). Retrospectively, some of the questions could have been better worded and more consistent, requiring less interviewer time and involvement, although it is not thought that the results were altered by the need to rephrase them.

The questions were arranged in a certain order. The order aimed to be straightforward and make the questionnaire easier to use – all questions were grouped into manageable chunks, and consistency in questioning was provided within these chunks. The type of questions were varied to provide interest (Moser and Kalton, 1992), although nearer the end of the questionnaire similarity in the questions was difficult to avoid. The first set of questions were shorter and simple, then more protracted and involved questions were introduced (Easterby-smith, 1991). Initial questions were aimed at putting the respondent at ease and introducing a structure that was relied upon later. Respondent classification questions were asked last (Moser and Kalton, 1992). The interviewer was given some freedom in question sequence. This helped reduce boredom in the interviewer, but, more importantly it was found that interviewees benefited from making a choice on question order because it aroused some interest in the unfolding "story" of the questions. As with rephrasing questions, it was believed that reordering selected questions provided more benefits than detrimental affects.

5.4.5 Process of measurement

Measurement is the allocation of a number or symbol to represent the characteristics of objects or events in a way that represents some kind of reality (Tull and Hawkins, 1993). Therefore, measures should be taken of characteristics about the objects or events, rather than the objects themselves being measured (Churchill, 1995). So, in order to measure the characteristics of the objects or events, the characteristics (items) that define the measure and the scale on which it is measured were required to take this research forward.

5.4.5.1 Item development

The first step in the process of item development for this questionnaire was to search in the literature for assistance. For most of the pieces of information to be gathered there are recognised and previously used items available. There was wide availability of information on items that could be used for company descriptors, the source of new product ideas and the activities of the NPD process (Cooper and Kleinschmidt, 1986, and 1993; Story, 1999; Bearden *et al.*, 1993; Von Hippel, 1988b). Also, there had been some previous empirical studies using company groupings and information collection and dissemination methods within product design and development (Calantone and Di Benedetto, 1988; Court *et al.*, 1993; Service *et al.*, 1989; Conway, 1995). Appendix G lists the information required and the items developed from previous work.

Unfortunately, for the list of customer needs (product attributes) little could be found on previously used items for measurement. Most product attributes were stated as examples within texts (Hollins and Pugh, 1990; Holt *et al.*, 1984; Jobber, 1998). Certainty no definitive list could be obtained for use in a questionnaire and therefore a list was developed specifically for this research. The requirements for the list of customer needs information, in the form of product attributes were: that the terms were temporally robust (i.e. they would not become quickly outdated and meaningless); that they did not offer bias; that they could be measured on a scale of importance; and that they were mutually exclusive and collectively exhaustive for possible customer needs. Initially, as many items as possible were included. The list used in the exploratory research offered 56 different items that were grouped according to implied higher level customer needs (see appendix C). However, during the exploratory research it became very evident that having both a large number of items and using groupings was misleading and impractical. The respondents sometimes found it difficult to differentiate between items and often thought that the headers for the groups were adequate, scoring all items within the groups similarly. The list of items used in the final questionnaire was therefore reduced to 20 attributes (21 attributes were eventually used, as "customisation" had to split into two, for clarification). The attributes that were selected for use in the final questionnaire were chosen because they were found in the exploratory work to represent views on the most important aspects of the product across all different customer types. They were expected to be attributes that were pertinent to all industrial products. Words and phrases were used that were mutually exclusive and most easily understood by respondents in the pre-test.

5.4.5.2 Scale development

A measurement scale is a means by which an object, event or person can be given a dimension (Moser and Kalton, 1992). Scale development for this research included determining the type of scale required for each item, establishing the form of response on the questionnaire and producing the scale format.

Type of scale

It is not the object itself (e.g. the constructs), but the items used to describe the object (i.e. those detailed above) that determines the most powerful scale that can be used (Churchill, 1995) and therefore the form that responses on the questionnaire will take. The power of a scale is the amount of information that it can convey and the permissible statistical analysis that can be applied to the data obtained (Diamantopoulos and Schlegelmilch, 1997). The scale level can be (in ascending order of power) nominal, ordinal, interval or ratio. The items described above in section 5.4.5.1 were examined to determine what the most appropriate scale type was to measure them (Churchill, 1995). The majority of the scales were chosen because they were the most powerful possible for the type of items being measured. However, on a few occasions a lower level scale was used (e.g. questions A1, A2, B3 and X2 used ordinal scales rather than interval scales, as this was sufficient for categorising products and companies). In other cases, the respondent could not be expected to give an exact ratio value and also some of the information being asked could be deemed as sensitive, therefore ordinal scales were used (Tull and Green, 1993) (e.g. questions B2 and Y1, Y2, Y3 and Y4) . The type of scales used in the final questionnaire are listed next to each item in Appendix H. A pragmatic view was taken for importance and market superiority and they were both accepted as being measured on an interval scale (Diamantopoulos and Schlegelmilch, 1997). Data analysis took into consideration the assumption made that these data were interval, and that there was a possibility that there may be unequal differences between the points on the scale.

Form of response

The form of response in questionnaires can be open-ended or closed-ended. Open-ended questions allow the interviewee to respond in the way they feel is most appropriate (Tull and Hawkins, 1993). Closed-ended questions can take the form of multiple-choice (multichotomous), dichotomous or scales (Churchill, 1995). Open-ended questions allow the respondent free reign to give answers and is most suitable for nominal data that is coded after the collection process, open-ended questions may also ask for an integer as a response, and can therefore be used for collecting ratio data. Closed-ended responses purposefully seek to restrict answers to pre-determined choices (Aaker *et al.* 1995). Closed-ended questions can be used for all scale levels of data, but are especially suited to nominal, ordinal and interval data.

For this research, open-ended questions were restricted to a few occasions where the researcher did not want to pre-empt what the interviewee was going to say (Aaker *et al.*, 1995) or where the researcher needed to identify other alternatives (Tull and Hawkins, 1993). The questionnaire allowed open-ended responses to personnel category questions (questions in "X" section of questionnaire), idea source (question "A3") and questions on collection and dissemination methods (questions "G1" and "H1"). In these cases the respondent had the opportunity to add a category, if they felt this was necessary. There was one other place where an open-ended question was used, this was a prompt for customer types (question "C1"). The responses to this question were then used immediately by the interviewer to ask the questions that followed in that section (questions "C2" onwards).

The majority of the questionnaire used closed-ended questions. The advantages of using closed-ended over open-ended responses is that they are generally easier to ask, easier to answer, they reduce interviewer bias, there is less potential for recording errors, make data analysis much easier and provide better comparability between respondents (Aaker *et al.*, 1995; Tull and Hawkins, 1993; Malhotra, 1996). One disadvantage of closed-ended choices is that the researcher must spend significant time and effort developing the appropriate responses (Malhotra, 1996). There is also danger that the format and content of answers offered may distort results (Tull and Hawkins, 1993) or force respondents to make choices that are arbitrary, rather than their true feelings (Moser and Kalton, 1995).

Scale format

There was particular attention paid to the layout of the scales and the format of the items and responses. The scale formats in the questionnaire used for the main study are listed in brackets next to the type of scales used in Appendix H, and can be seen in the final questionnaire in Appendix F.

Nominal scale data were collected by use of open-ended questions (e.g. for question C1) and lists of mutually exclusive and collectively exhaustive categories for the object being measured (Diamantopoulos and Schlegelmilch, 1997) (e.g. question X2).

Ordinal scale measures were made by ordering the items that characterised the object being measured. Ordinal scales were presented as separate boxes alongside the categories they represented (e.g. A1 and Y2). The categories and boxes were listed down the page in an attempt to remove the implication of equal intervals between the choices (Moser and Kalton, 1992).

The majority of the data collected were dichotomous, that is: they had only two possible answers (e.g. in question E2, the respondent either did or did not think that each function collected information on each of the product attributes). Some dichotomous scales force the respondent to make a choice between one of two boxes. However, this would have been impractical for the number of variables being sought in this research (e.g. Appendix F: question E2, where there are 189 separate variables for one set of information required). Therefore, dichotomous scales developed for this questionnaire required the respondent to either check or not check the corresponding box. This layout was produced for ease of display and use by the respondent. It also made collation and data entry simple. However, the danger in this format is that interviewee may not pay as much attention to each of the items, or that they may skip over some of the responses. This implies that some of the boxes that were not checked may actually be item non-responses rather than a definite "no" to the question and may affect the reliability of the questionnaire instrument. To help reduce this, the interviewer asked questions at pertinent times and kept a check on each sheet as it was filled in, subtly flagging any responses that seemed unusual. Also, a response for "N/A" was included for each of the product attributes, so if there was no response at all on the line of that product variable, a question could be asked and non-response recognised. In pre-testing the questionnaire, this form of response was found to be practical, usable and efficient by both the interviewer and respondent. Therefore this scale format was assumed to collect the information required in as a reliable manner as possible in the interviewing circumstances.

Two types of question used interval scales, those rating importance (questions A3 and C3) and one rating competitive superiority (question B5). All interval scales were itemised rating scales, presented with categories equally spread across the page in order, implying positions along a continuum (Churchill, 1995). Rating scales were the most appropriate choice for this research because they focus upon the importance attached to an attribute (Tull and Hawkins, 1993). Although itemised rating scales are the most common form of attitude measurement, there is no best format and therefore the questionnaire was adjusted to fit the nature of the information and the characteristics of the respondents (Tull and Hawkins, 1993). The scales used in this research had an odd number of response alternatives, with equal favourable and unfavourable responses and a central, neutral point. A neutral point was included as it is possible that the respondent could feel neutral about importance (Malhotra, 1996). Five scale points were offered. Respondents should have no problems discriminating and understanding the differences between five points (Churchill, 1995). Also, this number of points is advised if several scales are to be summed for one score (Tull and Hawkins, 1993). All five of the scale points were labelled, but not numbered, in order to reduce clutter. The labels on the scale points used opposite terms, either side of the neutral point (Malhotra, 1996). Options for "Don't know" and "N/A" were also offered, as the researcher did not want to force a response that was not appropriate. As the questionnaire was interviewer administered, there was less likelihood of the respondent not answering, or using the "N/A" category, because the interviewer made it clear that they were just as likely to ask the respondent why they put "N/A" as much as why they gave any other responses.

5.4.6 Physical characteristics of questionnaire

The layout of the questionnaire can make a difference to the interest level of the respondent and the amount of time they are willing to devote to filling it in (Easterby-Smith *et al.*, 1991). The physical characteristics of the questionnaires used for this survey are described below.

Page layout. Instructions were placed at the top of each page. Questions were numbered and preceded the responses. White space was used to separate out all questions. New types of questions were given a new alphabetical prefix and were presented on new pages. Page numbers were included at the bottom of the page to aid the researcher, rather than the respondent.

Typeface and readability. All questions and most responses used 10 point Times New Roman typeface. Some responses, especially those above tick boxes, required the use of smaller fonts (9 and 8 point), to make the information more legible by spacing out the text across the page. Questions were differentiated by use of bold typeface.

Question explanation and instructions to respondents. No general instructions were included on the final design of the questionnaire. The interviewer was relied upon to introduce and explain the general aspects of the study and how to fill in the questionnaire (e.g. that the majority were simply tick-box answers). Each section also had a one or two line explanation and instructions. Important aspects of the response were underlined in the question (e.g. "do you think", "currently" etc.). Concepts within questions were presented in capitals (e.g. "collect information", "communication methods" etc.).

Layout of response fields. All tick boxes were a single character in size, boxes requiring a value were 6 characters wide and free-text responses had a line of dots that was dictated by the amount of space available.

Analysis of questions. The layout of the questionnaires bore in mind the requirements for analysing it later: all questions were numbered; responses were well spaced out not only for the respondent, but also for ease-of entering coding data next to items; where appropriate, some questions offered a tick-box scale, rather than a whole number (e.g. question B2). No coding for analysis was shown on the questionnaire because including this coding would have cluttered the page with too much information that was irrelevant to the respondent.

5.4.7 Questionnaire pre-testing

Questionnaire pre-testing and piloting is the key to good design and administration (Moser and Kalton, 1992). Pre-testing helped to ensure clarity and precision in the design and execution of the research questionnaire. Other researchers also advocate the use of pre-testing questionnaires and provide helpful advice on undertaking it

(Churchill, 1995; Moser and Kalton, 1992; Tull and Hawkins, 1993; Frey and Mertens Oishi, 1995). Items that were of particular relevance to this study were:

- Assessment of individual questions and their sequence;
- Determining the degree of accuracy in question and response wording;
- Identifying questions that were not worth asking;
- Disclosure of items and responses that were not previously anticipated by the researcher;
- Discovering difficulties with understanding instructions or layout;
- Investigation of the practicalities of interviewing as the administrative technique;
- Providing essential practice for the interviewer;
- Increasing the ease of analysis.

The questionnaire was tested at two levels. Firstly, the questionnaire was shown to peers and other researchers. Secondly, the questionnaire was pre-tested on a trial-basis (Churchill, 1995), and interviews were carried out with a set-up the same as expected for the full survey.

The first peer-review pre-test resulted in a number of changes that were mainly to add extra information and to change some of the layout of items. The changes made were: all itemised rating scales originally had numbers and labels but just using the labels was deemed to be enough information and removed some clutter from the questionnaire design; the addition of "N/A" box to questions B5, C, E1/2/3 and F1/2/3; boxes under headings were re-aligned to give more white space between boxes; and the order of what was questions E1/2/3 and F1/2/3 were changed. The first questionnaire (before these changes) is not provided in the appendices, as the questionnaire is long, changes were small and the next two versions of the questionnaire are included.

The main pre-test interviews were carried out using the second version of the questionnaire (see Appendix D). These typically took 3 hours to administer, a whole hour longer than the final questionnaire took to complete. The extra time in the pre-tests was used up by asking interviewees about the way they interpreted the question, probing specific issues within the questionnaire, and completing two extra questions (G3 and H2), that were not included in the final version. Four full interviews were carried out for the pre-tests. Respondents were selected from participating companies, as this was expected to produce pragmatic results (Tull and Hawkins, 1993).

Only minor changes were required to produce the final version of the questionnaire. The outcome from the pre-test was more positive than was expected from accounts in the literature (Churchill, 1995; Tull and Hawkins, 1993). In fact, it was so successful that it was appropriate to use the responses from the pre-test in the final analysis (item non-response due this is covered in section 5.7). Changes between the second version and the final version are listed in Appendix F. Also, the pre-tests used tape-recording to get the interviewer used to using the machine during the interview and when reviewing the interview. Listening back to the pre-test interviews resulted in the purchase of a new, higher sound definition tape-recorder.

5.5 Sample

Designing the sample and then collecting the data followed the detail of planning the data collection method (Tull and Hawkins, 1993). According to Churchill (1995), choosing a sample for the research requires six steps:
(1) defining the population;
(2) identifying the sampling frame;
(3) selecting a sampling procedure;
(4) determining the sample size;
(5) selecting the sample elements;
(6) collecting the data from the designated elements.

Churchill (1995) p.575.

Each of the first five steps will be discussed here. The issues of data collection (step 6) are an integral part of the discussions throughout this Chapter.

5.5.1 Defining the population

A population is defined as "the totality of cases that conform to some designated specifications" (Churchill, 1995, p.574). This research focuses upon companies that produce industrially bought products (not consumer products), where the end user does not buy the product (see sections 1.1.2 and 2.2.1 in this thesis). As the research is about customer needs perceptions in the NPD process, the companies must also be involved in the design and manufacturing aspects of the product. It was also deemed necessary that the company should have contact with some kind of customer (rather than wholesaler). The population, therefore, includes all companies in the U.K. who design, manufacture and sell industrially bought goods and are directly involved with customers, other than just their retailers.

5.5.2 Identifying the sampling frame

The sampling frame is the listing of the elements from which the actual sample will be drawn (Churchill, 1995). This differs from the whole population, as it is only one means by which the population may be represented. The sampling frame for this study was the list of a hundred companies that already had contact with the university. The danger of using a pre-selected frame such as this, is that it is not a complete representation of the whole population and introduces bias before the sample is even taken. However, because of the nature of the research, and the time that would need to be invested by the participating companies, it was expected that these companies would be more willing to participate in the study rather than those that might become involved using "cold-calls". As this is descriptive research, rather than causal, the dangers of bias were accepted in order to find companies that would be committed to the research.

5.5.3 Selecting a sampling procedure

As the sampling frame did not contain a list of the whole population, random (or probability) sampling was not statistically possible. As such, non-probabilistic sample plans were investigated: quota samples; judgement samples and convenience samples. Both quota and judgement samples try to ensure that the sample taken is representative. They look at the sample elements and assess the characteristics that they possess and attempt to pick elements that can best be applied to the whole population. As this research area is immature, it was difficult to say what aspects of the sample elements (i.e. companies) would most affect the sample. Also, although information was available from published accounts, it was expected that other aspects would be more pertinent for judging how representative the company would be. This type of information was not readily available (e.g. design team size and composition, number of new products, turnover from new products, percentage invested in R&D, and market research etc.).

Therefore, the reality of the situation was that the sample would be based upon that of convenience. In this case, convenience was determined by proximity to the University (to reduce costs); and the interest and willingness to participate in an involved project that would mean an investment of time by the company. The problem of using a convenience sample is that there is no way of knowing how representative the sample is. Therefore, generalisations can only be made in the findings across the sample, not the population.

5.5.4 Determining the sample size

Normally, the sample size is determined for probability samples through estimating variance or other statistically based calculation. As the sample for this research was chosen by convenience, within a restricted sampling frame, the sample size was mostly determined by environmental factors. Time, money and willingness of companies to be involved affected the eventual sample size.

The intention of the study was to look at six companies, as determined by time and cost restraints. All of the sample frame were looked at for suitability and fifteen companies were approached to be involved in the research. Of these, eight showed interest and were visited. Eventually, half of these dropped out, due to personnel changes or because they could not afford the time. Therefore, the number of companies that were involved in the study was four. The sample size was not large enough to make any statistically significant conclusions. However, this was not the objective of this descriptive study (Churchill, 1995).

5.5.5 Selecting sample elements

The characteristics of the sample elements (companies) that were eventually used in the study are shown in table 5.3. All companies were part of the target population for the study: that is they design, manufacture and sell industrially bought products (not consumer products), directly to customers (not wholesalers). Some of the details in table 5.3 are necessarily ambiguous, in line with maintaining company confidentiality.

A decision also had to be made for the sample size for the number within the company. This was a judgement (purposive) sample. The researcher spoke with managers within each company and, using own judgement, determined what would be representative of the design and manufacturing views within each company. In each company all of the individuals involved in the design and manufacture of one particular product were asked to participate in the study.

Table 5.3. Company characteristics

	Company A
Types of products produced	Medical (UK. SIC code 37203)
Type of product investigated	Implant device
Approximate market share for product	Approx. 25%
Number of employees	Approx. 500
Turnover	Approx. £120m (1998)
	Company B
Types of products produced	Heavy Plant (UK. SIC code 32541)
Type of product investigated	Excavation vehicle
Approximate market share for product	Approx. 30%
Number of employees	Approx. 150
Turnover	Approx. £30m (1998)
	Company C
Types of products produced	Automotive (UK. SIC code 48360)
Type of product investigated	Fuel and exhaust component
Approximate market share for product	Approx. 90%
Number of employees	Approx. 300
Turnover	Approx. £25m (1998)
	Company D
Types of products produced	Infrastructure (UK. SIC code 50200)
Type of product investigated	Railway infrastructure
Approximate market share for product	Approx. 80%
Number of employees	Approx. 300
Turnover	Approx. £30m (1998)

Interviewees were included because they were believed to have knowledge that was important to the study, such that they would be able to give an opinion (Moser and Kalton, 1992). In each of two companies, all but two people were actually interviewed. In the other two companies, where the teams were much larger, a 75% interview rate was achieved. Tables 5.4 5.5 and 5.6 show the characteristics of the people interviewed in the course of the main study. The characteristics are those as reported by the respondent – how they see their role in the NPD process.

Table 5.4. Job functions of respondents

Job Function	A	B	C	D	Total
		Company			
R&D	5	3	1	3	12
Product design	2	7	1	1	11
Marketing	2	2	1		5
Sales		1	2	2	5
Manufacturing		1	2	1	4
Other		1	1	1	4
Total	9	15	8	8	40
Total in product team for each company	12	19	8	8	47

Table 5.5. Level of management of respondents

Level of management	A	B	C	D	Total
		Company			
No management responsibilities	3	1		1	5
Some functional/ product		2	1	2	5
Functional manager	1	4	5	1	11
Product manager		3	1		4
Senior manager	5	4		4	13
Director		1	1		2
Total	9	15	8	8	40
Total in product team for each company	12	19	8	8	47

Table 5.6. Involvement with customers of respondents

Customer involvement	A	B	C	D	Total
		Company			
Never spoken to customers		1			1
Spoken to customers in the past, but not recently		2			2
Occasionally converse, out of interest	1	1			2
Occasionally converse, on specific issues	1	5	2	2	10
Regularly converse on general issues		2		2	4
Regularly converse to solve specific problems	1	2	1	1	5
Major part of the job is to converse with customers	6	2	5	3	16
Total	9	15	8	8	40
Total in product team for each company	12	19	8	8	47

5.6 Data analysis

For *each* respondent, in total, there were 1505 basic variables, plus up to 184 customer variables (dependant upon how many customers were identified). Also, senior managers were asked responses to 14 company variables. As such, a lot of data analysis was required to provide useful and meaningful information.

When the questionnaire was designed, the method of analysis was also considered (Hague, 1992). A master coded document was produced to aid data entry. Questions were coded logically, with the same codes used for equivalent responses (e.g. "8" for don't know etc.). Answers to open-ended questions were recorded in two ways: firstly, they were given a code and secondly they were recorded in full in an Excel spreadsheet. All non-responses and missing items were recorded and checked. Company and individual confidentiality was maintained by using arbitrary company codes (A through to D) and simply numbering each respondent. Characteristics that could identify individuals were not used.

All questionnaire responses were coded and entered into the data analysis package "SPSS" (Statistical Package for the Social Sciences). This package allows for easy and quick assimilation of results through descriptive and other appropriate statistics. Initially this was also useful for checking possible mistakes in data entry (Easterby-Smith *et al.*, 1991).

5.6.1 Interval scale data analysis

Interval scales do not have an absolute zero and therefore numbers were assigned by the researcher to the most appropriate responses (Diamantopoulos and Schlegelmilch, 1997).

5.6.1.1 Importance scales

For importance scales (questions C3 and A3) no zero was used, a scale that started at "1" for "definitely not important" and finished with "5" for "definitely important" was assigned for the raw data collected. The point score used in the equation 5.2, in section 5.6.3.2, for ***P*** was the "average" response for the importance of each attribute. As there were only a few respondents in each company, finding an "average" view was difficult. Mean, median and mode were all assessed to produce the collective (average) response for these variables. Judgement was then used to produce a point on a scale from 1 to 9 (which was the equivalent of using a scale of 1 to 5, as with the raw data, but allowing for 1.5, 2.5, 3.5 and 4.5 as the average response).

5.6.1.2 Competitive situation scale.

The competitive situation scale (question B5) was also taken to be an interval scale. In this case, the scale was set from minus two (-2) to plus two (+2), making the zero point at the response "about the same". "Average" views for the competitive situation also used judgement and ranked the result on this –2 to +2 scale. This is reflected in the value for ***C*** in equation 5.4, in section 5.6.3.4.

5.6.2 Dichotomous scale data analysis

Dichotomous answers were given a response of "1" for a positive answer (yes/ correct) and "2" for a negative answer, although as this was dichotomous data, statistically this was purely arbitrary (Diamantopoulos and Schlegelmilch, 1997). For an "average" response, normally, it was taken that if more than 1/3rd of the respondents answered "yes" this happens, then it was taken as a positive response. Also, where there were large discrepancies, the view of the respondent(s) who should know (i.e. the question was asked about their group) was taken as the answer. The use of this judgement was based on the fact that the question wording, in retrospect, may have been inappropriate. Respondents who were asked "do you think" were correct to answer questions with "no", even though they did not know the answers. E.g. some respondents from R&D or design etc. did not *know* whether marketing was involved, but they *thought* or even *assumed* that they were (or were not) and therefore answered the question with this opinion. As such, it was taken to be appropriate to assume that if at least one third of those asked thought that the answer was "yes" then it was likely to be true. In reality, this was not a particular issue in the analysis of the data, since respondents were quite consistent in their answers.

5.6.3 Development of consensus views for perception

One of the key parts of the data analysis was to produce values that were meaningful in context and could be compared within and between companies. The research aims to understand the differences in perceptions of many different product attributes and the role of information management with respect to each of these attributes. As such, there is a need to reduce the data set to values that can be handled from this perspective.

Therefore, there was a requirement to produce values for the consensus view of:

K_M : each customer's importance;

Z_{iM} : the importance of the different product attributes to each of these customers;

A_i : the overall company perception(s) of product attributes, that takes into account customer importance;

Qi : a quality index for each attribute, that includes aspects of attribute importance and the competitive situation.

Each of these is discussed and the equations used in the data analysis are presented in the following sections.

5.6.3.1 The importance of each customer (K_M)

Respondents were asked a prompted, but open-ended question for who they saw as the "customers" of their products. Each respondent offered as many customer types as they believed relevant (e.g. driver, surgeon, financial assistance etc.). They were then required to rank these customers in order of importance (the term "importance" was specifically left vague, as this could mean "buying power", "involvement with the product" etc. depending upon the respondent's perception).

$$K_{M_Y} = \frac{\sum_{x=1}^{n} M_{YG_x}}{\sum_{y=1}^{N}(\sum_{x=1}^{n} M_{yG_x})} \qquad \text{(equation 5.1)}$$

Where

K_{M_Y} = overall weighting given to the specific customer type for the company perception of the customer's importance (and where $0 \le K \le 100$)

M = customer type

M_Y = the specific customer type

G_x = the weighting points given by an individual respondent

n = the total number of different respondents

N = the total number of different customer types

x = the counter for individual respondents

y = the counter for individual customer types

The importance of each customer was determined by adding each of the respondent's ranking points together and then dividing them by the number of points, thus giving a percentage weighting of importance for each customer. This is described by equation 5.1 and demonstrated by the example of the weighting given to Company A's customers, in table 5.6. Some respondents gave equal ranking to several customers, in this case the total number ranking points was split equally between the customers.

Table 5.7. The importance weighting (K_M) of each customer for Company A

Respondent	Customer type (M)					
	A1	A2	A3	A4	A5	TOTAL
R1	5	3	4	2	6	20
R2	6	2.5	4	2.5	0	15
R3	6	5	2	3	4	20
R4	6	4.5	3	2	4.5	20
R5	4.5	6	3	4.5	0	18
R6	5.5	2	4	5.5	1	18
R7	6	5	2.5	4	2.5	20
R8	6	5	4	3	2	20
TOTAL	45	33	26.5	26.5	20	151
WEIGHT (K_M)	**29.80**	**21.85**	**17.55**	**17.55**	**13.25**	100

Also in the data analysis, to provide a platform for comparisons between companies, the customer types were analysed for their roles as customers. As detailed in Chapter 2, section 2..2.1, there are many ways of looking at the customer. Unfortunately, as the research unfolded, it was found that none of them captured all of the different customer types specified by companies during the research. As such, new customer units were produced for this research based upon an understanding of the identity of those involved, the buying decision process for each company and the type of buying decision (Webster and Wind, 1972). The customer units identified and used during the 'between company' analysis were:

Decision unit - Who have the authority to select the supplier and product. (Webster and Wind, 1972; Bonoma *et al.* 1977; Wilson *et al.* 1996);

Buying unit - Who execute the buying decisions and negotiate the sales contract. (Webster and Wind, 1972; Bonoma *et al.* 1977; Wilson *et al.* 1996);

Control unit - Who are responsible for policy making, which may place constraints upon the purchase. (Wilson *et al.* 1996);

Information unit - Who provide information and decision criteria about the requirements for the product. (Wilson *et al.* 1996);

Installer - Who are responsible for installing and commissioning the product before use. (Owen and Hills, 1996);

Retailer - Who are intermediaries, providing access to the product, company and/ or the customers. (from exploratory);

End user - Who has the main relationship as an end user of the product. (Webster and Wind, 1972; Wilson *et al.* 1996; Owen and Hills);

Other user - Who are involved in the use of the product, indirectly (e.g. a car driver is the "end user", but passengers are also "other users". (Webster and Wind, 1972; Wilson *et al.* 1996; Owen and Hills);

Maintainer - Who is responsible for the maintenance of the product during its serviceable life. (Owen and Hills)

5.6.3.2 The importance of product attributes to each customer (Z_{iM})

Each respondent was asked to fill in a separate answer to question C3 for each of the customer types they had named. This provided a picture of the respondent's perception of the product attributes that were important to each customer. The "average" response for the importance of each attribute (***P***) was determined by judgement, as described in section 5.6.1.1 above. However, as there were only a few respondents, and a lot of attributes, there were many attributes that had exactly the same absolute scores. Therefore, it was deemed appropriate to not only give each attribute for each customer a point score (P), but also to rank the attributes in order of importance (as determined by the respondent's scores). This ranking (***R***) provided a way to differentiate between attributes that had a mode of 9, but a mean of 8.2 and an attribute also with a mode of 9, but with a mean of 9. To ensure that each attribute could be compared with each other both within and between companies, they were all divided by the number of ranks (*w*=21, as there were 21 attributes) multiplied by the total possible point score (*s*=9). This figure (189) was used as a divider for all companies, allowing comparisons of Z_{iM} on an absolute basis. Equation 5.2 describes this relationship.

$$Z_{iM} = \frac{(P_{iM} * R_{iM})}{s * w} * 100 \qquad \text{(equation 5.2)}$$

Where

$\boldsymbol{Z_{iM}}$= weighted perception of attribute importance for a particular customer (and where $0 \leq Z \leq 100$)

$\boldsymbol{i}$ = the attribute

$\boldsymbol{M}$ = the customer type

$\boldsymbol{P_{iM}}$ = point scale rating given to the importance of the attribute for the particular customer type

$\boldsymbol{R_{iM}}$ = the ranking weight given to the attribute for the particular customer type

$\boldsymbol{s}$ = the number of scale points used

$\boldsymbol{w}$ = the number of attributes to be ranked

Rankings started with the most important attribute (i.e. weighted such that R=21). Where attributes had the same point score and number of responses in each category, each of the attributes were ranked at the higher rank, with the next attribute being placed 2 ranks below. Thus there was always an attribute ranked 21 and always a cumulative value of 236. If an attribute was deemed "not applicable" for this company or customer, it was given a point score of 0, which always multiplied out to provide a Z_{iM} of 0.

5.6.3.3 The overall perception of product attribute importance (A_i)

The research sought to gain an overall perception of what the company sees as customer needs for a particular product. This is equivalent to the "product needs definition" as seen in figure 4.2 in section 4.1.2, Chapter 4. Only one value for each of the 21 product attributes is being sought. However, there are a number of customers, and they may have differing views on what are important product attributes. Therefore, the overall perception of the importance of each product attribute must somehow take into account the differing views of customers. As such, the overall perception of the importance an attribute (Ai) is calculated by using the weighting of the customer importance (K_M) to factor their perception of importance for that attribute (Zi_M). The difference between using a weighted total for Ai, or not is investigated in Appendix I.

Equation 5.3 describes the overall perception of attribute importance. As the total weighting for customer importance is 100% for each company, the overall importance value (A_i) can be compared between companies. It is also possible and permissible to end up with totals for some attributes that are the same.

$$A_i = \sum_{y=1}^{N} (Z_{iM_y} * K_{M_y}) \qquad \text{(equation 5.3)}$$

Where

$\boldsymbol{A_i}$ = overall company perception of attribute importance for a particular product (and where $0 \leq A \leq 100$)

$\boldsymbol{i}$ = the attribute

$\boldsymbol{Z_{iM}}$ = the weighted perception of attribute importance for the customer type

$\boldsymbol{K_M}$ = weighting given to the customer type

$\boldsymbol{N}$ = the total number of different customer types

$\boldsymbol{y}$ = the counter for individual customer types

$\boldsymbol{I}$ = the counter for individual attributes

5.6.3.4 A quality index for each product attribute (Q_i)

The equations above aim to provide a cumulative score for each product attribute. The final value calculated in the data analysis aims to and represent how well the company is doing at meeting the customers needs by including a competitive situation score. Equation 5.4 shows the calculation for the "quality index". This is a score from –1 (very important, but definitely inferior to competitors products) to +1 (very important and the company has the product that is definitely superior to the competitors). The score for the competitive situation was measured on a scale from "definitely inferior" (-2) to their competitive rivals to "definitely superior" (+2). The use of the scale was described in section 5.6.1.2. The advantage of using a scale with positive and negative points is that any products that are "about the same" as their competitive rivals have a product of zero. This zero score allows concentration upon products that are inferior or superior, i.e. those that may eventually be perceived as differentiating factors by the customer. This "quality index" is an important value because it can show whether the product is better or worse, by using positive and negative signs in front of them. It can also show the size of the possible advantage of the problem.

$$Q_i = \frac{A_i * C_i}{200} \qquad \text{(equation 5.4)}$$

Where

$\boldsymbol{Q_i}$ = "quality index" for the particular product attribute for that company (and where $-1 \leq Q \leq +1$)

$\boldsymbol{i}$ = the attribute

$\boldsymbol{A}$ = the overall company perception of attribute importance

$\boldsymbol{C}$ = competitive situation of the product

All of the data analysis techniques and equations described above were used consistently to provide the information and for the findings in Chapter 6.

5.7 A note on the accuracy of the main study

As mentioned in the analysis of the exploratory work, any research measure should be able to face examination in terms of how valid and reliable it is (see section 3.4, Chapter 3).

Validity is how closely the measure predicts the true score of the characteristic of the object being measured (Churchill, 1995). As far as possible, the research instrument was tested for pragmatic or predictive validity (whether it predicted correctly), content or face validity (whether the measure adequately assessed the characteristic) and construct validity (what the instrument was in fact measuring). This was done by looking at previous literature, by following good methodological procedures, by defining the constructs at an early stage and using these constructs to develop the research instrument, by undertaking pilot tests and by including as many appropriate respondents as possible in the study (Churchill, 1995; Easterby-Smith, 1991; Tull and Hawkins, 1993).

The reliability of the research instrument to reduce random errors during data collection was determined through subjective testing. With such few respondents, and large number or items, it was inappropriate to carry out any statistical reliability coefficient testing.

One source of error in measurement is that of non-response and the failure to capture information about the population that the research is aiming to assess (Churchill, 1995). Tables 5.4, 5.5 and 5.6 in section 5.5.5 indicate the number of people who were involved in the study from each company. The percentage of people involved in the study for the identified sample was particularly high (75% in 2 companies, 100% in the other 2 companies) and is likely to be representative of the whole population of interest in each company. However, in Company B it was noted that the sample contained all 7 of the possible 7 people from design, but only 3 from the 6 in R&D. Therefore, non-response by this group of people may be a source of error (Tull and Hawkins, 1993) and was considered during data analysis.

Item non-response was more of a problem for the study. This relates to whether specific items have answers, and whether these answers are correct (Diamantopoulos and Schlegelmilch, 1997). The design of the dichotomous questions was particularly an issue for item non-response. Normally, dichotomous questions have a low relative probably of ambiguity in the answer given (Green and Tull, 1978). However, because of the number of questions and limited space, the two options were offered to the respondent in the form of one box. The choice was to check the box if the answer was positive and to leave it empty if the response was negative. This means that any non-response to particular items may be hidden the negative response rate. The design of the questionnaire tried to trace item non-response by addition of "don't know" and "N/A" categories, where the respondent may have not answered otherwise. Also, the interviewer attempted to track answers during the interview and the analysis followed patterns in positive responses, rather than negative ones. Therefore, the possibility of missing data was accepted with these reduction measures in place. In some cases, due to time pressures, the respondent did not answer a whole set of questions and this was recorded as such, to help avoid inaccuracies in data analysis. Also, there were some missing data from the questionnaires used during the pre-test, as a few questions were changed or added. Missing data was always coded differently during data analysis and data collection, data entry and analysis methods were investigated where issues arose.

Chapter 6
Customer needs compliance study findings

This chapter describes the findings from administering questionnaires in the four UK design and manufacturing companies that participated in this research. As with many research projects, there were lots of different pieces of data collected and therefore there were many aspects that could be investigated both between and within companies. Much more data analysis was carried out than is presented in this Chapter. However, the most pertinent and interesting findings are included.

The first section presents a description of each company in terms of the markets and product characteristics. The four sections that follow, detail the results from within company analysis, starting with specific findings relating to the importance of customers and product attributes. A perceptual map describes the possible *quality* of product attributes in terms of importance (A_i) and competitive position (C_i). The recognised activities that take place in the NPD process for each company are also explained. The final main section in this chapter provides an overview of appropriate comparisons between companies. The section compares the perceived importance of customer units between companies, highlighting trends. The similarities and differences between companies for collection, use and dissemination of customer needs information are then described in some detail.

6.1 Company and product descriptors

Company characteristics, in terms of size and business were described in table 5.3, in Chapter 5, section 5.5.5. Other descriptors were collected via the questionnaire and these are summarised in table 6.1. Information on the source of new product ideas was also collected and analysed, and the results for all companies are presented in Appendix S.

All of the companies are quite similar in general terms. They are perceived as being a combination of market pull and technological push, and all generally aim their products at both niche and mass markets. All of the products investigated also have similarities – they are established products, having been produced for at least 10 years and the latest new development for the product was either to replace the old product, or to supplement the existing line of products. These company and product descriptors are used in later sections to help provide possible explanations for trends in the results of attribute importance and quality and information management.

Table 6.1. Categories for the companies and products investigated

COMPANY A	
Company A categories	**Product investigated**
Combination of market and technology driven	Combination of mass and niche markets Produced for over 20 years
Combination of mass and niche markets	**Latest development category for this product** *Addition* – A new product that **supplements** the company's established product lines.
COMPANY B	
Company B categories	**Product investigated**
Combination of market and technology driven	Mass market Produced for over 20 years
Combination of mass and niche markets	**Latest development category for this product** *Improvement* – A new product that provides improved performance or greater perceived value to **replace** existing products.
COMPANY C	
Company categories	**Product investigated**
Combination of market and technology driven	Combination of mass and niche markets Produced for approximately 10 years
Combination of mass and niche markets	**Latest development category for this product** *Addition* – A new product that **supplements** the company's established product lines.
COMPANY D	
Company categories	**Product investigated**
Combination of market and technology driven	Mass market Produced for approximately 15 years
Combination of mass and niche markets	**Latest development category for this product** *Improvement* – A new product that provides improved performance or greater perceived value to **replace** existing products.

6.2 Company A findings

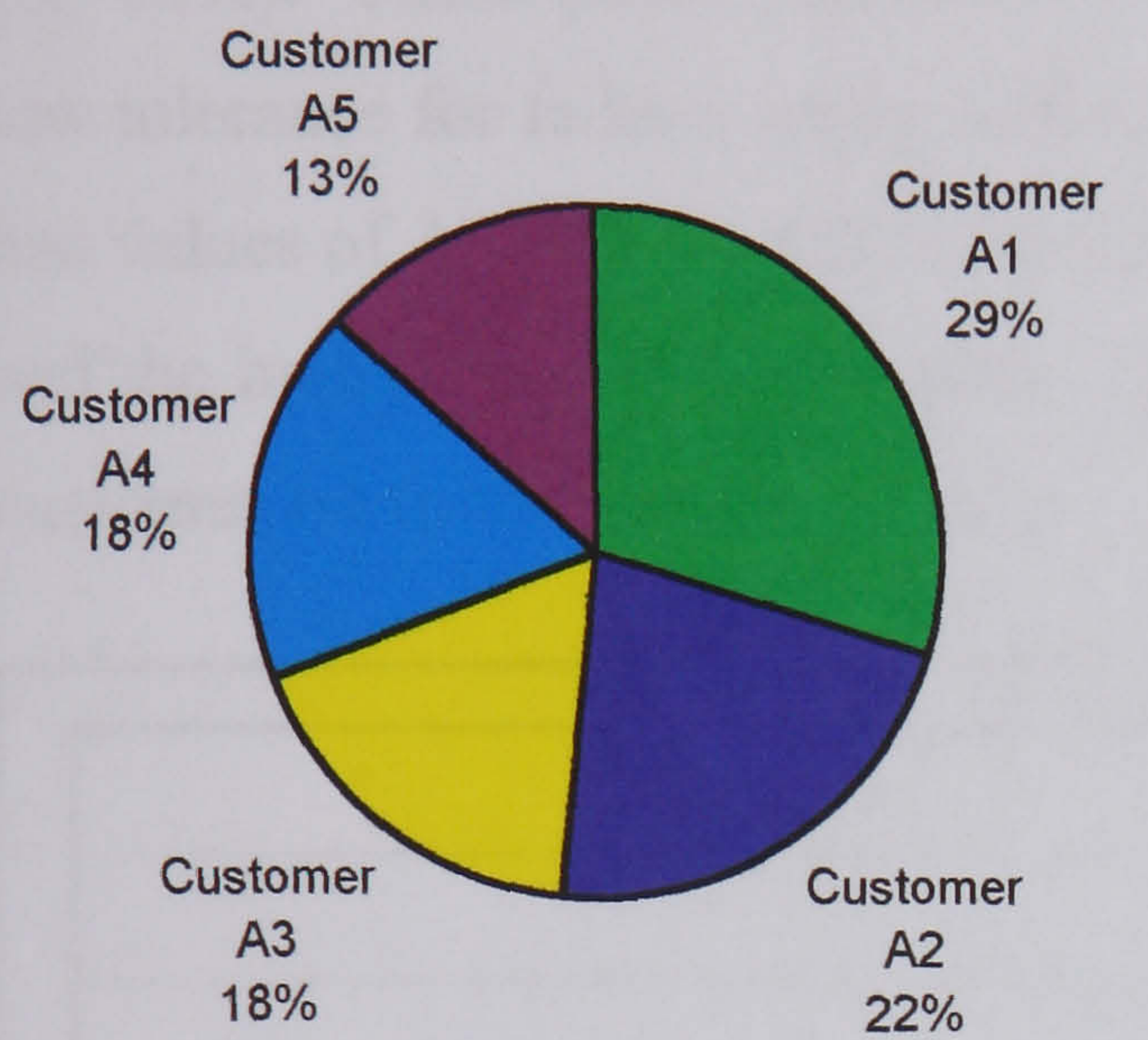
The product identified for Company A typically had a project team size of 12. Of these, 9 were interviewed. Tables 5.4, 5.5 and 5.6, in section 5.5.5 of Chapter 5 details respondent groups in terms of functional and management responsibility and their involvement with the company's customers. Responses to the questionnaire were analysed and cross tabulated to uncover any possible trends in the results. However, with such a small sample size, there were no conclusive differences in the findings between company groups. As such, all results presented here are consensus views and cumulative frequencies.

6.2.1 Company A: Importance of different customers (K_M)

Figure 6.1 provides an overview of the "customer" for Company A. The pie chart shows the relative importance given to each of the company's customer types (K_M) (for calculation of K_M see equation 5.1, in section 5.6.3.1). The table on the left hand side then shows how each of the customer types, that are specific to Company A, can be described as part of generic customer units. The overall, implied rating for these customer units are compared in the bar chart at the bottom of figure 6.1.

Figure 6.1 shows that Company A regards all customer types as quite important. The figures in the pie chart for customer weighting (K_M) indicate that none of the customers have an overriding influence and none of the customers are insignificant, although customer A1 is perceived as more than twice as important as customer A5. It can also be seen that, although customers A3 and A4 have very different roles and relationships with the product and the company, they have equivalence in their perceived importance as customers.

The bar chart in figure 6.1 shows the picture of influence of customer units, in general terms. It is important to note that the two most important customer types (A1 and A2) are two very different groups of people. However, they have in common the fact that they both make decisions on the product and also control the policy for purchase decisions. There is also a similarity for customers A1 and A3 as they have an installation relationship with the product. However, similarity in individual roles does not make the perception of customer types equal in standing for importance. It appears to be the combination of roles that has an influence upon the importance of the customer type. In terms of customer units, the importance of customer type A1 can be understood, as they are involved in the four most important roles: installing the product; providing information about decision criteria; setting policy on purchase and making the decision itself.



	K_M					Total rating
	A1	A2	A3	A4	A5	
Decision unit	29	22				51
Buying unit		22				22
Control unit	29	22				51
Information unit	29		18			47
Installer	29		18			47
Retailer					13	13
End user				18		18
Other user						0
Maintainer						0

Description of each type of customer for company A in terms of their role(s).

The importance of customers A1 to A5 are shown in the pie chart, the total rating for customer units are shown in the bar chart.

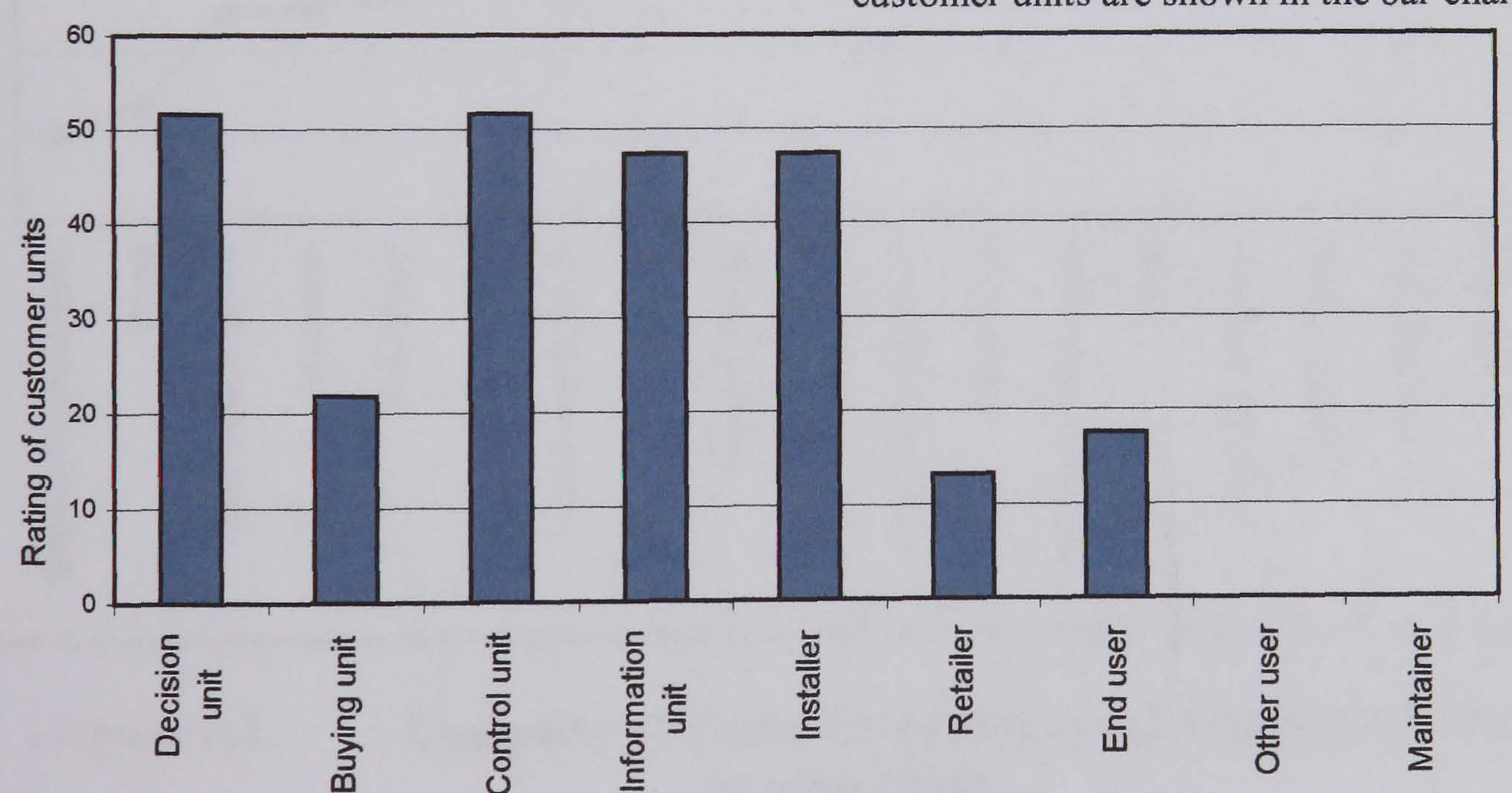


Figure 6.1. Company A: the importance of customer types and implied rating of customer units

6.2.2 Company A: Importance of product attributes (A_i)

The overall perception of the importance for product attributes (A_i) that were applicable for Company A were collated to produce figure 6.2. Only 19 out of the 21 product attributes were considered by the respondents as applicable to the product being investigated (use maintenance and servicing and warranty were not applicable and are therefore not show in the graph).

The graph shows some attribute groupings. The top three attributes for importance, in Company A were effectiveness (A_i=67%); reliability (A_i=56%) and install expertise (A_i=52%). These reflect the nature of the product, a medical implanted device, with low tolerance for failure, using skilled installers. A secondary group of 4 attributes all had values of A_i between 42% and 48%. Again, these reflect the nature of the product and the industry (health and safety, risk, technical performance) and the influence of customer A1 (personal preference).

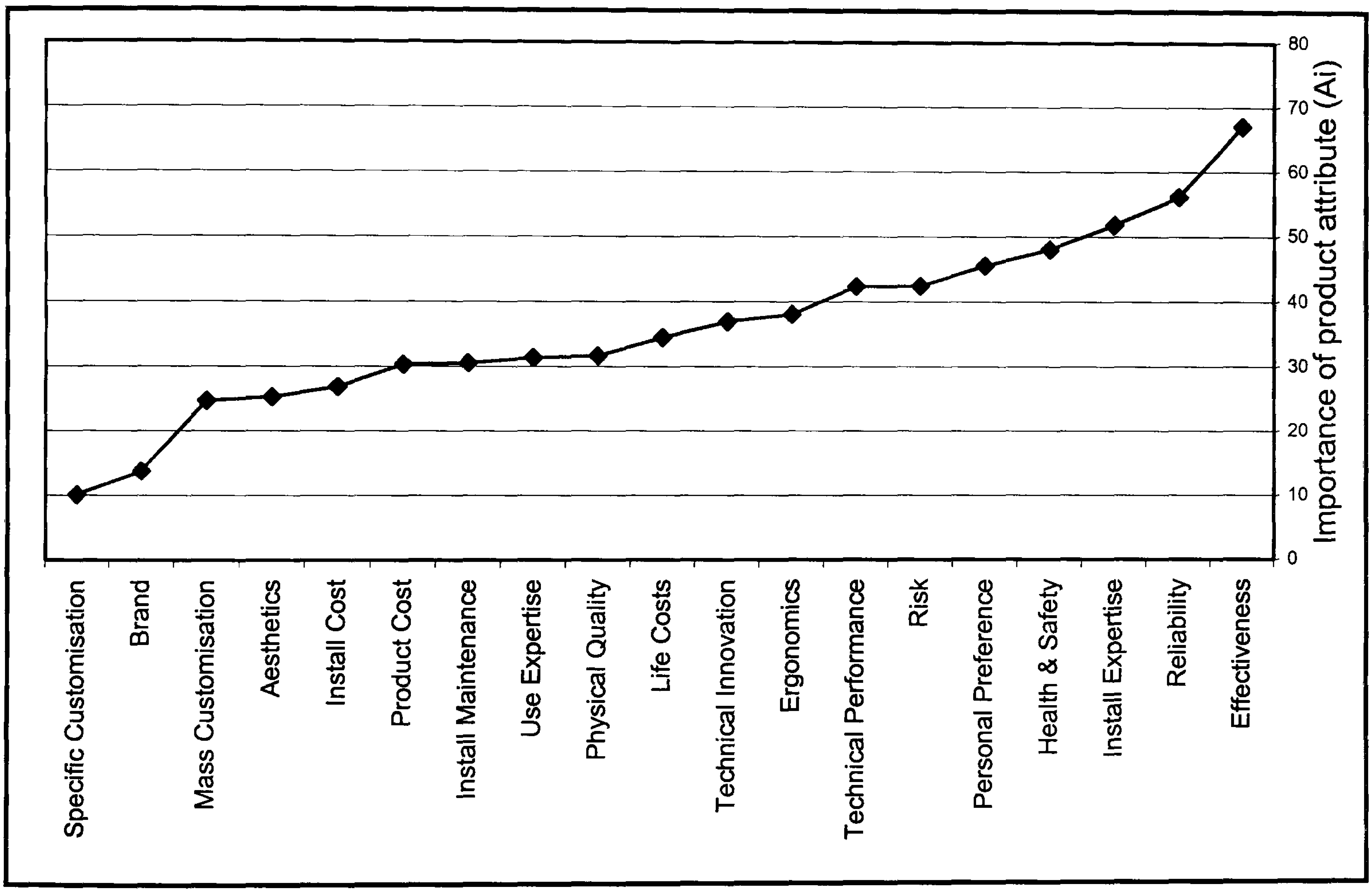


Figure 6.2. Company A: Importance given to product attributes (A_i) in rank order

Other, noticeable trends showed costs with mid to low ranking for importance. Bearing in mind the high importance of installation expertise and the importance of the installer as a customer role, it is interesting to find "install cost" and "install maintenance" with quite low importance scores. Effectiveness and reliability were the highest ranked attributes, but there was much less importance placed on physical quality – the company perceives that the customer is more lenient for dimensions and conformity issues of the product. Specific customisation is perceived as the lowest importance, because, although specific customisation is possible, it is not common with this type of product.

6.2.3 Company A: Quality index (Q_i) and perceptual map

For each product attribute, a quality index, described in section 5.6.3.4, in Chapter 5 was produced. A perceptual map was produced to place the attributes in relation to one another in terms of their importance (A_i), their competitive standing (C_i) and their quality index (Q_i). The use of perceptual mapping methods is described in the literature review, in section 2.3.2.2. The perceptual map in figure 6.3 is representation of the relative *quality* of each attribute. That is, the importance of the attribute is placed in regard to how well the company competes in the market place for the particular attribute. The importance of the attribute is show by a high A_i and a larger bubble. Good competitive standing is shown by a positive C_i, inferior competitive standing has a negative C_i, and the attributes that are perceived to be about the same as the competitors are on the zero line. Attributes in figure 6.3 have the same value for A_i as in figure 6.2.

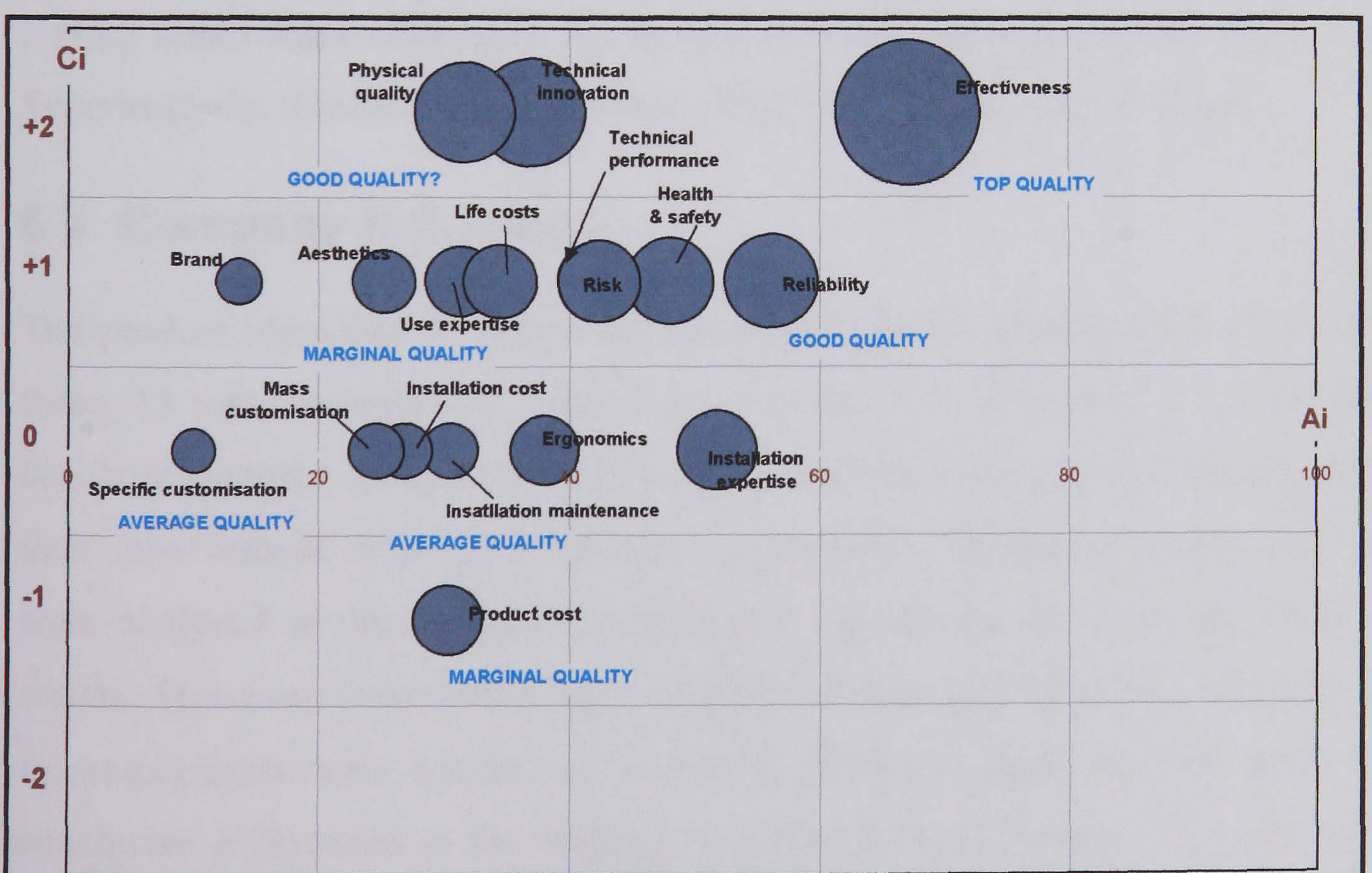


Figure 6.3. Company A: Perceptual mapping of importance (A_i) Vs competitive standing (C_i) (the size of the bubble is proportional to Q_i)

Overall, Company A believes that it competes well against it's competitors. For all but one of the attributes, they believe they are the same or better than competitive products. The exception is product cost, where they are "worse" than competitors' products. In this case, it meant that products were more expensive. However, although the company believed that on an absolute basis the company fared badly against the competition, this attribute is never taken in isolation and is weighed against other attributes. Therefore, the company itself viewed this as a acceptable position to be in.

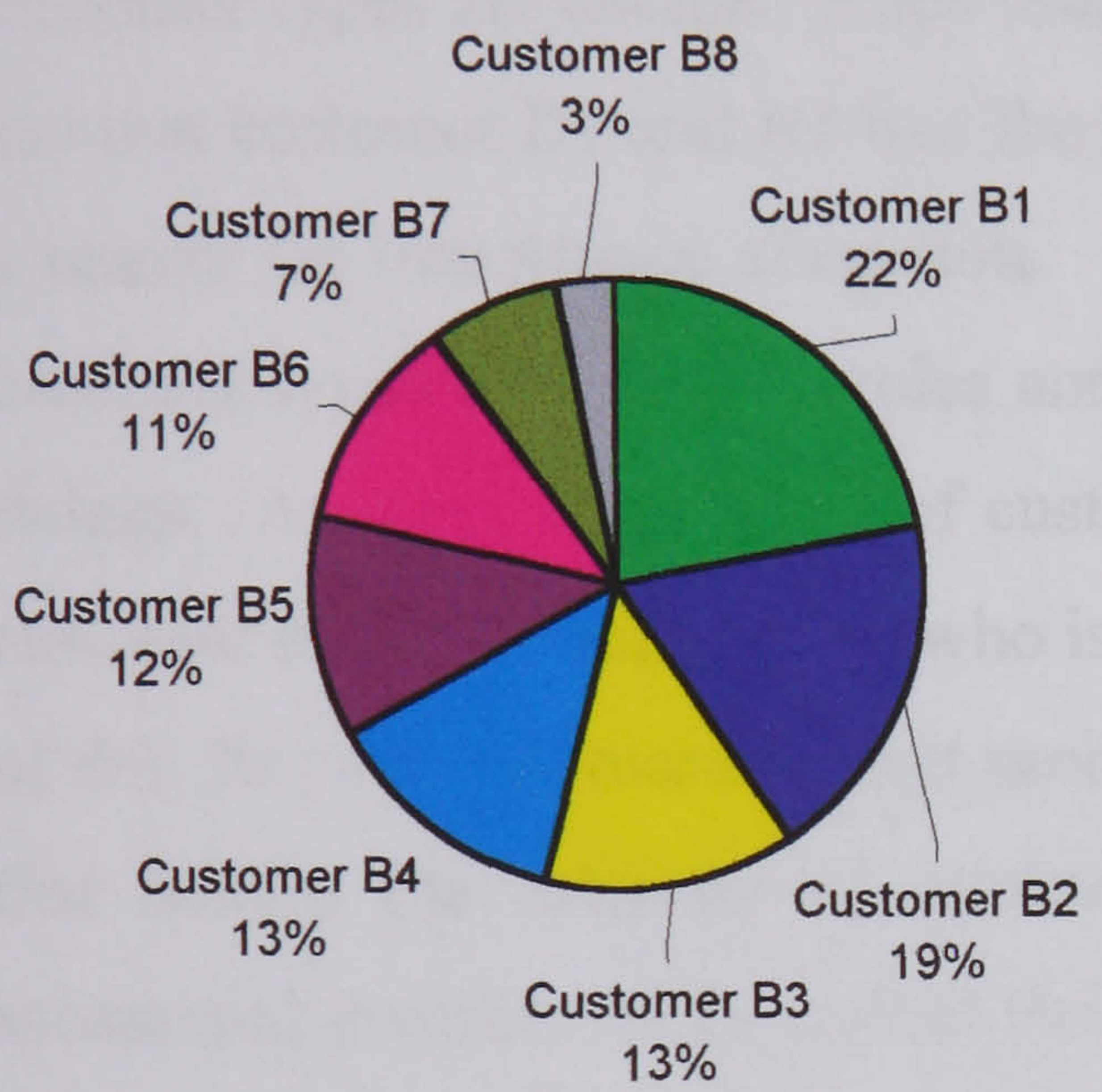
The perceptual map clearly shows that the company perceives that it is achieving "top quality" for reliability – this is the attribute of highest importance to its customers and the company is superior to competitive products. The company also perceives "good quality" for other high importance rated attributes of health and safety, personal preference, risk and technical performance. Some attributes maintain a status-quo, being the same as other companies. These include mid-range attributes (e.g. ergonomics, installation maintenance and installation costs). However, the high importance-rated installation expertise is also classed as being the same for competitors products. This is an area that is highly competitive, with companies putting much sales effort into it, offering courses and demonstrations for installers. Superiority for this attribute is therefore difficult to achieve and maintain.

6.3 Company B findings

The product identified for Company B typically had a project team size of 19. Of these, 15 were interviewed. Tables 5.4, 5.5 and 5.6, in section 5.5.5 of Chapter 5 details respondent groups in terms of functional and management responsibility and their involvement with the company's customers. Responses to the questionnaire were analysed in depth and cross tabulated to uncover any possible trends in the results. However, even with a larger number of respondents than the other companies, the respondents were spaced out across the different groupings and there were no conclusive differences in the findings between company groups. As such, all results presented here are consensus views and cumulative frequencies.

Unfortunately, it was not possible to interview all of the people in one project team. Of the 7 designers in the nominated project team for the product being investigated, 7 were involved in the study. However, only 3 of the possible 6 R&D people were interviewed due to work commitments. This may have some influence on the findings, with bias towards the design group, or away from R&D but it is difficult to say whether any large differences were observed because of this possible bias.

6.3.1 Company B: Importance of different customers (K_M)



	K_M								Total rating
	B1	B2	B3	B4	B5	B6	B7	B8	
Decision unit	22	19		13			7	3	64
Buying unit	22	19		13			7	3	64
Control unit	22	19		13			7	3	64
Information unit	22	19		13			7	3	64
Installer									0
Retailer			13						13
End user	22					11			33
Other user					12	11	7	3	33
Maintainer	22	19		13	12		7	3	75

Description of each type of customer for company B in terms of their role(s).

The importance of customers B1 to B8 are shown in the pie chart, the total rating for customer units are shown in the bar chart.

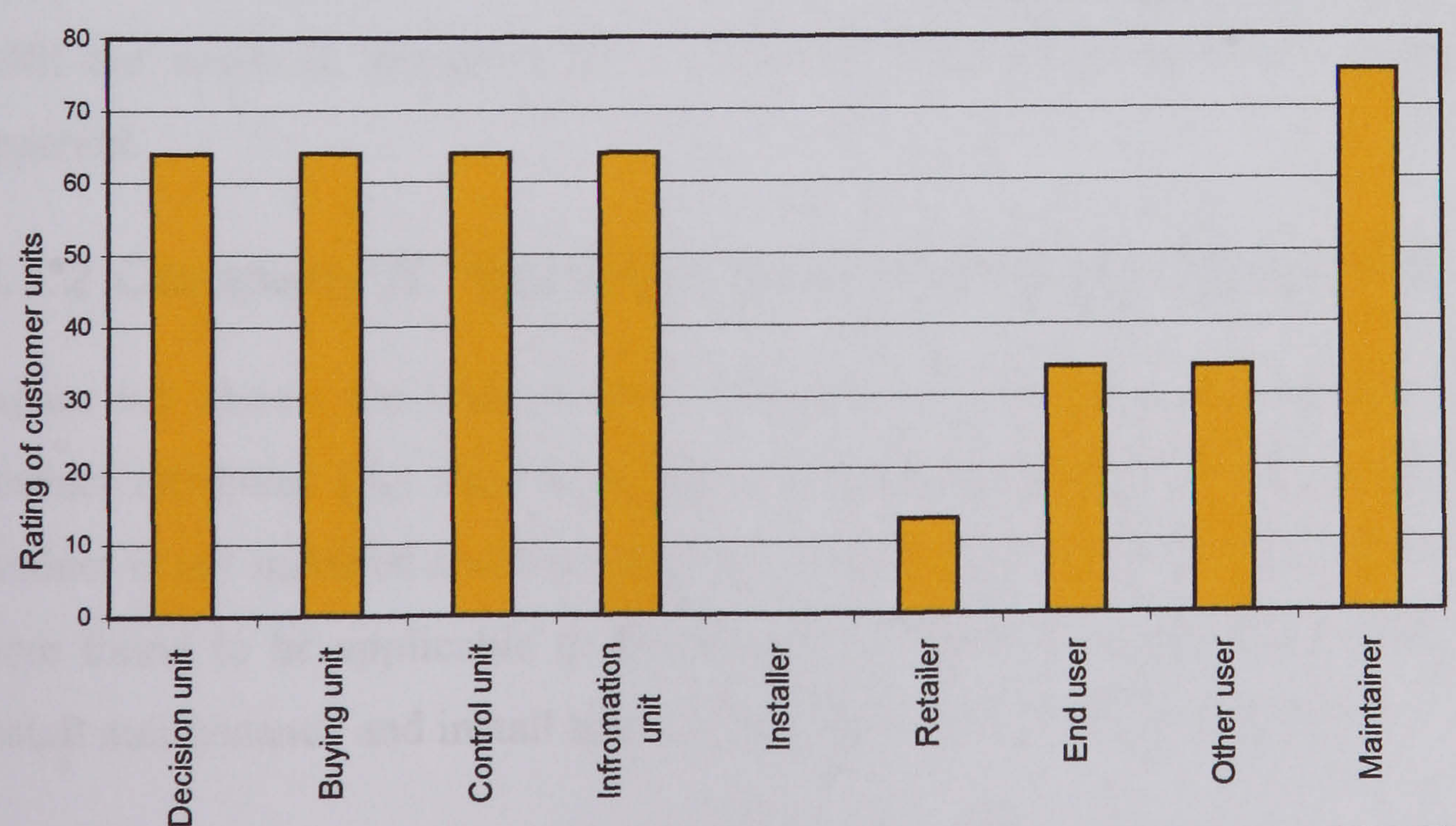


Figure 6.4. Company B: the importance of customer types and implied rating of customer units

Figure 6.4 provides an overview of the "customer" for Company B. The pie chart shows the relative importance given to each of the company's customer types (K_M) The table on the left hand side then shows how the ratings for customer units, that are used in the bar chart at the bottom of the figure, were found.

Figure 6.4 shows that there are two customers with high importance (customers B1 and B2). These two customer types have similar roles in terms of customer units. However, this cannot necessarily be seen as any reason for their importance, as three other customer types (customers B4, B7 and B8) have the same set of roles and these customer types are deemed much less important than B1 and B2. It is also not true to say that customer B1 and B2 buy the most number of products, so this is not currently a reason for importance allocation. The nature of this type of product is that many customer types have similar roles and therefore most of the customer units have high ratings. As such, importance of customer types does not seem to be associated with customer units, but rather with who is seen as the "traditional" influence in the market of this 20 year old, mass-market product. Customer B1 was previously the customer that bought the majority of products, with customers B2 and B4 providing the substantial majority of the rest of the buyers in the marketplace. The retailer also has traditionally made a difference to the numbers of the product sold. However, today these influences are very different, and in fact customer B1 only accounts for 10% of sales. It is noticeable that within the company there is some nostalgia for wanting to fulfil the needs of customer B1. No other patterns of customer importance are apparent.

6.3.2 Company B: Importance of product attributes (A_i)

Figure 6.5 shows the rank order of the overall perception of the importance for product attributes (A_i) that were applicable for Company B. For Company B, the product is not installed and therefore only 18 out of the possible 21 product attributes were found to be applicable to the product involved in the study (install expertise, install maintenance and install cost are therefore not shown on the graph).

The nature of the product appears to be the main influences in the product attributes seen as most important. Operational aspects of the product have priority, with reliability and use maintenance with very much higher A_i scores than any other attributes. The need to keep the product running and get the customers' money's worth out of the product also seems to affect the priority of other attributes (servicing and warranty, effectiveness and product cost). It is very interesting that brand has such a high priority, this is almost certainly due to the competitive nature of the mass marketplace and it is noticeable that the company puts a lot of effort into maintaining company brand images. Attributes that have low importance scores also reflect the type of market in which the product competes. Customisation and technical innovation are perceived as unimportant to mass market customers.

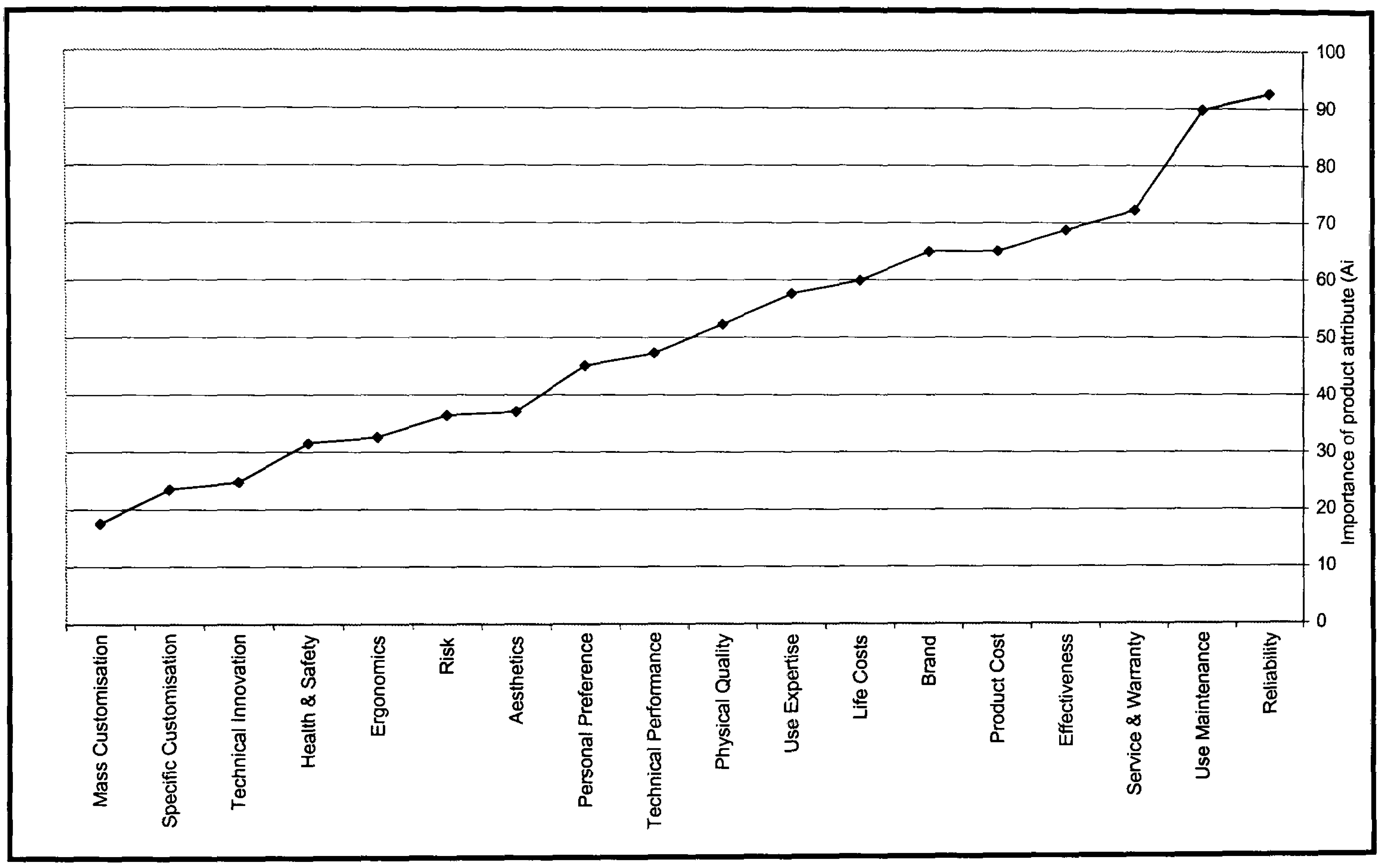


Figure 6.5. Company B: Importance given to product attributes (A_i) in rank order

6.3.3 Company B: Quality index (Q_i) and perceptual map

Figure 6.6 presents a perceptual map of one view on the *quality* of the product attributes for Company B. Section 6.2.3 describes how a perceptual mapping technique was applied for the importance of attributes (A_i), competitive standing of the same attributes (C_i) and quality index for the attributes (Q_i). Attributes in figure 6.6 have the same value for A_i as in figure 6.5.

The position of the largest bubbles (those attributes with a high Q_i) shows that the company believes that they have a number of attributes where Company B's products are better than the competition. As there are no bubbles with a negative C_i, it is obvious from the diagram that the company does not recognise any attributes where they are inferior to the competition. In fact, they believe that they are better than the competition for 13 of the 18 attributes. This picture may be correct, and there may be other reasons why Company B's product has dropped to 30% of the market, from a commanding position of 70%, 10 years previously. However, when investigated further, it was found that the competitive situation for product cost is not as analysed from data collected in the questionnaire. Product cost was recorded as being superior to the competition, but the respondents were found to be more likely to view "product value" as being superior. Company B actually charges a premium price for the product, even though they compete in a mass market. Their premise for this is that they are superior on many of the product attributes and do offer higher "quality", but at a price. As such, the product cost bubble should be in the minus two region of the graph for competitive standing (C_i = -2). This highlights a problem with asking about price, generally: respondents obviously found it difficult to determine what "better price" is, they perceived it to be a summary of "value for money"; whereas other companies' respondents were more unattached and scored a cheaply priced product being "better" and more expensive being "worse".

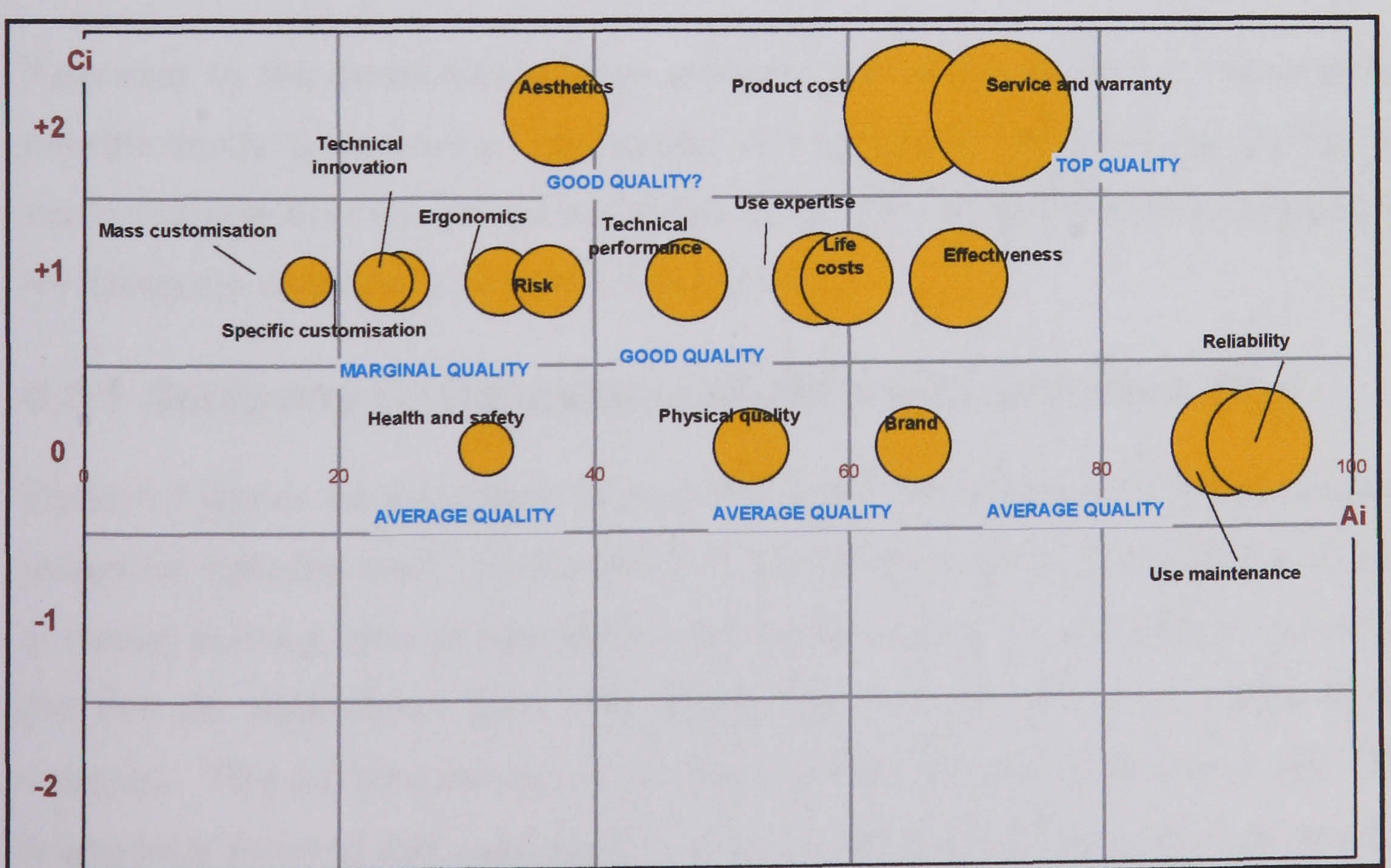


Figure 6.6. Company B: Perceptual mapping of importance (A_i) Vs competitive standing (C_i) (the size of the bubble is proportional to Q_i)

6.4 Company C findings

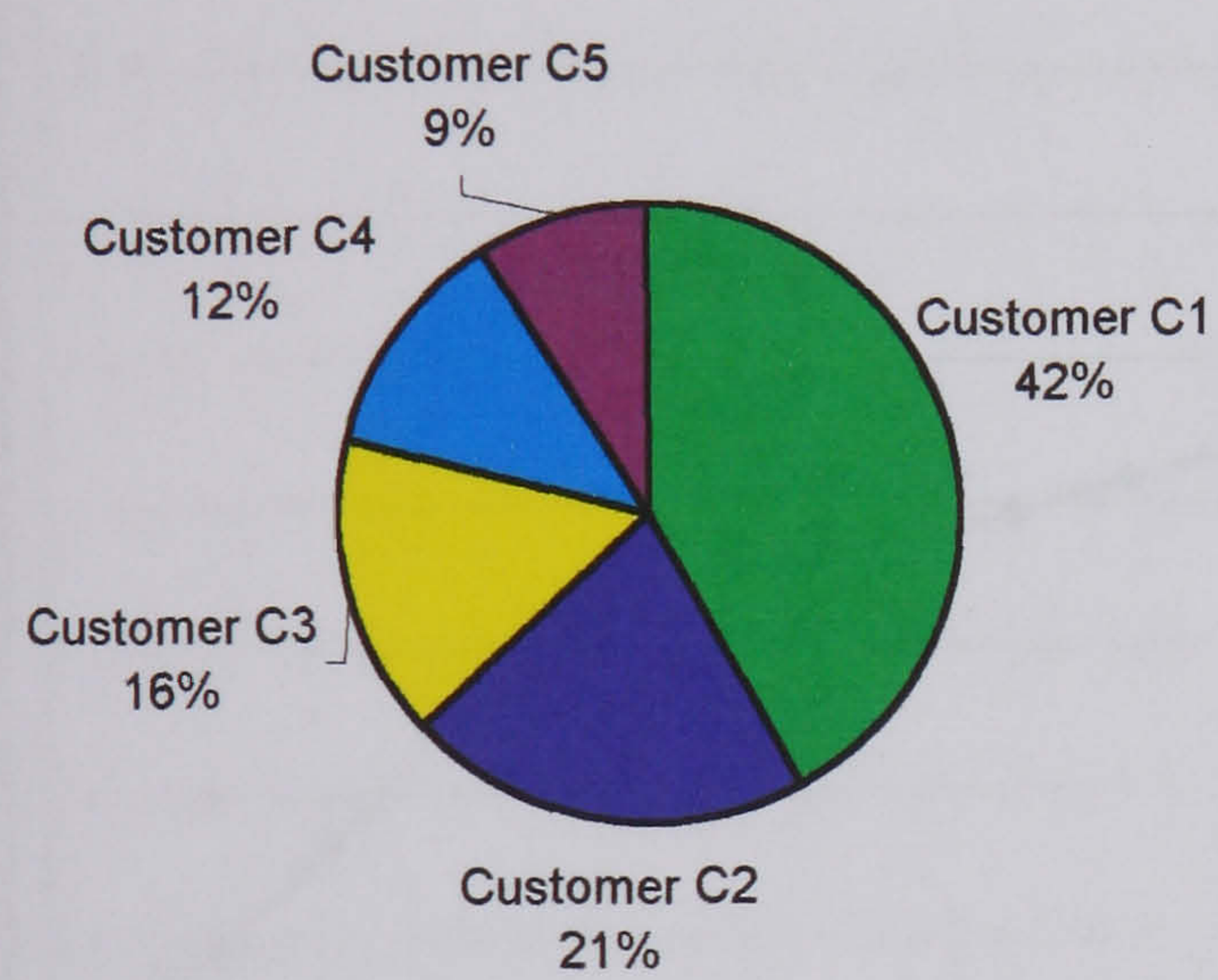
The typical number of people involved with the development of one product for Company C was eight. All eight of the development group for the product being investigated were interviewed for this research. The groupings of respondents, that reflects the typical team composition is show in section tables 5.4, 5.5 and 5.6, in section 5.5.5 of Chapter 5. The group allocations presented in these tables are those that were self-declared by the respondents. Of particular note are the different functional roles of those in the team. Only one person each said that their main function was R&D or design. Others involved heavily in the development of the product were from marketing, manufacturing and quality (the "other"). One of the "marketing" respondents carried out technical design and produced new ideas for the product but saw their role in talking with customers and discussing specification as marketing, rather than design (or even R&D). The whole set-up of the company was based on fitting in with the customer and regularly changed certain parts of the product very close to delivery times. This relied heavily upon interaction with the customer and 5 of the eight stated that a major part of their job was to talk to customers.

Responses to the questionnaire were analysed and cross tabulated to uncover any possible trends in the results. The number of respondents was small and finding any trends within or between groups was not possible. Therefore all results presented here are consensus views and cumulative frequencies.

6.4.1 Company C: Importance of different customers (K_M)

Figure 6.7 shows the importance of customer types for Company C, and the implied ratings for customer units. For Company C there is one dominant customer type, who is viewed as being twice as important as the next customer. This customer type is the one that the respondents liase with closely and who are the most visible to the company. This can also be seen in the perceived importance of the buyer unit. The respondents believed that customer C1, who are perceived to be the central decision and information units would sway any decision, over and above customer C4.

Customers that have direct contact with the product (i.e. installer, user, maintainer) are not seen as important to Company C. This may be due to the product being a component part, and therefore the people who make decisions about which parts to use are seen as much more important, since the company will never directly sell their product to the end user. What is interesting is that the installer is not seen as an important customer of their products, yet they are the customers who interact most with the product and would probably notice first if their were any problems with it. It appeared to be the view of interviewees in Company C that, because they did not have any direct dealings with installers, they expect that the main customer (C1) would ensure that the needs of the installers were taken into account.



			K_M			Total
	C1	C2	C3	C4	C5	rating
Decision unit	42			12		54
Buying unit				12		12
Control unit		21		12		33
Information unit	42	21				63
Installer			16			16
Retailer						0
End user					9	9
Other user						0
Maintainer					9	9

Description of each type of customer for company C in terms of their role(s).

The importance of customers C1 to C5 are shown in the pie chart, the total rating for customer units are shown in the bar chart.

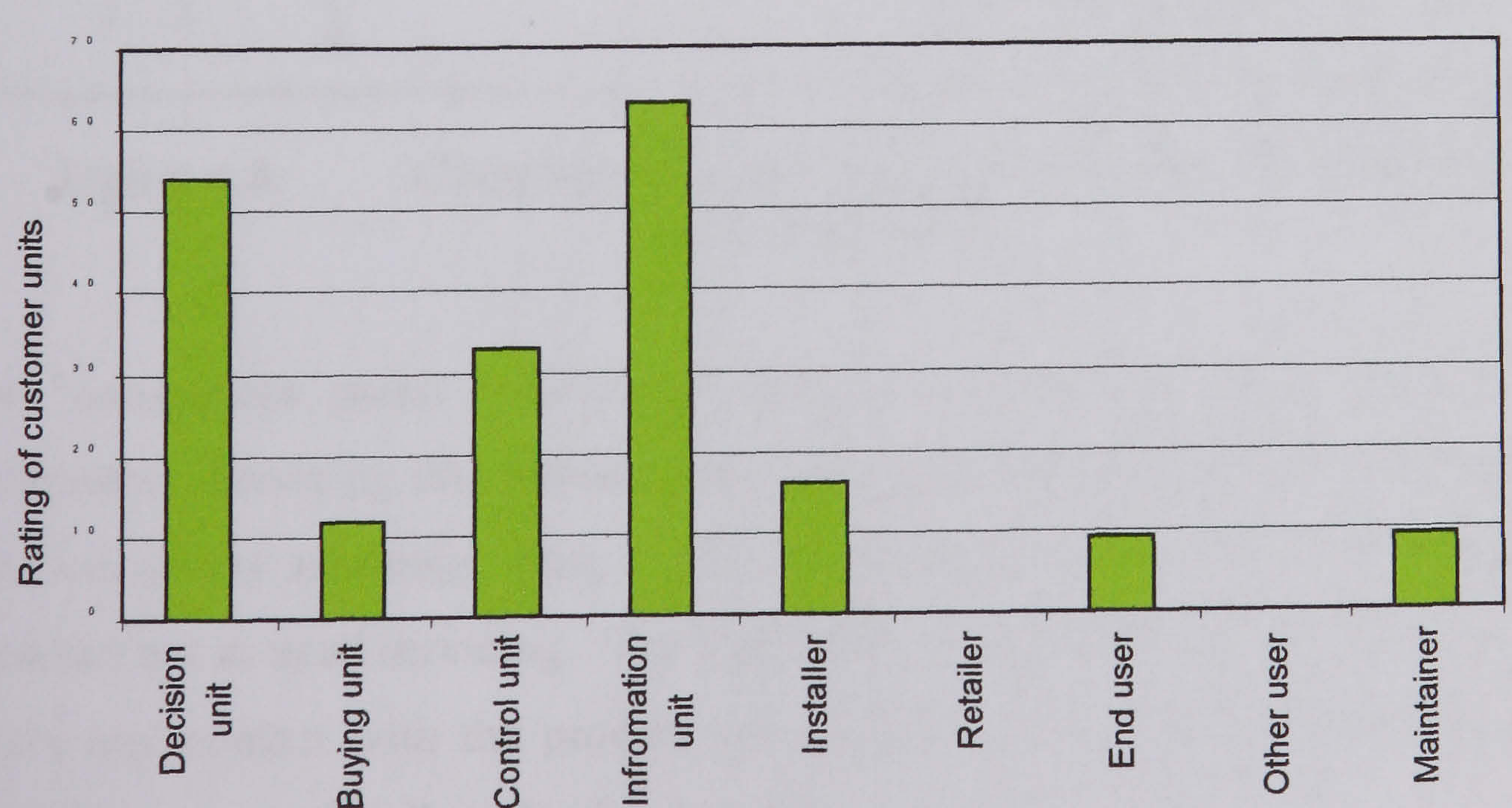


Figure 6.7. Company C: the importance of customer types and implied rating of customer units

6.4.2 Company C: Importance of product attributes (A_i)

Figure 6.8 shows that the attributes that amount to the efficacy of the product are given priority (reliability, effectiveness, physical quality). This may be due to the general attitude of the company: that component parts are about achieving standards in manufacturing and quality. This is highlighted by the composition of the design team, as 2 people from manufacturing and 1 quality person are seen as integral members of a team of eight.

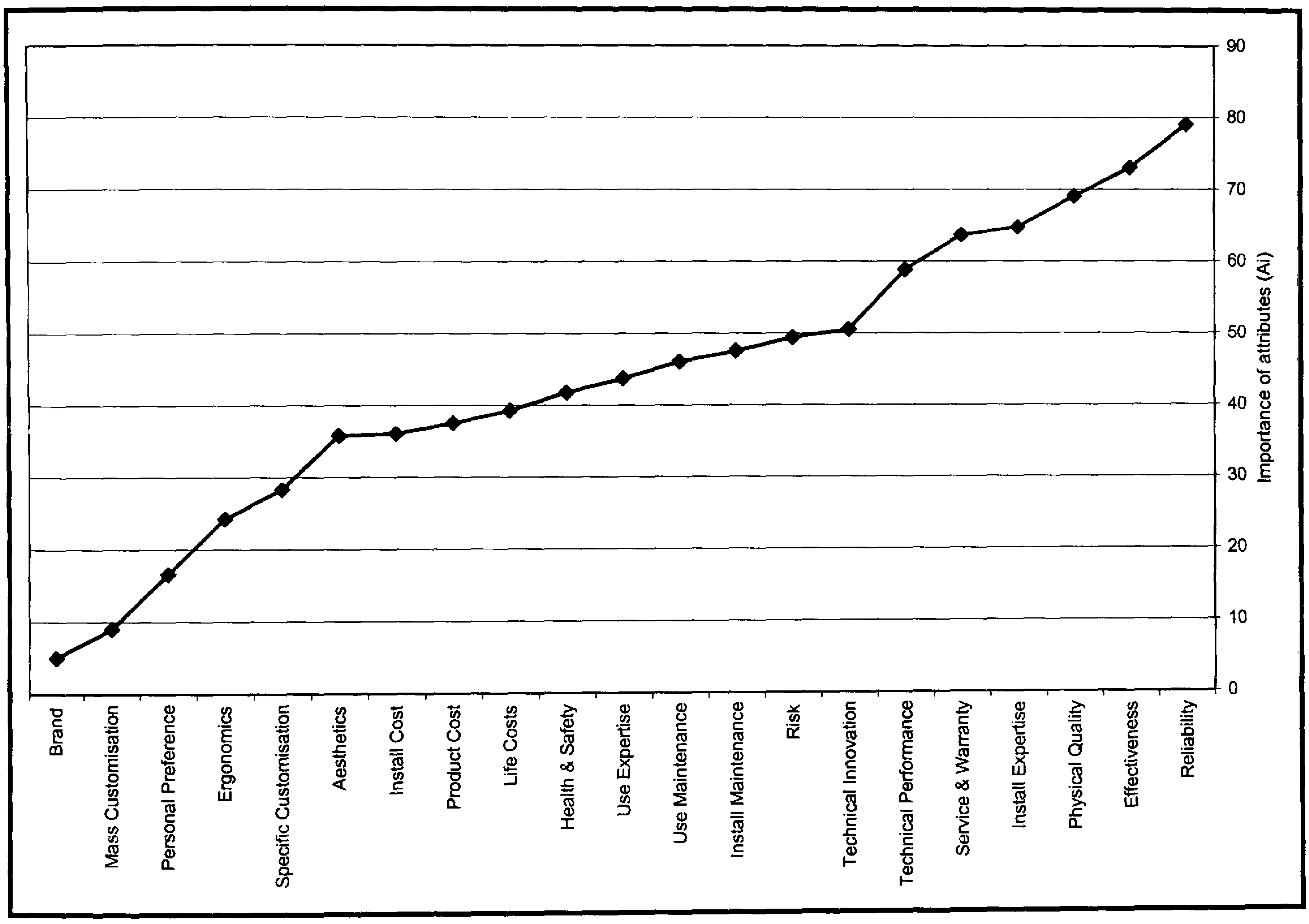


Figure 6.8. Company C: Importance given to product attributes (A_i) in rank order

For component parts, installation expertise scores high for important product attributes. Servicing and warranty are also important because the customer does not want to do any servicing. They expect the product to have a very long life and for the product not to need servicing. The respondents also implied that the company did not have any contact with the product after delivery, unless there were any inspection problems reported to them by the customer.

Brand and personal preference had very low importance scores. Respondents said that the customer did not have much choice in the marketplace (the company had around

90% market share). As such, they believed that these product attributes were of little influence in the grand scheme of things. An interesting result was that Company C did not recognise either type of customisation as important. However, the main work of this company is producing a standard set of products, that are altered for a particular customer. This could be deemed by an external observer as some form of customisation (probably mass customisation). The respondents did not think so. They all agreed that customisation was of low importance. This perception may be due to this activity being the norm and that those involved may see each customer as requiring a different product, rather than a customised product, as new part numbers and drawings are normally produced for each new customer.

6.4.3 Company C: Quality index (Q_i) and perceptual map

A perceptual map of one view on the *quality* of the product attributes for Company C is shown in figure 6.9. Section 6.2.3 describes how a perceptual mapping technique was applied for the importance of attributes (A_i), competitive standing of the same attributes (C_i) and quality index for the attributes (Q_i). Attributes in figure 6.9 have the same value for A_i as in figure 6.8.

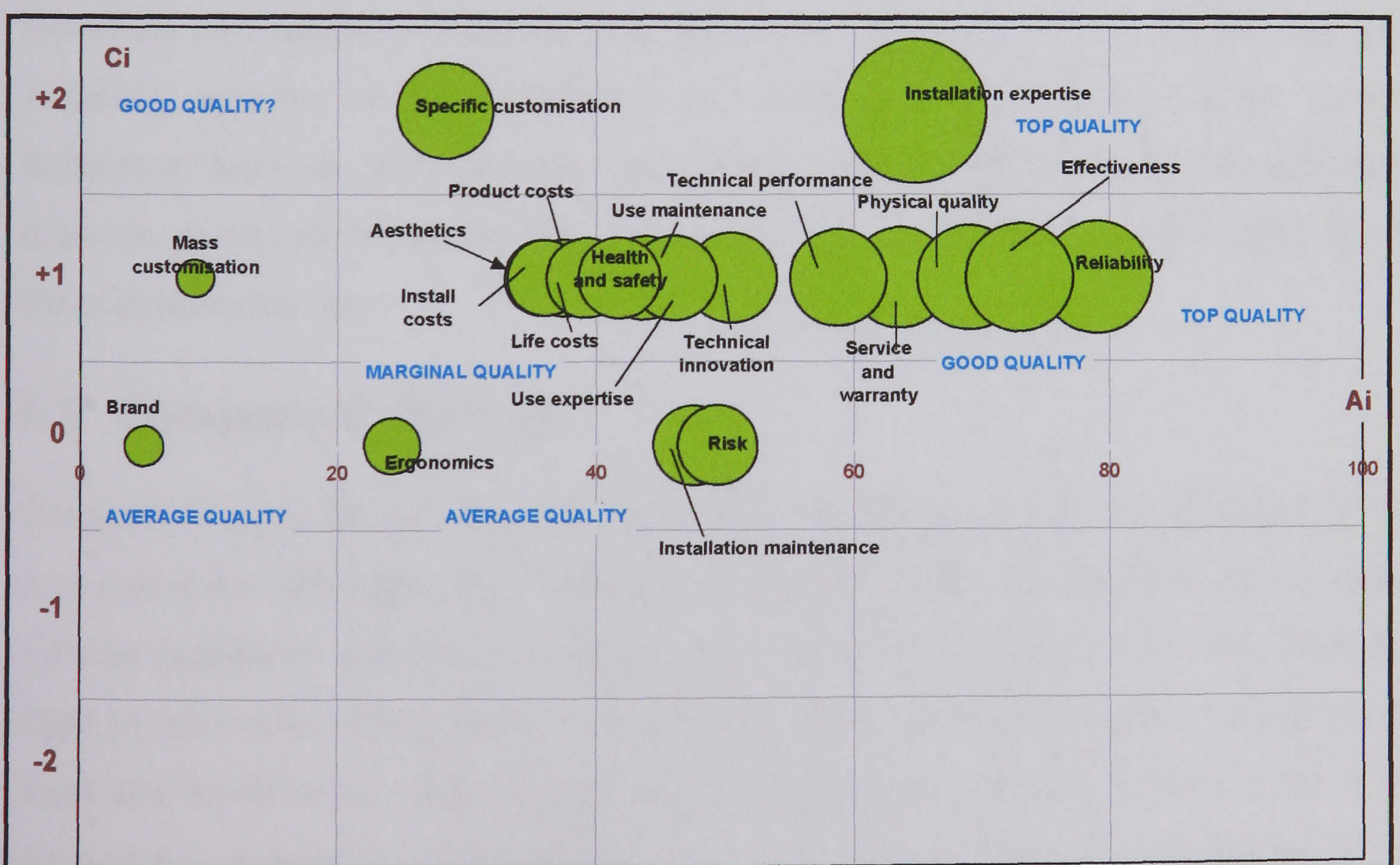


Figure 6.9. Company C: Perceptual mapping of importance (A_i) Vs competitive standing (C_i) (the size of the bubble is proportional to Q_i)

Results from Company C show that the respondents did not believe that the company was worse than the competition for any of the attributes for the product being investigated. In fact, they perceived the company to be somewhat better (C_i= +1) or definitely superior (C_i= +2) to competitive products for all but four of the attributes. This perception may be because of the commanding position the product has in the marketplace and may also be influenced by the huge differences between Company C's product and the competition. When the study was undertaken, the product being investigated was made in a very different way to the competition, using newer methods and materials. The general opinion within the company was that this affected everything positively and on the whole they did not need to worry about what the competition was doing. Because of the newness of the product design, it may have been expected that "technical innovation" would be an area where Company C excelled. They did class themselves as being somewhat better than the competition, but did not include the attribute with the two that they believed they were superior at.

The perceptual map in figure 6.9 shows an interesting anomaly in the perception of "specific customisation". As discussed in section 6.4.3, the respondents gave the impression that customisation was not particularly important to their customers. However, the company believes that this is one of the two things that they are definitely superior to the competition on. This result may be due, again, to the differences between their products and those of competitors: that even though they don't do much customisation they could customise products more easily because of the materials they use.

6.5 Company D findings

Company D typically involves eight people in the detailed design and development of a new product, although many more are occasionally asked for opinions or for other specific (generally technical) information throughout the process. For this research, eight people were interviewed and their groupings in terms of function, management level and involvement with the customer are presented in figures section tables 5.4, 5.5 and 5.6, in section 5.5.5 of Chapter 5. The group allocations presented in these tables are those that were self-declared by the respondents.

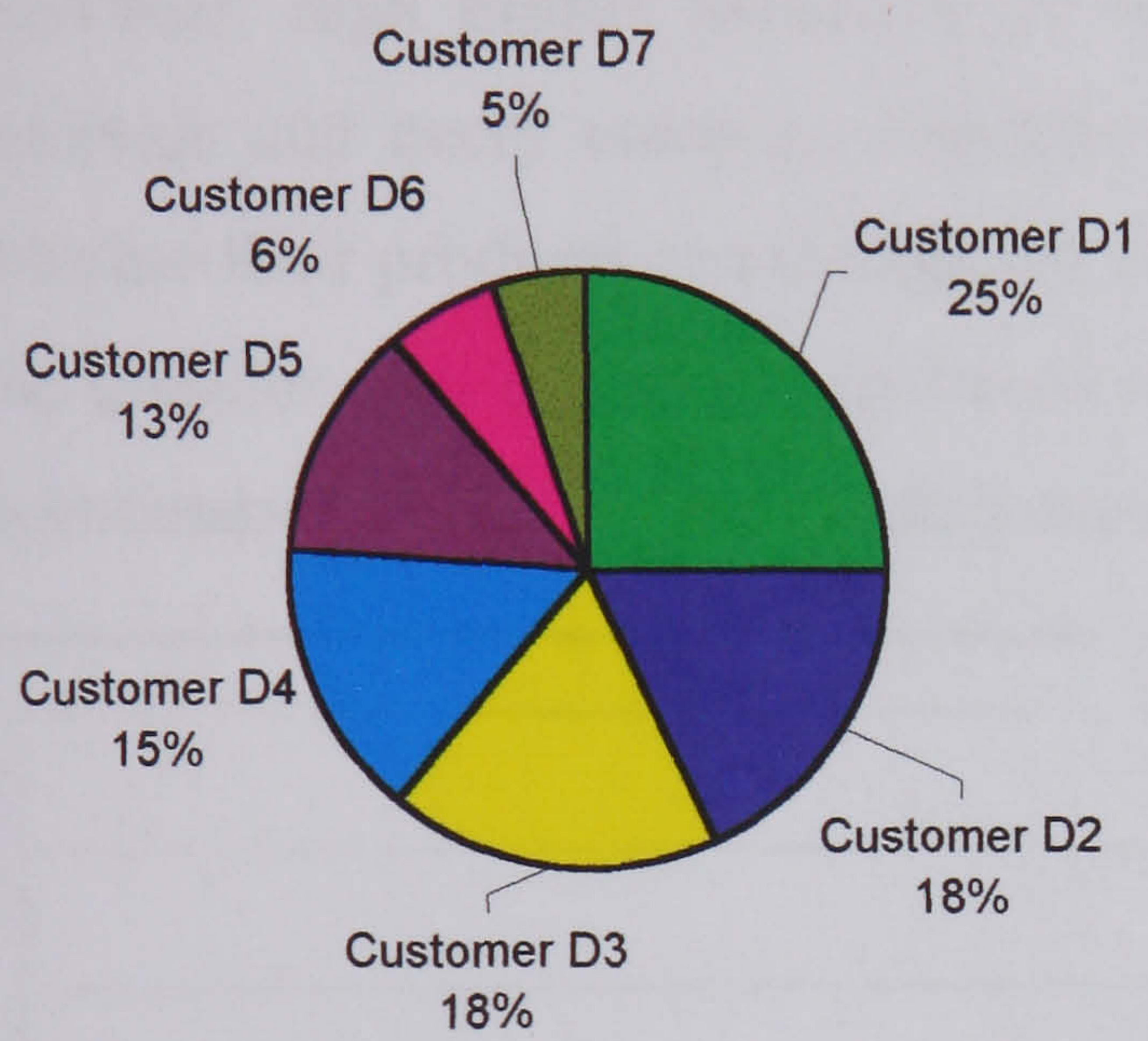
Company D does not have anyone (at all) who is designated as "marketing". Technical managers and sales men undertake marketing tasks as and when necessary. All those interviewed stated that they have some form of contact with the customer and the majority said that this was regular or was a major part of their job, which may help the company's lack of specific marketing personnel.

6.5.1 Company D: Importance of different customers (K_M)

The importance of different customer types (K_M) and their implied ratings for customer units are shown in figure 6.10. The pie chart shows that there are seven customer types for the particular product being investigated. It also illustrates that five of these customers are perceived as being much more important than the other two.

The customer that is perceived as being the most important (D1) is the one that the respondents liase with most often, although the company is also in regular contact with customer types D2, D3 and D4. This involvement with the customer may be a reason for their perceived importance. However, the company also negotiates through Customer type D7, with whom the company has a one-on-one relationship. The lack of importance given to customer D7 may be due to them being perceived as mostly a buyer unit. However, there is evidence that this customer does appear to have some influence over policy and cost requirements of the product. The respondents also said that customer D7 "did not care" about the product, because at no stage did they have a vested interest in the product, whereas all the other five customers were affected by the product.

The bar chart shows the influence of customer units, in general terms. It can be seen that the information unit is rated as the highest, as four of the seven customer types gather information, requirements and decision criteria about the product. The involvement in the information unit is another similarity between those customers that are given high importance. This is true in all cases except for customer D2, who is only involved in the maintenance role. The inclusion of customer D2 as second highest in importance is reflected by the fact that the product requires a high amount of involvement from maintainers. In fact, in some cases respondents indicated that the commissioned product relied heavily upon good maintenance to sustain a good competitive standing. Therefore the relationship between the company and the maintainer was very important. In fact, the eventual perception by users of how good the product is, was stated as often being outside of the control of the company. As such, Company D also suggested that another importance influence on the ability of the product to fulfil its full potential was how good the installer does the job. This is seen by the installer having the third highest rating.



	K_M							Total rating
	D1	D2	D3	D4	D5	D6	D7	
Decision unit	25			15			5	45
Buying unit				15			5	20
Control unit				15			5	20
Information unit	25		18	15	13			71
Installer			18	15				33
Retailer								0
End user						6		6
Other user					13			13
Maintainer		18						18

Description of each type of customer for company D in terms of their role(s).

The importance of customers D1 to D7 are shown in the pie chart, the total rating for customer units are shown in the bar chart.

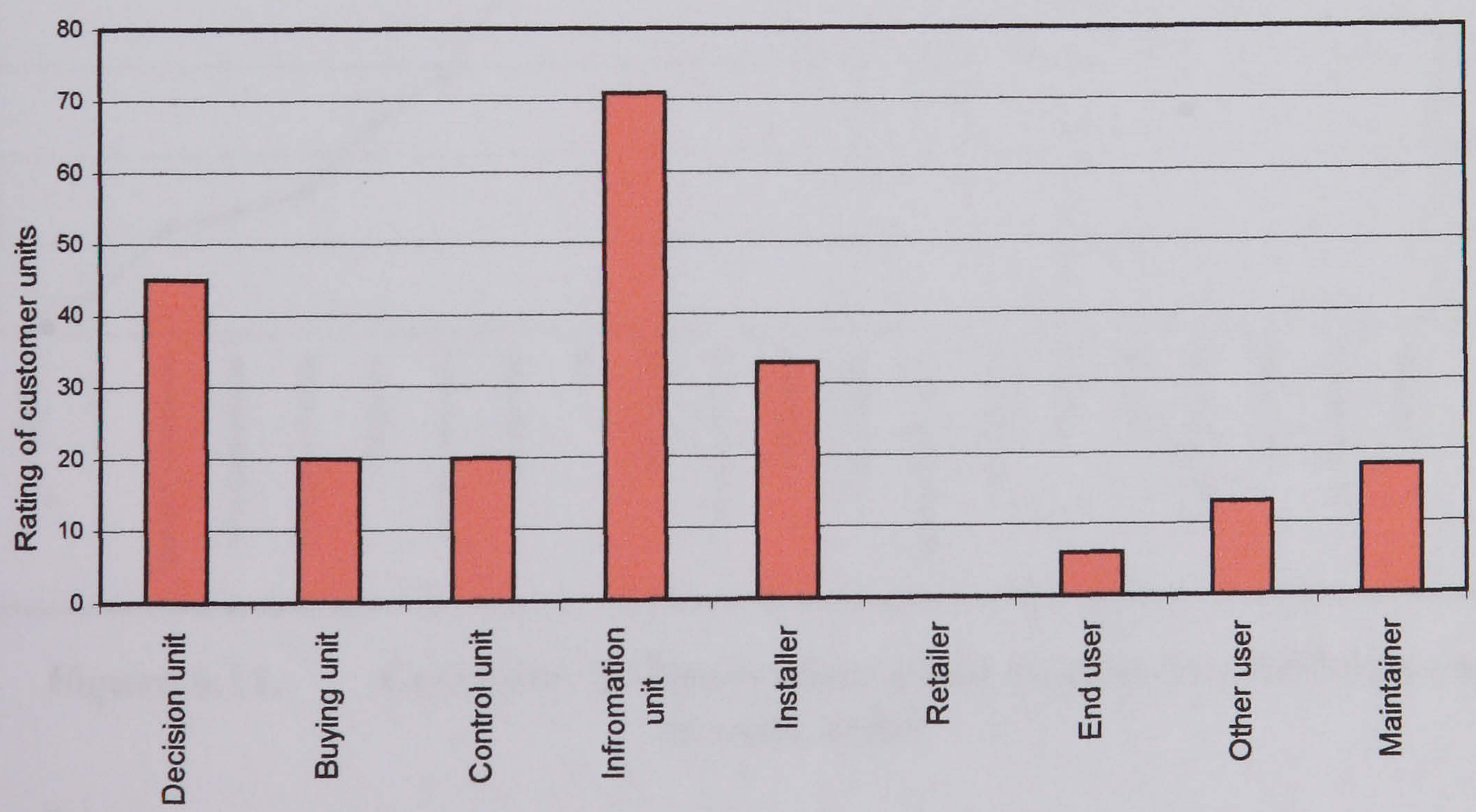


Figure 6.10. Company D: the importance of customer types and implied rating of customer units

6.5.2 Company D: Importance of product attributes (A_i)

Figure 6.11 shows the importance given to product attributes (A_i), in order of importance. The top two product attributes, in terms of perceived importance, are reliability and use maintenance. These are both related to keeping the product in use, as failure in the product is viewed as very undesirable to all customers. Health and safety are essential watch-words of the industry within which the company operates. Interestingly, the product itself is capable of having few health and safety features. However, high profile accidents in the industry unfortunately happen at regular intervals and every company therefore views health and safety as very important, whether their products can change the situation noticeably, or not. The importance of the installer as a customer can be seen by the high importance placed upon install maintenance, install cost and install expertise.

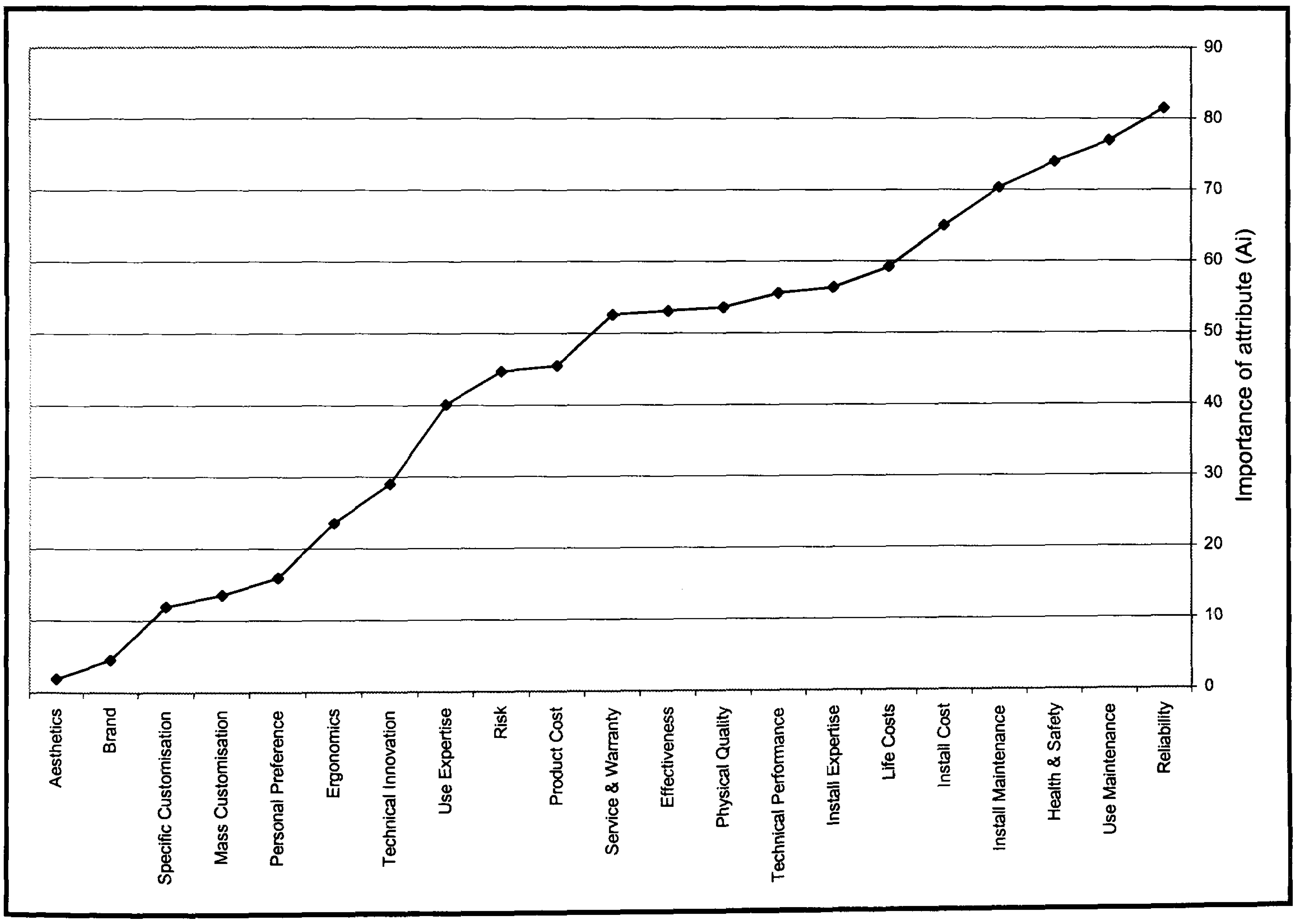


Figure 6.11. Company D: Importance given to product attributes (A_i) in rank order

Product attributes that are seen as very unimportant are aesthetics and brand. Respondents believed that there are no aesthetic features of the product and that the customer has no interest in the look of the product – the efficacy has priority. Branding is an issue that the company has started to use for other product lines but the respondents believed that branding was not required by the customers. However, having said that, the company believes that the corporate name is important and plays a role in them maintaining their near monopoly status for this product in the U.K.

6.5.3 Company D: Quality index (Q_i) and perceptual map

For Company D, a perceptual map of one view on the *quality* of product attributes is presented in figure 6.12. Section 6.2.3 describes how a perceptual mapping technique was applied for the importance of attributes (A_i), competitive standing of the same attributes (C_i) and quality index for the attributes (Q_i). Attributes in figure 6.12 have the same value for A_i as in figure 6.11.

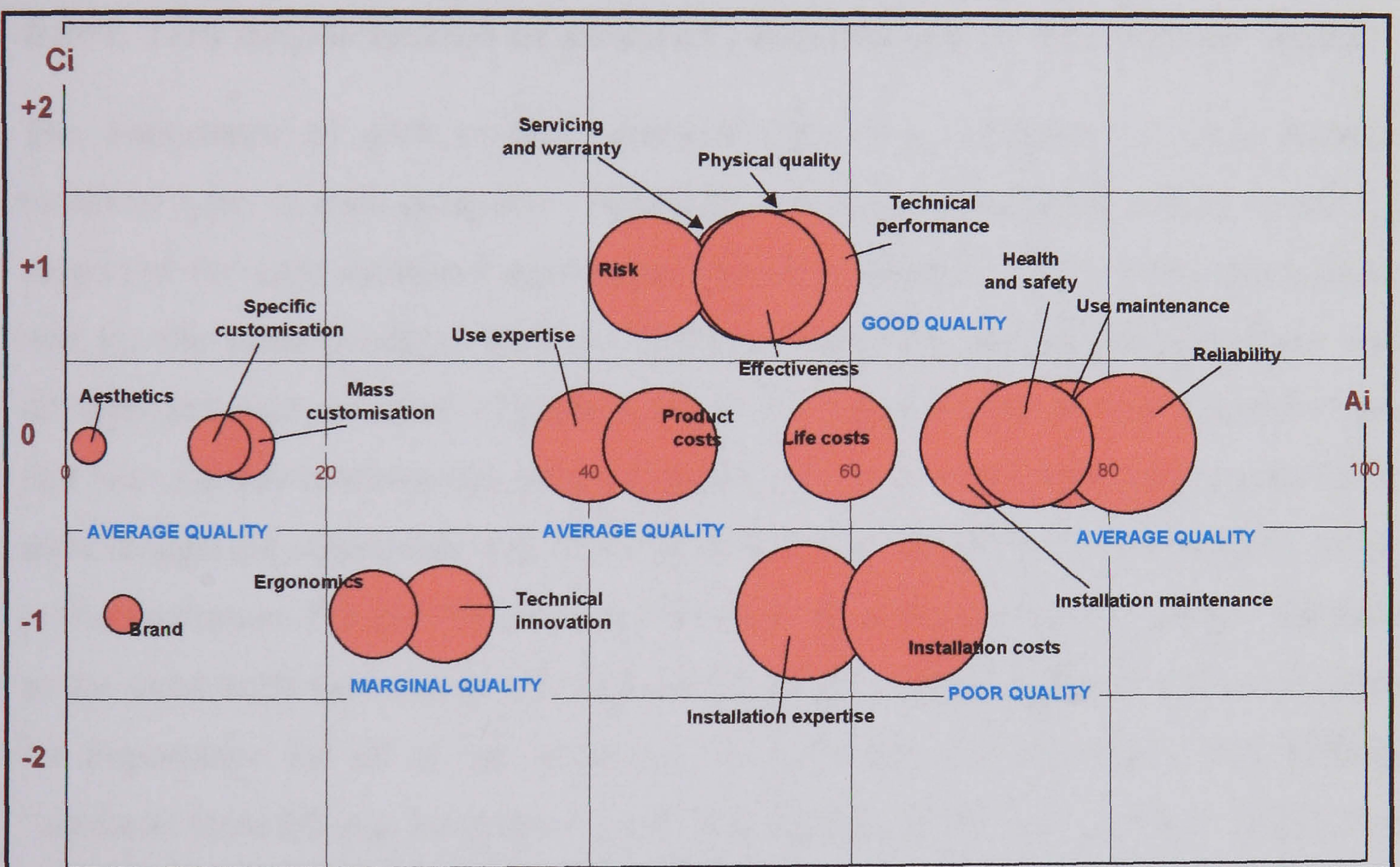


Figure 6.12. Company D: Perceptual mapping of importance (A_i) Vs competitive standing (C_i) (the size of the bubble is proportional to Q_i)

The perceptual mapping of importance in figure 6.12 shows that Company D does not have a very good competitive standing for the most important product attributes for the product being investigated. For the attributes that have the highest seven A_i scores, the respondents reported that the company either is the same as the competition, or worse. This is a very candid revelation. It possibly reflects the competitive nature of the industry, that Company D have been dominant in the market for this product type for 15 years. Respondents stated that this product is seen as "stagnant" and that little has been invested in technical innovation (C_i= -1) or other product improvement for at least 5 years. This has the affect of respondents viewing the company as being a less risky choice for customers. The company does have good production facilities and these have been used to improve the performance, physical quality, effectiveness of the product and the servicing and warranty situation.

6.6 Cross company findings

The previous sections have shown findings that are company specific. The following sections present pertinent results from the research that may be compared between the four companies.

6.6.1 The importance of product attributes to customer units

The importance of each product attribute (Z_{iM}) was collected for each different customer type, in each company. Appendix J presents unweighted results for the Z_{iM} perceived for each customer against each product attribute. These bar charts show that for the same product, different types of customers are perceived to have very different priorities in terms of product attributes. They also show that customer types that have similar relationships with the product place similar importance on attributes, even though the respondent was thinking of the type, not the role. An example of this is that customers B2 and B4 are very different types of individuals, but are classified as the same units (see figure 6.4, section 6.3.1) and, in turn, have very similar values for importance for all of the attributes, even though the respondent was thinking "customer type B2 e.g. contractor", and "customer type B4 e.g. manager" when they answered the questionnaire.

What the bar charts do not show is what role each of these customers play, in terms of customer units above. The unit affiliations of each customer (as shown in figures 6.1, 6.4, 6.7 and 6.10) were used to develop a picture of the importance of attributes to each of the customers' possible roles. These are presented in the snake plots in Appendix K and L (Chapter 2, section 2.3.2.2 discusses the use of snake plots). The snake plots give a different overview of the product, highlighting how the aspects of the roles particular customers have (control unit, end user etc.) make a difference to the way the product is perceived.

The snake plots in Appendix K show that there is often a trend within the companies for particular attributes (e.g. in Company A, "technical performance" and "mass customisation" are perceived as similar for all customer types). The plots also show the perceived differences between customer units within each company (e.g. in Company A, the installation cost is not seen as important to the end user or other users, but it is seen as important to all of the other units, especially the installer).

There are further snake plots in Appendix L, that separate out each of the customer units and compare them between companies. These plots use a scale that is relative for each company, so that the highest rated attributes are placed in equivalent positions on the chart. The relative snake plots provide depth to the information that is difficult to see when customer units are kept within the company setting. Many issues are raised by investigating the plots. The following points provide summary points on the results from between company comparisons on customer units and product attribute importance:

Trends are evident in every one of the customer units between all four of the companies involved in the study. However, for some customer units these are only on a few points out of the 21 product attributes investigated.

The decision unit is perceived to place importance upon the aspect of decision making – risk – and also upon the tangible aspects of reliability, effectiveness, physical quality and technical performance (see figure L.1, Appendix L). They are also perceived to place mid to high importance on product, installation and life costs, together with use and installation expertise (where applicable). The decision unit is perceived to place less importance upon customisation (mass and specification). The decision units were all perceived to have very different importance ratings for aesthetics, technical innovation, brand, personal preference and health and safety, which are aspects (with the exception of health and safety) that are often presented as differentiating factors for industrial goods in marketing text books (Hutt and Speh, 1992; Hague, 1992; Jobber, 1998; Kotler *et al.* 1984; Wilson *et al.* 1996). This may be due to the product type and industry situation for each of the companies. For example, companies B and D both score low for technical innovation, which may be due to them being in mass markets for the products being investigated (see table 6.1). Also, that personal preference is more important to products where there is more choice in the marketplace – companies C and D rate personal preference low and are in a market where they have around 80% share, whereas companies A and B only have around 25% share and place personal preference higher in importance. Health and safety is likely to be due to the operating circumstances of the product – with medical devices and railway infrastructure giving high importance to this attribute.

The buying unit is perceived to place high importance on product, life and installation costs and servicing and warranty (where applicable). As the main job of the buying unit is the undertaking of money/ goods exchange, costs are likely to be high on their priority list. They also rate risk and effectiveness as mid to high importance. They are perceived to be split in the importance given to use expertise, installation expertise and maintenance. Interestingly, the perceived importance of personal preference is also different between companies for the buying unit. The buying unit are perceived to place lowest importance upon customisation (mass and specification) and are also expected to be less concerned with ergonomics, aesthetics and technical performance (see figure L.2, Appendix L).

The control unit for every company were perceived to place high importance upon reliability, product cost, life costs, together with installation costs, servicing and warranty and use maintenance (where applicable). Also, there were similarities in perception of high to mid-range importance for effectiveness, physical quality, risk and use maintenance (where applicable). There were similarities of mid-range for risk, physical quality, life costs and use expertise (see figure L.3, Appendix L). The control unit for each company all scored low perceived importance for customisation (mass and specification).

Those customers that were part of ***the information unit*** were perceived as placing high importance upon reliability, effectiveness, installation expertise, use maintenance and servicing and warranty (where applicable). Attributes that scored similarly at mid-range were use expertise and risk. Both physical quality and technical performance scored between high and mid-range perceived importance but there was quite a lot of difference between the scores. There were very mixed views on the importance of product, installation, life costs and health and safety for the information unit (see figure L.4, Appendix L).

An installer role was recognised for companies A, C and D . These all placed a high perception of importance upon install expertise (see figure L.5, Appendix L). However, mid-range scores were given for install maintenance, which were similar to the general scores for reliability, use expertise and health and safety. They all gave very similar lower mid-range scores of perceived importance for life costs and risk. Interestingly, installation costs were split, with two of the companies (A and C) giving installation cost very low importance, and one (Company D) giving it very high importance. This may reflect whether the installer has to pay for installation: in Company A, the product manufacturer pays for much of the installation material and equipment; in Company C, the installer is a particular job only, and carries none of the costs; but in Company D the installer has to pay for all costs, including transportation to the installation site. Brand and specific custom were given low importance as these were perceived as not affecting the installation role.

Only companies A and B recognised customers in the ***role of retailer***, as companies C and D did not use an intermediary for selling their products. Similarities in the product attributes that were perceived as important to the retailer were brand, reliability, product cost and to a lesser extent effectiveness, life costs and technical performance. With the exception of brand, these are attributes that are high for all other customers, and the retailer is reflecting this. Brand is often important to the retailer, because they may have an easier job, if the customer recognises branding. There were similar, lower mid-range scores for ergonomics, mass customisation, health and safety and use expertise. These too, reflect a general consensus for many of the products. Both companies perceived personal preference as being unimportant to the retailer, which is due to these particular retailers being restricted to selling only one company's products. Figure L.6 in Appendix L also shows the large differences between product attributes of aesthetics and technical innovation. As discussed in the section about the decision unit, these may be due to Company B (low score) competing in a mass market and Company D (high score) having some niche areas for the product under investigation.

Figure L.7 in Appendix L shows the perception of important product attributes for ***the end user***. In all cases, Reliability was perceived as being of high importance.

Other attributes that had similar scores were health and safety and technical performance which were upper mid-range importance; technical innovation which was lower mid-range; and install maintenance and customisation (mass and specification) that were seen as not being important. There were divided perceptions of importance for aspects that could be seen as traditional "user" attributes: effectiveness, use expertise, ergonomics, risk, product cost, aesthetics, use maintenance and servicing and warranty.

Companies B and D also recognised some "***other users***" of their products (who were not the main end user). As for the end user, there was a consensus on the high perceived importance of reliability. However, as opposed to the end user, there was a clearer similarity for many of the attributes: effectiveness, use expertise and use maintenance all had higher mid-range importance scores; life costs had a similar mid-range score for both companies, and technical innovation and mass customisation were grouped as lower importance attributes aesthetics (see figure L.8, Appendix L).

A maintainer role was recognised for the products of companies B, C and D. There were few very clear similarities between all three companies for the perception of important attributes to the maintainer (see figure L.9, Appendix L). Consensus existed for low importance of mass and specific customisation; mid range for technical innovation and ergonomics; and high perceived importance for life costs and reliability. The results from maintenance were mixed for servicing and warranty perceptions. They were relatively high, but they were quite spaced out between companies. This may be due to the cost implications for the maintainer – the maintainer of the product from Company D does not pay out any money at all when things go wrong with the product. For Company B the cost may be covered by a warranty but the maintainer is generally someone that will loose out by the product being out of commission. Company C's product is expected to have a very long life, but replacement is expensive for the maintainer. Conversely, Company C places low importance upon use maintenance, because they do not expect any to be required. Whereas the maintainer of the products from companies B and D are expected to want to get the product back into commission as soon as possible.

6.6.2 Collecting customer needs information during the NPD process

A lot of different data were gathered to try and understand the aspects of customer needs information collection. Four questions were asked on the questionnaire to gain an understanding of who is involved with information collection, when it is collected, what is collected and by what means (questions E1,2,3 and G1).

6.6.2.1 Involvement of different groups in information collection

Appendix Q indicates the involvement of each functional group in the collection of customer needs information during each of the NPD process activities. The bar charts show who is and isn't involved (only a "yes" or "no" answer was obtained, with a bar indicating "yes"). Complimentary to Appendix Q, the tables in Appendix M provide the decomposition of which product attributes are collected during each of the NPD process phases. Figure 6.13 summarises the totals for each of the process phases, for comparison between companies.

Results shown in the bar charts in Appendix Q demonstrate that there are some similarities between companies in terms of functional involvement, but also some obvious differences. Generally, there are two extremes: with companies A and B using many different groups during many different activities. However, companies C and D collect information during fewer activities and recognise fewer different groups collecting the information. Similarities do exist, and when the results are looked at in terms of NPD process phases it is noticeable that all companies have more different groups involved in data collection during the pre-development phase (activities of initial screening, preliminary market assessment, preliminary technical assessment, detailed market study, business/ financial analysis). In all companies, no one group was relied upon throughout the NPD process to collect information, although there were occasions in all companies where only one of the functional groups was recognised as collecting information during a particular activity.

In two companies (A and B) marketing have a strong role in customer needs information collection. In Company D marketing is only visible in two of the initial activities, and then later on, in the analysis before the market launch and during the launch activity. In Company C, marketing is only recognised as being involved at the very beginning of the process. There was no pattern to the involvement of the design functional group between companies. In only one company (B) did design have a major role in information collection throughout the NPD process. In Company A design was limited to involvement in four key activities, and in two companies design was only reported as collecting information during a single activity (for Company D this was preliminary technical assessment and for Company C it was product development). Generally, there was sporadic involvement of R&D in data collection. Although, there appears to be a pattern of involvement for information collection by this group. All companies indicated that R&D was involved during preliminary technical assessment, product development and in-house testing. Also, 3 of the 4 companies said that they recognised R&D being involved in the collection of information during the initial screening and customer test activities as well. It can be seen that two of the companies do not get involved in information collection

6.6.2.2 Number of attributes collected

Appendix Q shows that, in general, more different groups are involved in the pre-development information collection. However, what figure 6.13 shows, is that this collection only involves less than 60% of the different types of attributes. This suggests that during pre-development a number of different groups are collecting information on the same set of attributes, but that no one is collecting information on other certain attributes. In fact, there is a strong similarity for all companies that the most number of different attributes are collected during development (the activities of product development, in-house testing, customer tests, trial sell, trial production and pre-commercialisation business analysis). However, still less than 80% of potentially relevant product attributes are not collected during this phase. During other phases, this figure drops to around 50%. This means that information collected during other activities must be collated and communicated for use during other activities.

There are also similarities in the post-launch phase, where 3 of the 4 companies have low collection rates (less than 30%). An exception is Company B, collecting twice as many product attributes as other companies during post-launch activities. This is accounted for by Company B having a formal task of follow-up research that they always undertake 6 months after the product is sold.

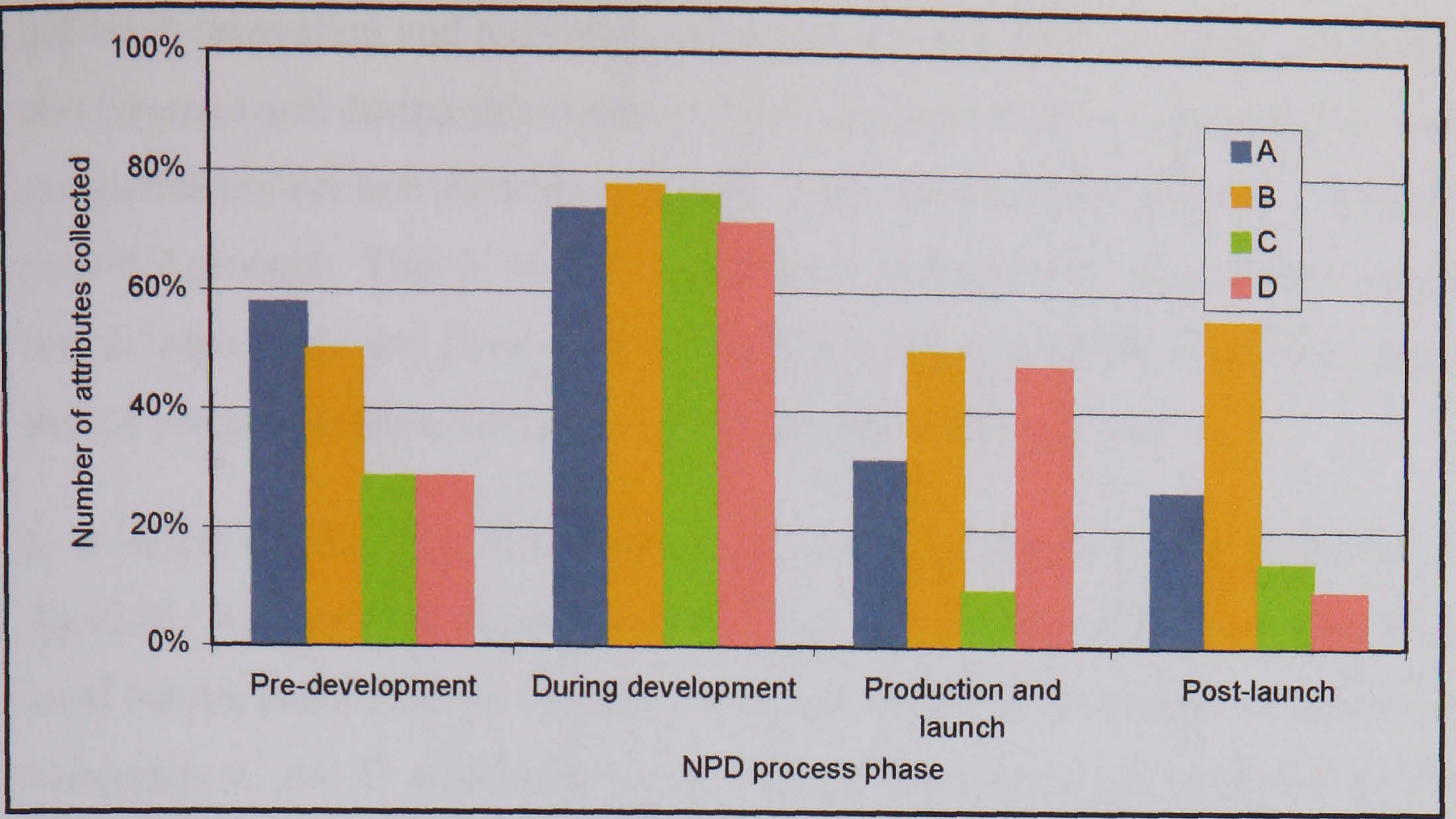


Figure 6.13. All companies: Number of product attributes *collected* during each of the product development process phases

There were many similarities between companies as to what product information are collected during each phase of the NPD process (see Appendix M). During pre-development the similarities were for what was *not* collected, rather than what was. Only technical performance and costs of the product and installation are collected by all four companies during pre-development. However, none of the four companies collects information at pre-development on: use expertise; use maintenance; install maintenance; servicing and warranty; life costs; or health and safety. For product development, more similarities were found in the product attributes that were collected by all four companies. All companies collect customer needs information during product development for technical innovation, risk, effectiveness, specific customisation, use expertise, installation expertise and installation maintenance (where applicable). One of the companies did very little product and launch information collection. For the other three that do, physical quality was the only attribute that they commonly collect. For two companies post-launch activities did not include the collection of any more than three product attributes. However, in these and the other two companies there was a similarity in the type of information collected: costs (product, life or installation) and "traditional" items for complaint (reliability, effectiveness and technical performance).

Mostly, large differences exist between companies on the number of times information is collected during the NPD process. The only similarities are that technical innovation and technical performance information are collected both at pre-development and during development in all companies. Also, interestingly, 3 of the 4 companies collect information on specific customisation during at least two phases of the NPD process. This is interesting, because customisation was always seen as very low in importance and there were much higher rated attributes for importance levels, that do not get the same collection effort across the NPD process.

It is worth noting that there are some discrepancies between Appendix Q and Appendix M (which is summarised in figure 6.13). The differences exist in similar areas but are more obvious in some cases than others. For example, respondents from companies C and D said information was collected on a few attributes at the post-launch phase of the NPD process (post-launch analysis activity). However, they do not recognise any one group as being involved in the post-launch activity. This does not necessarily suggest that they are mistaken on either count. This was a problem of the questionnaire design: having 3 sets of information that are related and only being able to collect one against one at anyone time. However, it is possible that no one group can be identified as having specific responsibility. Therefore, even if it were possible to have collected all three sets against one another, that these results may still have been found.

6.6.2.3 Collection methods

The means by which customer needs information is collected within companies was of interest to this research. Therefore, the questionnaire included a question about how product attributes were collected. Results are summarised in figures 6.14 and 6.15.

Figure 6.14 summarises the methods used by each company to collect customer needs information generally. Results from the research have shown wide variations in the absolute number of times a particular method is used to collect customer needs. However, there are clear patterns in the use of methods for each company. There is a reliance upon unstructured collection methods, with all four companies using "1 on 1" means to collect a lot of their information, that is informal data collection through customer visits, phone calls and chance meetings. This is coupled with observations and specifications to collect the majority of customer needs. Interestingly, user focus groups (UFGs) also have a considerable presence in the collection methods for three of the companies. This was in contrast to the traditional market research method of questionnaires, that only Company B used to collect customer information. The company sent out structured questionnaires to the registered owner of the product after six months of purchase but none of their other customers were canvassed.

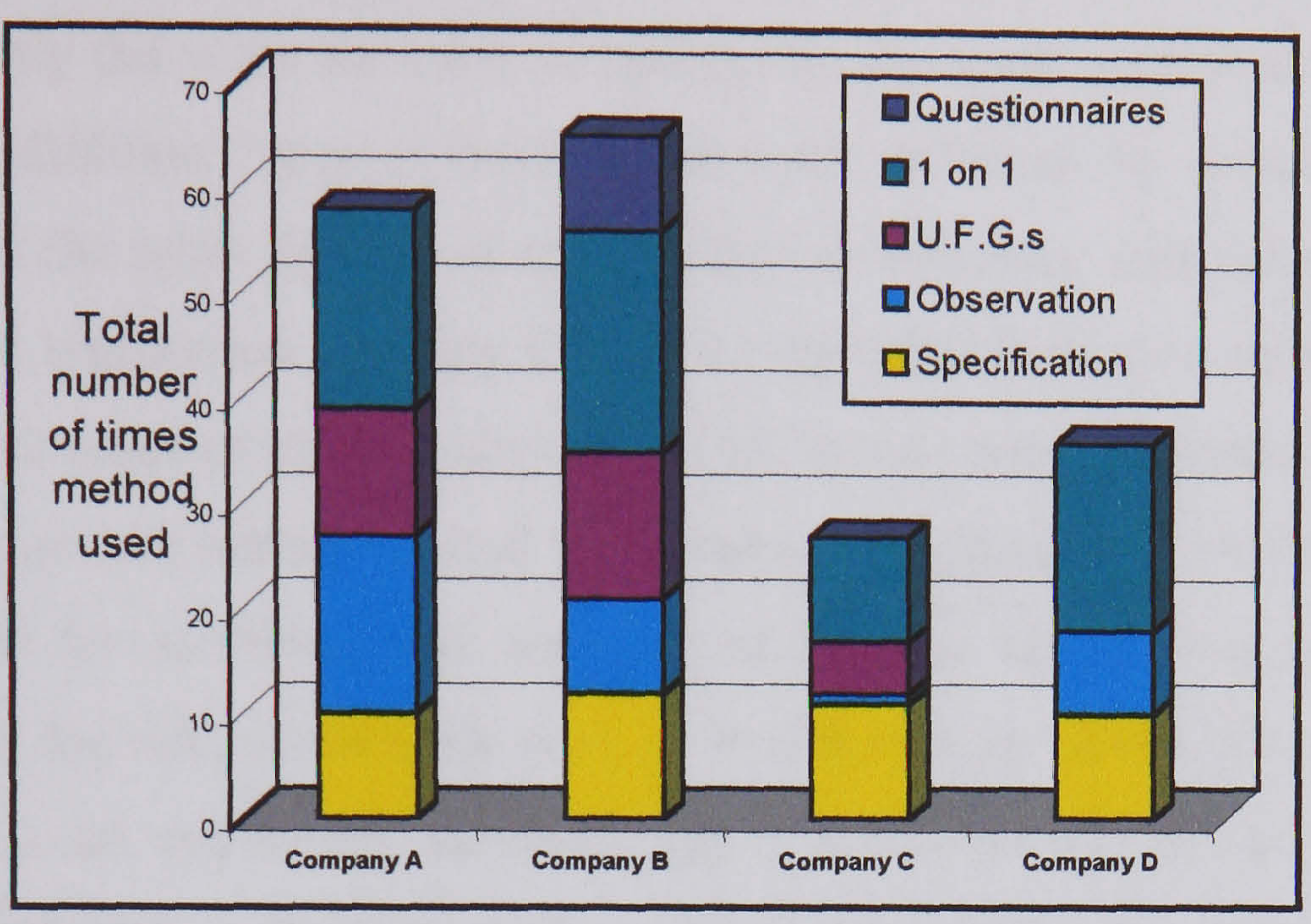


Figure 6.14. All companies: The methods employed to collect customer needs information by each company

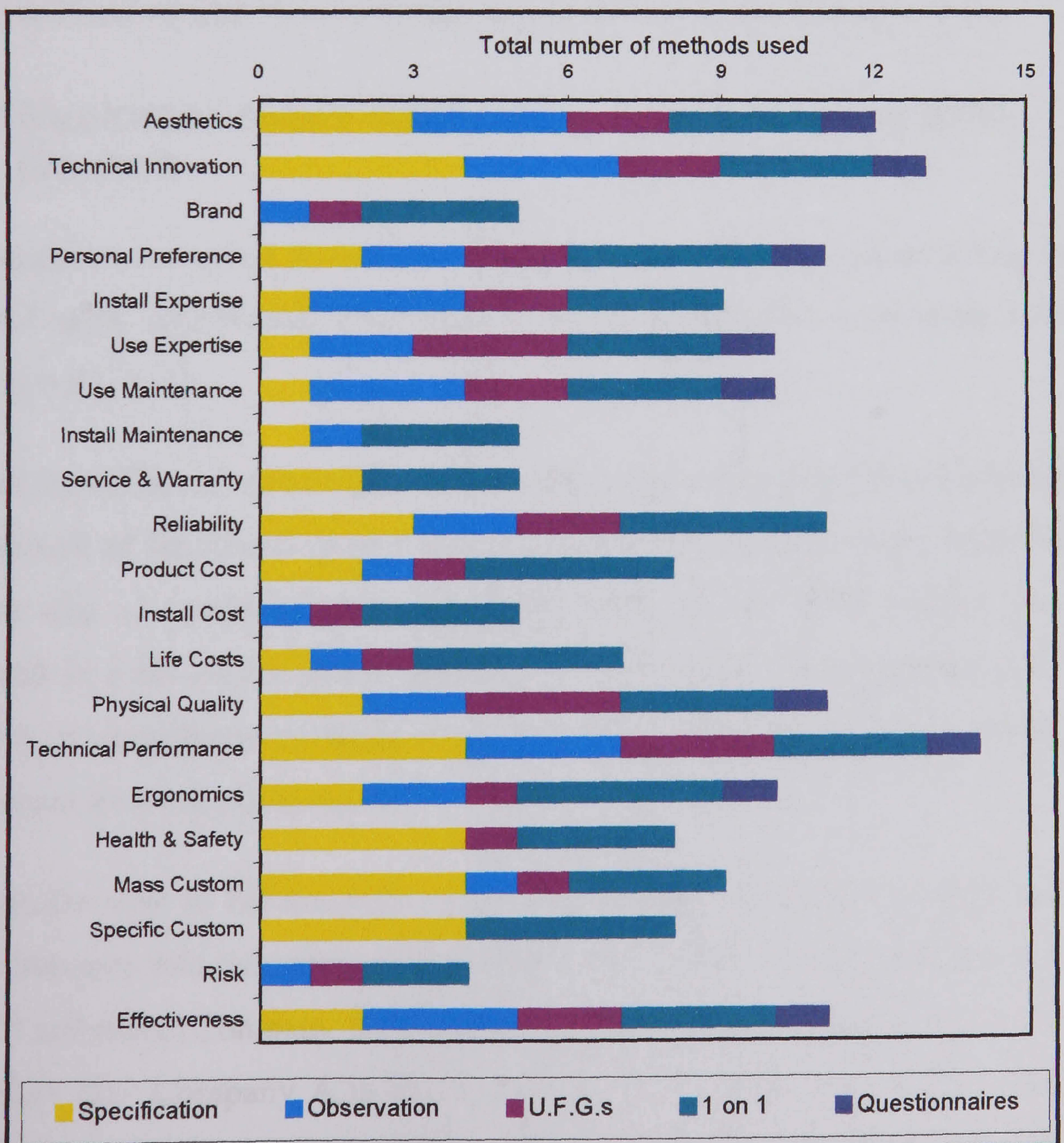


Figure 6.15. All companies: total number of collection methods used for each product attribute

An overview of the methods used to capture the different types of product attributes is shown in Figure 6.15. The bar chart is a consensus view from all companies identifying the types of methods used to collect information. Obviously, the results were not exactly the same for each company, but the chart achieves the objective of showing that different types of information were collected by similar means. The chart indicates the main finding of the research in this area: that there is a wide and quite balanced application of many different types of information collection methods for the different types of product attribute. Differences between product attributes and information types are mainly limited to the relative emphasis on these methods: UFGs were not used for servicing and warranty or specific customisation; specifications were not used for risk, installation cost, or brand; and no observation methods were reported for health and safety, servicing and warranty or specific customisation. In fact, all information collection used at least three differing methods apart from servicing and warranty and specific customisation. These two both relied upon using only specifications and "1 on 1" collection methods in near equal amounts.

6.6.3 Customer needs information use during the NPD process

Respondents were asked three different questions to gain an understanding of who is involved with information use, when it is used and who uses what information (questions F1, 2, 3).

As with the collection of customer information, the results from each company for the involvement of functional groups in the use of customer needs data and information, and the use of product attributes during each of the NPD process phases, are presented in a set of bar charts and tables respectively (see Appendices R and N). Figure 6.16 summarises the totals from Appendix N for each of the process phases, for comparison between companies.

In a similar way to information collection, the use of customer needs information differs between two extremes of very high involvement by many groups in a number of NPD activities (Company B) and minimal involvement in activities by few groups (Company D). Company A is like Company B, in that it is generally involved in a number of activities but respondents did not recognise as many different groups requiring the information. Company C recognises the least number of activities, but, unlike Company D, in those activities that it does undertake, a higher number of different groups use the information. Similarities exist in the requirements of information for initial screening, where it is apparent that both marketing and technical functions are involved. Also, during the actual "product development" activity, for all companies, R&D use the information and in 3 out of the 4 design is also seen as requiring the use of customer needs information. The difference in Company C could be accounted for by the general attitude towards "product design" – the company has a very low representation and recognition of this type of function.

The 6 activities that take place during the "development" phase have the highest requirements for use of information, from all functional groups (see Appendix R). The results from the number of different types of attributes used concur with this situation (see figure 6.16). Figure 6.16 shows that, for three companies, over 80% of attribute types are used during the development phase. This equates to 16 out of 19 applicable attributes for Company A, 16 out of 18 for Company B and 19 out of 21 for Company C. Company D, uses few attributes on more than one occasion (only 5 of the same attributes are used out of 21 during both development *and* production phases). Respondents in Company D did admit to a "fire-fighting" culture – that information was sought when it was needed, rather than having a plan to look at and use particular types of information earlier on in the NPD process.

All companies, except Company B, reported that they only used 1 or 2 types of customer need information during pre-development. These were product cost, risk and specification customisation. Company B generally reported using many more product attributes throughout the NPD process, including pre-development and post-launch, which was a similar situation to their approach to collecting attributes.

Comparing figure 6.16 (use) with figure 6.13 (collection): during pre-development companies *collect* more throughout the pre-development activities that they use; they *use* more during development and production and launch than they collect; and there is similar amount of activity for collection and use during post-launch activities. What is clear from these diagrams and, especially, Appendices N and M, is that on many occasions information on an individual attribute is collected at one time and used at another. Therefore, there is a need to collate and communicate customer needs information during the phases of the NPD process.

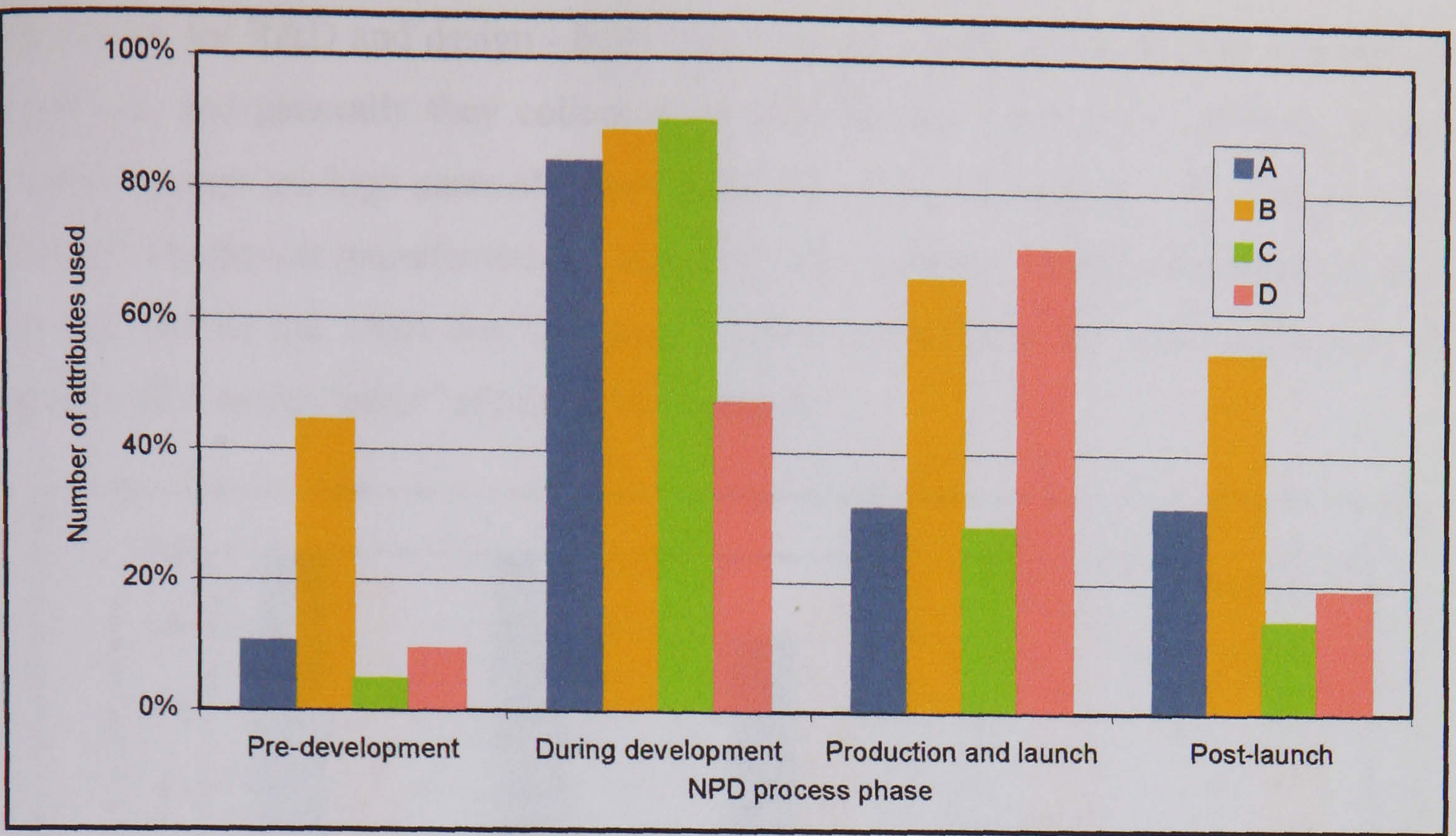


Figure 6.16. All companies: Number of product attributes *used* during each of the product development process phases

6.6.4 The requirement for information dissemination between groups

The previous two sections have compared the specifics of information collection and use during the NPD process. Results have indicated that different groups are involved in the collection and use of information at different phases in the NPD process, and that there is a requirement for communicating information *between the NPD phases.* This section summarises the overall situation of collection and use by the different groups in the companies, in order to establish if there is a pattern of the need for information dissemination *between different functional groups.*

Figures 6.17, 6.18, 6.19 and 6.20 show charts for each of the companies, in terms of information collection and use. The scales show how many of the total applicable attributes are collected or used by the functional group (i.e. 19 for Company A, 18 for company B, and 21 for companies C and D).

There are some clear relationships to note between the companies. Firstly, the design group uses considerable more than they collect. They are one of the heaviest users of customer needs information in each company, but are one of the least involved groups in the collection of information. Secondly, R&D use at least as much as they collect and generally use more. Thirdly, that the trend for marketing and sales is opposite to the trends for R&D and design - both marketing and sales collect at least as much as they use, and generally they collect more than the use. A fourth similarity is that "other" groups are high users of information in 3 of the 4 companies. In most case the "other" function is manufacturing. However, the "quality" function accounts for half of the bar in the chart for Company C and service are the main collectors of information in the "other" result for Company B.

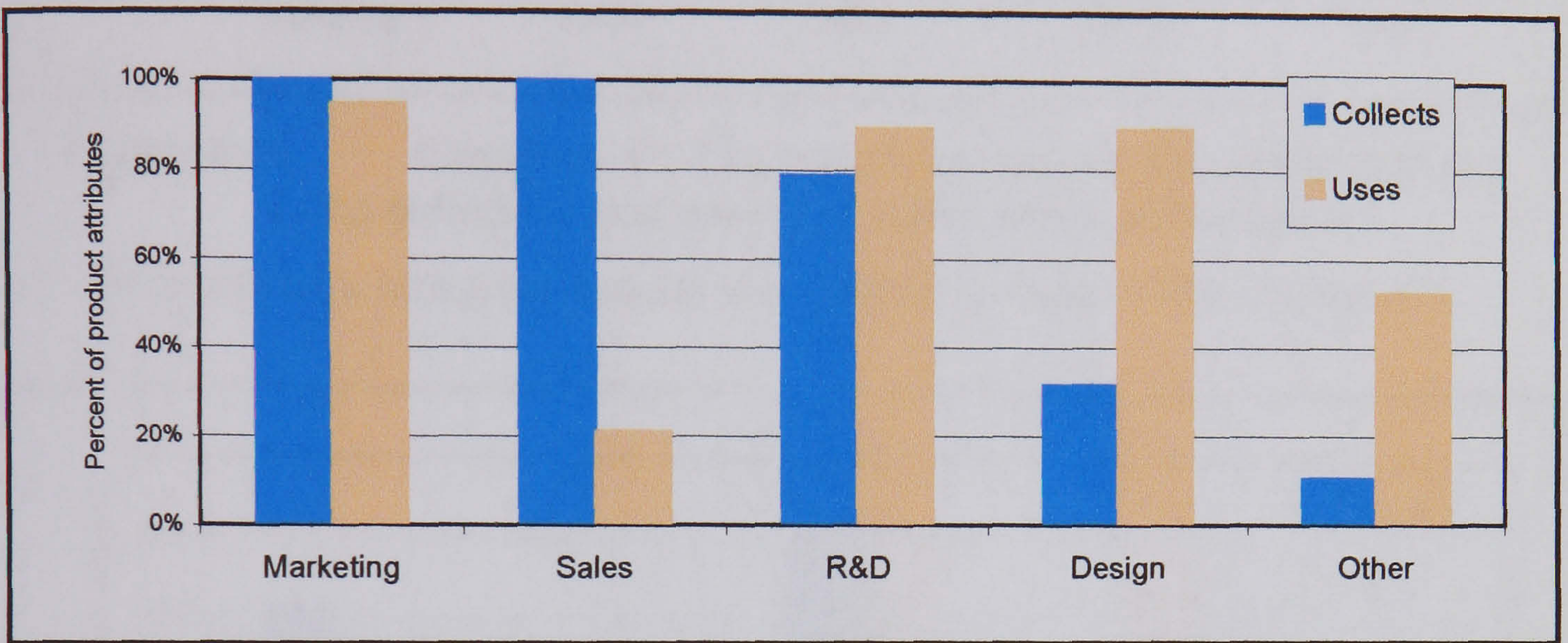


Figure 6.17. Company A: The involvement of each functional group in the collection and use of customer needs information

N.B. Only manufacturing was named as an "other" for Company A.

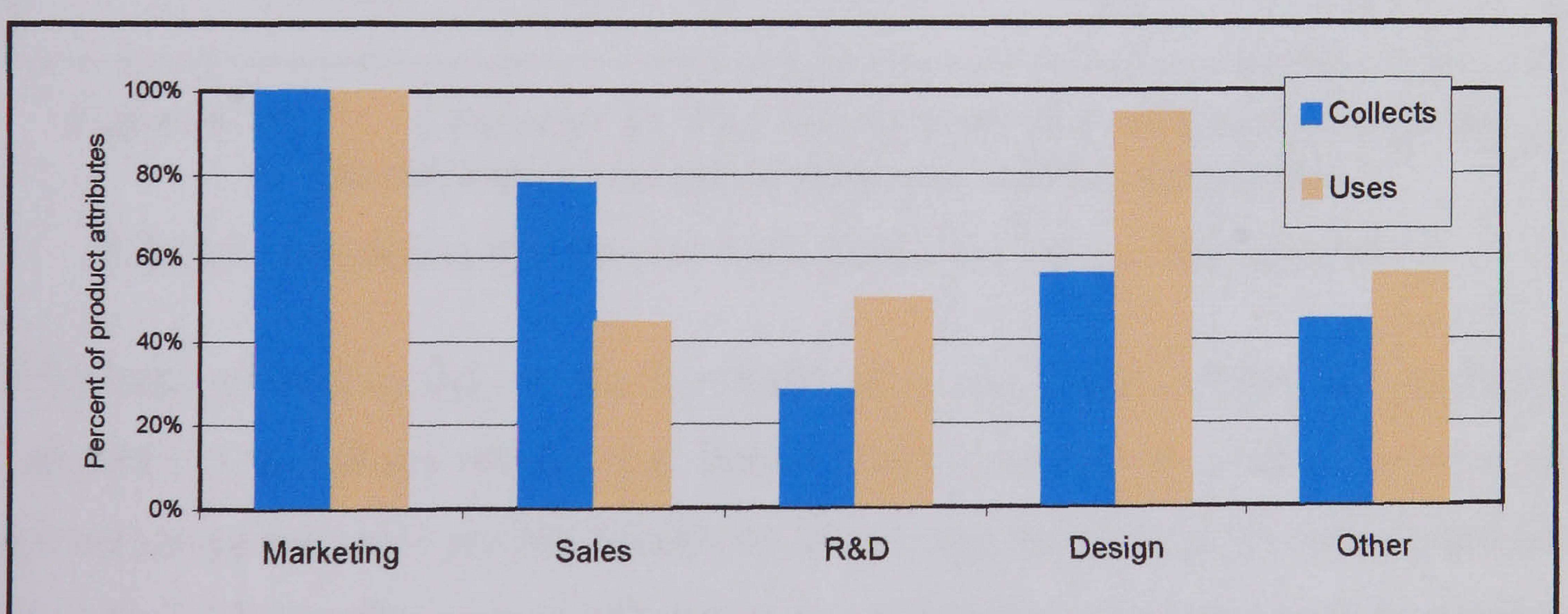


Figure 6.18. Company B: The involvement of each functional group in the collection and use of customer needs information

N.B. Manufacturing and service were named as "others" for Company B.

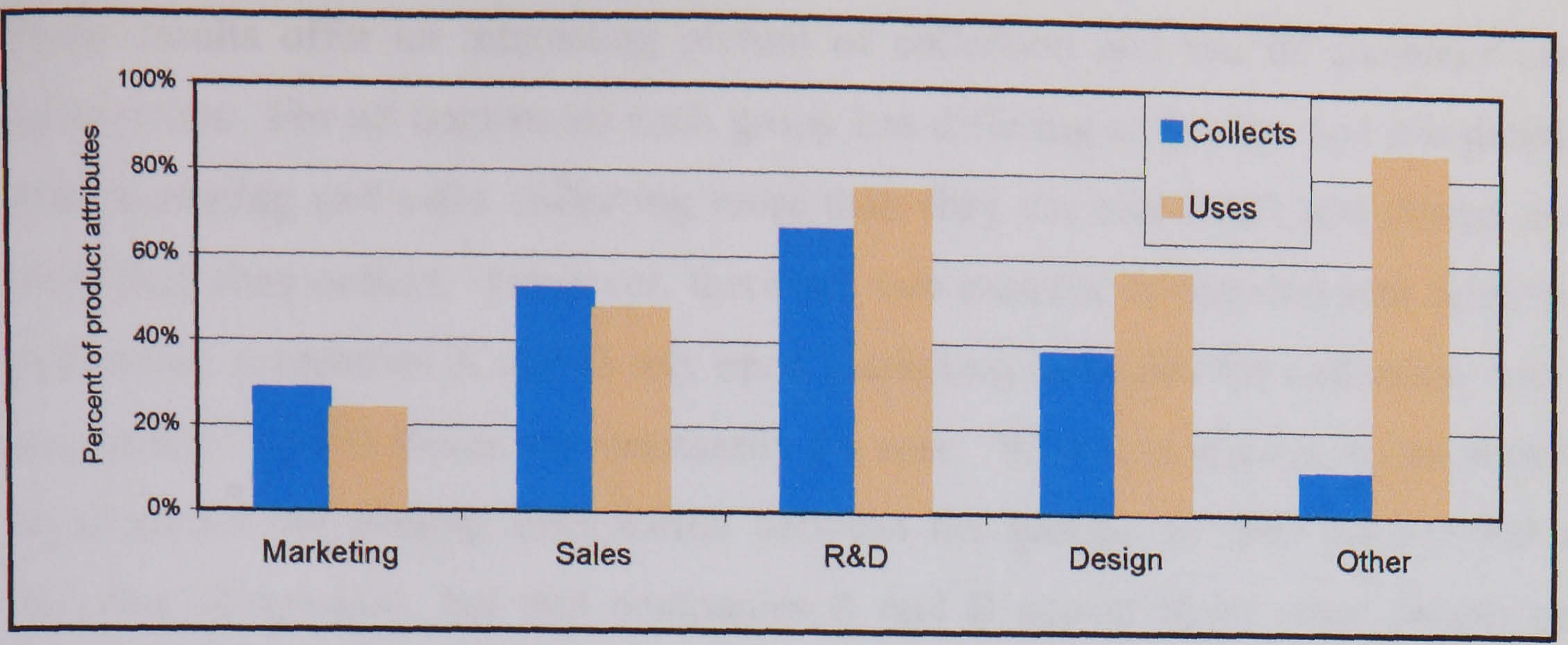


Figure 6.19. Company C: The involvement of each functional group in the collection and use of customer needs information

N.B. Manufacturing and quality were named as "others" for Company C.

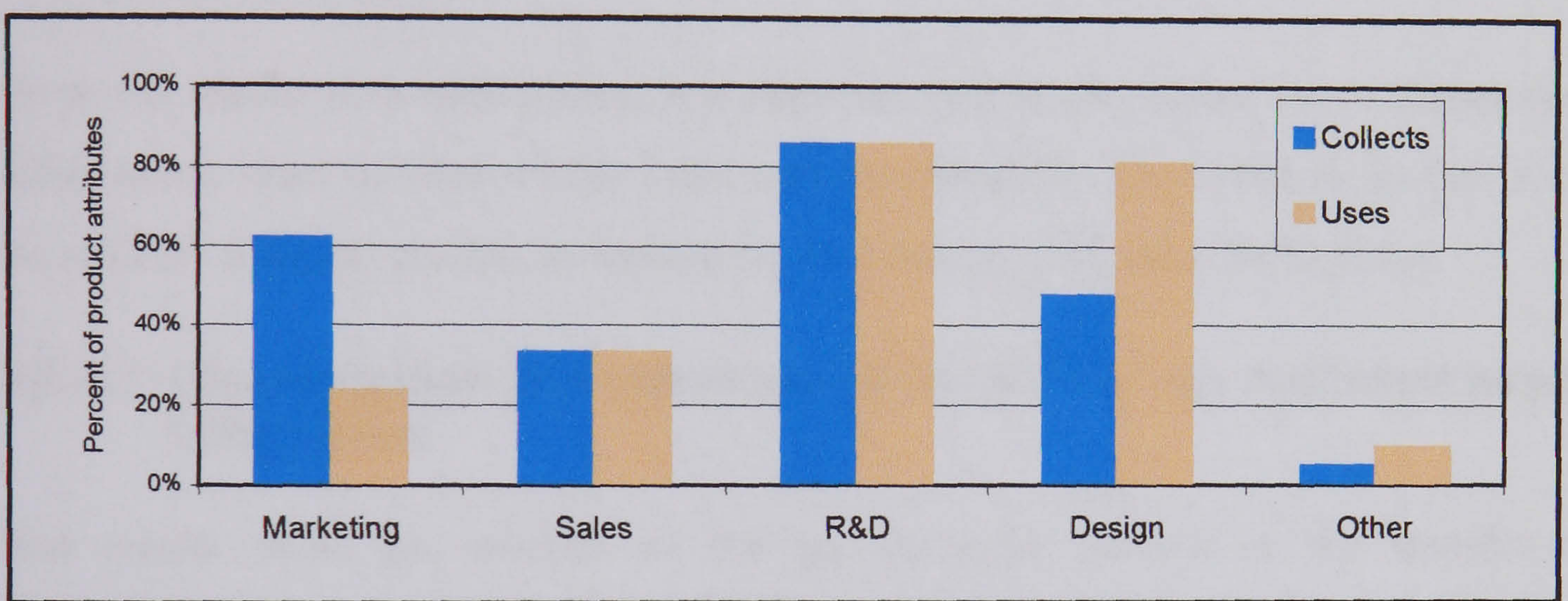


Figure 6.20. Company D: The involvement of each functional group in the collection and use of customer needs information

N.B. Manufacturing and finance were named as "others" for Company D.

Differences amount to the relative involvement of the groups within each company. Companies A and B are similar, that there is high involvement from all groups, and that marketing and sales are both highly involved in collection and use of information. Not only do they collect more different types of attributes than they use, they collect more than R&D and design, and use less than them. Companies C and D are different to this – R&D and design have stronger presence in the collection and use of information than marketing and sales. R&D not only uses more than all of the other functional groups, but they also collect more different types of information than any of the other groups. The marketing group in both companies C and D are not recognised as using information on many types of attributes.

These results offer an interesting picture of collection and use of customer needs information. For all companies each group has differing collection and use patterns, with marketing and sales collecting more than they use and R&D and design using more than they collect. However, there are two patterns of involvement relative to each other: companies A and B rely upon marketing and sales for collection, but for companies C and D this is not necessarily the case. What this implies is that there are requirements for passing information between the groups, as they collect and use different information, but that companies A and B appear to be more reliant upon communication that companies C and D.

6.6.5 Comparison of disseminating customer needs information

From the results discussed above, it is apparent that in all companies customer needs information must be disseminated and communicated by some means, so that it may be used by different groups, or kept to be used during a different NPD phase.

6.6.5.1 Dissemination and communication methods for customer needs information

The results from the sections of the questionnaire looking at the transfer and disseminating of customer needs information were examined to provide an understanding of the customer needs information management process. Appendix P contains detailed bar charts that show the total number of methods used for the transfer of information on each product attribute, in order of attribute importance (A_i). Figure 6.21 provides an overview of the findings for the total number of times methods are used to communicate customer needs information on the product attributes.

Results from analysing the patterns in company communication and dissemination showed that many attributes used a number of types of communication. However, attributes that were commonly reported as using few or no communication means were life costs, installation costs and brand.

Figure 6.21 shows that, in general, formal written communications (requirement specifications, general reports, market reports and compliance reports) are the most important methods in capturing and disseminating customer needs information within each of the companies. Every company has a formal written means for disseminating customer needs information for at least two thirds of their product attributes. In three cases, less than one quarter of product attributes did not use any formal means at all. There are three common types of attributes that are represented less in formal communication means for all companies, these are costs, risk and brand.

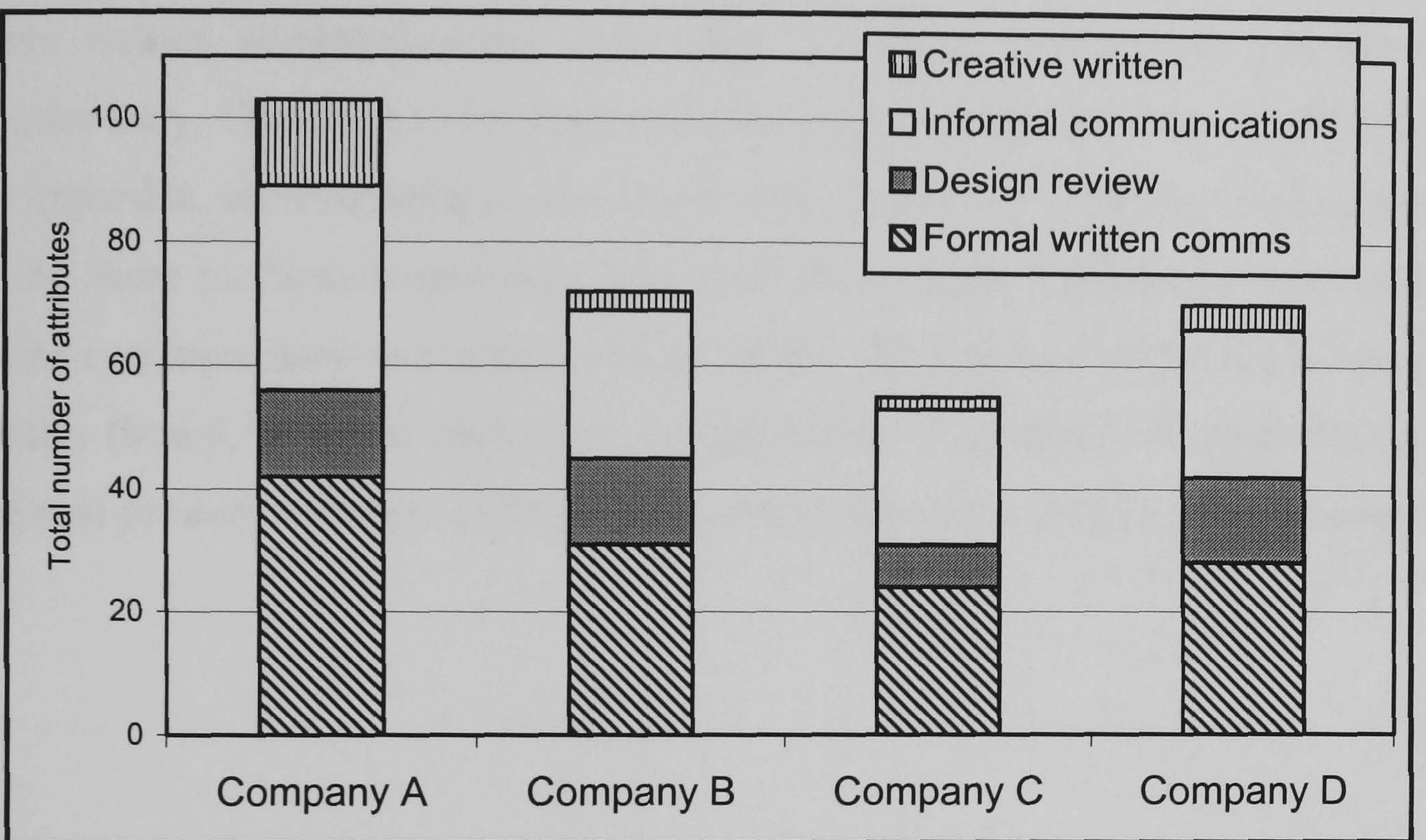


Figure 6.21. All companies: The means of disseminating and communicating customer needs information.

Informal communications (informal meetings and ad hoc communications) play a large role in information dissemination. However, there were differences between companies in the amount they relied upon informal communications. Company A had less emphasis on informal communications and always used at least two different types of dissemination method (except for life costs, where no communications means were identified). Company B and D were similar, with few attributes depending purely on informal communications (brand for Company B and install cost and ergonomics for D). Company C was different, with five attributes only being communicated via informal means. Typically, both formal and informal communications were used in companies for most attributes. In all companies, for every attribute where a communication method was identified, informal communications were always used if formal written means were not used.

A design review was used in all companies, although to differing extents – companies A, B and D used this method for at least two thirds of the attributes, but Company C only used a design review to communicate information on one third of their customer needs. Design review was never reported being used for installation or life costs and in no case was design review the only means of communicating a particular attribute.

Generally, there were few applications of creative written communications (theme boards, scheme diagrams, scenarios and metaphors). Three companies did not use creative written communications very often, Company B relied on this form for aesthetics only, Company C for expertise (use and maintenance) only, and Company D for expertise, use maintenance and innovation. However, Company A reported that they use these methods extensively, over half of the product attributes were reported as being communicated in creative written forms. They were used for both intangible attributes (brand, personal preference, customisation, expertise and ergonomics) and traditional product attributes (effectiveness, reliability and technical performance).

Chapter 7
Discussion

This research was stimulated by issues of product *quality* – what it is and how companies can try and produce a *quality* product. During the conceptual development work for this research, a model was produced that lead to eight specific research questions being produced. The discussion here is structured around these questions, as detailed in section 4.3, of Chapter 4. The sections describe how the findings made in Chapter 6 relate to each of the two sets of specific research questions posed in Chapter 4 of this thesis. Conclusions about whether the research hypotheses do offer a rationale for whatever results were obtained through answering the research questions are to be found in Chapter 8.

7.1 Perceptions of customers and their needs

The first set of research questions were aimed at understanding the companies' perceptions of their customers and their customers' needs. The questions asked:

> HOW DO COMPANIES DEFINE WHAT THE *CUSTOMER* WANTS?
>
> **What does the company think the *customer* wants?**
>
> **1.** - What are the different company (*group*) *perceptions of product quality*?
>
> **2.** - Can these perceptions be put into *groups*? (e.g. functional groupings, or by the amount of involvement with customers by people in the company?)
>
> (See section 4.3, figure 4.5, Chapter 4)

The following two sections addressed each of the two specific questions in turn.

7.1.1 Different company perceptions of product quality

The findings in Chapter 6 provide evidence that the perceptions of product attribute importance and *quality* (in terms of competitive standing) differ between companies. Also, these perceptions appear to have other factors affecting them. Product and industry type and the view of different customers seem to influence the opinions of what is important and what are product attribute priorities. The use of competitive standing of each product attribute is one view of product *quality* and is analysed in this research and discussed further here.

7.1.1.1 Product and industry influence

The type of product and industry are certainly influential, with specific types of attributes becoming more important. This is notable in each of the companies: Company A produces medical devices, so health and safety is of high importance; Company B produces plant machinery, so servicing and warranty scores highly; Company C produces component parts, so installation expertise is seen as an important attribute; and Company D produces railway infrastructure and gives the second highest importance score to maintenance in use (see sections 6.2.2, 6.3.2, 6.4.2, 6.5.2 in Chapter 6).

7.1.1.2 The influence of customers

Another apparent influence on product attribute importance is the customer type and the parts of customer units they are part of. The results from the research are found in section 6.5.1 and appendices J, K and L. For each company, each customer type was perceived as having different views on importance for the product attributes offered. Also, different customer units were found to often have different priorities within the company. However, there were trends that were uncovered for similar customer units *between* companies. Previous researchers and authors suggest that these results were generally expected, since each customer will have a different set of needs (Mørup, 1993; Sauerwein, 1999; Robertshaw, 1993), but that customer types can be grouped into units with similar needs (Jobber, 1998; Owen and Hills, 1996; Webster and Wind, 1972; Bonoma *et al.* 1977; Wilson *et al.* 1996).

There were similarities between the companies as to who were seen as the most important customer units. For all companies, the customer type that was seen as most important was part of the decision and information units. In addition, for all four companies, the highest total ratings for customer units included the information unit, and also included the control unit in the top ratings in three companies (see Chapter 6, figures 6.1, 6.4, 6.7 and 6.10). According to Hill, only these three units actually influence the buying decision itself (Wilson *et al.*, 1996). This research has found that there are two important issues to note with regards to the comments of Hill: firstly that the allocation of customer types to units may have an effect on the perception of the customer influence; and secondly that other customer units should not be discounted. The recognition of different customer units may make a big difference to the findings of customer importance. If, for example customer B1 of Company B was only seen as the user and maintainer of the product (as was a common view from some of the respondents who had no contact with the customer), the picture of influence would be different. It was also found that the cumulative total for some customer units were higher than the three major units mentioned above. For companies A and D, the installer had a high customer rating and in company B, the maintainer had the highest customer unit rating. The importance of these issues is that they limit the application of Hill's previous assumption. Therefore, some customer types may be generally seen only as users, installers or maintainers but they should also be given due consideration as part of the buying decision, as they have shown to have a strong influence upon the design team.

7.1.1.3 The competitive standing of product attributes

Three of the four companies had similar perceptions about their competitive standing, with many product attributes getting a positive Q_i value. Companies A, B and C all perceived that they were competing well for the majority of the product attributes. This implies that they believe the products to be of a high *quality* to their customers.

The perception and reality (i.e. what the customers really think) may be equivalent and the products may well be achieving the perception of high *quality* within the marketplace. However, a "halo" effect may also be in existence, as other researchers have found that respondents will often answer that the product is better than it really is (Churchill, 1995). It is possible that Company D did not suffer from this effect and the perceptual map is a candid view of the problems with the product being investigated. Another contributory issue could be the position of product cost against all other attributes. Company A said that this was the only attribute that they were worse for (i.e. most expensive) and, although Companies B and C said that they were better than the competition, it was subsequently discovered that they were perceiving "value" not "cost". As such the three companies (A, B and C) actually have a similar situation for product cost: that they are one of the most expensive products on the market. Kotler *et al.* (1996) states that costs are likely to be weighed out against what the product has to offer, and the respondents may perceive that the customer delivered value is high, thus stating that product is better than other product offerings.

Some product attributes were placed on the 0 line for C_i, that is they were perceived to be about the same as other companies. Some of the most important attributes came into this category. This may reflect the situation where companies have to achieve a particular standard for the product to even compete in the marketplace. These could be attributes with the "must-be quality" found in the Kano model (Sauerwein, 1999, p431). Mørup (1993) also suggests that these are "obligatory properties" and other research has also found that it is not necessary to communicate to the customer any more than the fact that the product fulfils their standard needs for this type of attribute (Peter and Olson, 1990).

For other attributes that are perceived as being better than the competitors, it is difficult to know how "good" the "quality" of the attribute is. Some companies believe that they are superior in many different areas, including some attributes that are much lower in importance. The company may use some of these as differentiating factors. These "marginal quality" attributes are not top importance to customers, but they could influence the buying decision, if all other attributes are similar between competitive products. The companies could be looking for, what Kano describes as "attractive" qualities (Sauerwein, 1999, p431). Although Peter and Olson (1990) argue that it is difficult for a company to position the product in the mind of the customer using more than two or three special properties. Therefore some of the companies in this study may be unnecessarily extending themselves to achieve a better competitive situation for many different product attributes.

7.1.2 Grouping perceptions within companies

For all companies, there were no noticeable differences or patterns in the perceptions of different respondents according to involvement with customers, functional or management or groupings. In all companies the number of respondents was small and there was a spread across most groups (see figures 5.4., 5.5 and 5.6 in section 5.5.5). Therefore trends were not possible to find.

Generally, most respondents had very similar perceptions, no matter what their affiliations in terms of management, functional group or involvement with the customer. These comparative views on product attributes may contribute to the high competitive standing positions perceived by the companies as it has previously been found that synergy between company functional groupings affects the success of products (Service *et al.*, 1989).

The results showed that regularly one or two of the respondents had a very different opinion to the rest of the company (although there was no pattern as to which respondents had differing opinions). Also, occasionally, consensus was difficult to achieve. There did appear to be a pattern to the occasions when there was little agreement between individual respondents. Three particular situations stood out: firstly for a few of the NPD process activities; secondly for who was involved in collecting and using particular product attributes; and finally for the methods and tools used to collect or disseminate customer needs information. In most cases, the questionnaire offered the respondent the opportunity to say that they did not know but this option was not taken up very often. Even so, it is expected that differences came from lack of knowledge of other groups and procedures. Informal networks and communications are relied upon by all of the companies during NPD (see section 6.6.5.1) and these may bring the synergies, but also the problems. Informal communications can be linked to good product quality (Conway, 1995), but their unpredictability can mean gaps in knowledge and difficulties in information management (Calantone *et al.*, 1993).

7.2 Information management and customer needs compliance

The second set of research questions attempted to understand the information management systems for of the companies involved in the study. They were split into two areas: one on collection and the other on transferring customer needs information via communications and dissemination methods. The set of questions asked about information management were:

WHAT IS THE ROLE OF *CUSTOMER DATA AND INFORMATION MANAGEMENT* IN ENSURING CUSTOMER NEEDS COMPLIANCE DURING NPD?

How does the *customer data and information collection process* work?

3. - Are different *groups* involved in data and information collection?

4. - When is the data collected? (e.g. during beginning, middle or end of NPD process)

5. - Are different methods of data and information collection used for different *product attributes*?

How does the *customer data and information transfer process* work?

6. - Are different methods of data and information transfer used for different *product attributes*?
7. - Which *groups* are the recipients of the information?
8. - When is the data used after dissemination? (e.g. during the beginning, middle or end of NPD process)

(See section 4.3, figure 4.5, Chapter 4)

The each of the following six sections addresses these questions in turn.

7.2.1 Who collects customer needs information

Different groups were found to be involved in customer needs information collection. Differences in collection involvement were found between functional groupings within companies, but few generalisations could be made between companies (see section 6.6.2.1, in Chapter 6).

Two companies (A and B) used marketing to collect information on most attributes, on most occasions; in another company marketing (C) collected around 60% of attribute types, but only during NPD activities that took place either early or late on in the NPD process; in the other company (D) sales, rather than marketing, was the primary collector of information. These varying degrees of involvement from marketing do not necessarily support the expectations and predictions that marketing would be involved more often in all industrial companies, and in greater depth, during the "information age" (Hutt and Speh, 1992) or that marketing people who can research customer information were in greatest demand (Hague, 1992).

Results from this study show that R&D and design are very involved in the information collection process. In every company either R&D or design were involved in collection during nearly as many activities as sales or marketing. In fact, in companies C and D a technical function were involved in customer needs information collection during more NPD activities than the marketing/ sales functions. Also, for all companies the dominant technical department collected at least 55% of the different types of product attributes, indicating that technical groups were not restricted to collecting specific technical information. All of these findings are contra to much of the literature that suggests that technical groups within the design process are limited to technical tasks and only recipients of information (Bailetti and Litva, 1995). The involvement of technical groups in the collection of information may have a positive affect on the end product, as all of the companies were found to compete well for at least some of the attributes that technical functions collected. This adds weight to anecdotal findings that the company may benefit from technical people spending time in the marketplace, so that they are not so isolated (Himmelfarb, 1992).

Although the actual time spent collecting information was not captured by this research, the findings also imply that a considerable responsibility of the technical functions is the handling of customer needs information. This corresponds with the importance of information management as a task of designers (Cave and Noble, 1986; Court *et al.*, 1993).

7.2.2 When customer needs information is collected

There is evidence of customer needs information being collected in the course of every NPD activity. At least one of the four companies recognised collection happening during each of the 14 activities offered (see section 6.6.2, in Chapter 6). However, commonality only occurred for half of the possible NPD activities. All of these were during pre-development and development phases (none were at production and launch or post-launch). Four dominant activities were initial screening, preliminary technical assessment, preliminary marketing assessment and product development. These are the activities that are implied for fusing customer needs and technical opportunities (Bruce *et al.*, 1996; Holt *et al.*, 1984), as collecting the information later would not allow the company to include pertinent aspects from the market in concept generation and embodiment design (Bruce et al, 1995a). Collecting and using market and technology information together at an early stage leads to more chance of successful products (Cooper and Kleinschmidt, 1996), and has been found to reduce overall development times by up to 40% (Page and Stovall, 1994)and may be linked to the high reported competitive standings in 3 of the companies.

All four companies carried out some form of preliminary market assessment. However, only two of the companies carried out a specific market research activity before development, the other two companies did not. Both of the companies that carried out specific market research reported a mostly positive picture of their competitive standing (C_i). Of the two who did not carry out market research, one reported a similarly positive situation for competitive standing. However, the other one had a number of attributes that were worse than the competition, two of which were of high importance to the customer. Other research has shown that carrying out marketing oriented, preliminary activities make a difference to product success through ensuring a "need pull" from the market (Freeman, 1973; Rothwell *et al.*, 1974; Cooper and Kleinschmidt, 1994). However, that is not to say that companies who do not carry out market research *will* fail, it is that research has found that they are more likely to (Calantone *et al.*, 1993). The results from this study present a similar findings, although they are certainly not conclusive.

7.2.3 Methods for collecting customer needs information

There are many different methods of collecting data and information relating to customer needs and are chosen appropriately for the phase of product development and what information is sought (Churchill 1995; Urban and Hauser 1988, 1996; Wilson *et al.*, 1996; Hague 1992). This research found that most attributes were collected using a variety of information collection methods (see section 6.6.2.3, in Chapter 6). "1 on 1" collection methods of customer visits, phone calls and meetings between individuals were used to collect information on every type of product attribute. Also observation techniques were employed, resulting in anecdotal evidence, stories and photographs or other schemes. Previous work has noted that customer requirements in many cases come from chance and informal approaches (Holt *et al.* 1984). However, companies reported that they often employed at least one other method in addition to informal means of collection. This reveals that the companies may be trying to avoid the shortcomings noted by other authors, in that informal methods are often used sporadically and issues may be missed (Pugh, 1991; Holt, 1990). These findings are contradictory to some other work, which implies that people rely upon their own data stores and do not use external information gathering (Bently, 1981). However, other authors relate that is not that no external sources are used, but rather that they are assessed by the person who gathers the information (Cooper *et al.*, 1998) and applied and the information is only forwarded into the design process with the bias of this assessment (Bailetti and Litva, 1995).

More formal methods of collection were specifications, questionnaires and User Focus Group (UFG) techniques. All companies reported specifications as important collection methods. This method, too, has been recorded by previous authors as a key collection method within the product development process (Araujo *et al.*1995; Pugh, 1991). Previous research has suggested that the correct use of formal market research techniques such as questionnaires can make a difference to a product's success in the marketplace (Calantone *et al.*, 1993; Bernsen, 1990; Urban and Hauser, 1980). However, questionnaires were only used by one company. They applied questionnaires extensively, but only post launch as follow up research. This indicates that the company relies upon the same methods as other companies to collect customer needs information at pre-development, during development and throughout product and launch of the products. Of these other methods, it was interesting to note the widespread use of User Focus Group (UFG) techniques. The UFGs, used in 3 of the 4 companies, were generally well organised and carried out at regular intervals. The benefit to the companies may be large, in terms of providing a better product or service. In fact, in previous discussions, UFGs have been found as essential to uncovering differences between the needs of the market and what the company or product is actually delivering (Kapp, 1989; Bruce and Morris, 1994). It is worth noting that the companies that report the use of UFGs are those that also have perceptions of better and superior competitive standings. However, UFGs are only used for around half of the possible product attributes, by any one company. Therefore, due to the number of other possible issues that have been uncovered by this research, this can only be offered as one possible reason for the perceptions of high competitive standing in the three companies that do use UFGs.

7.2.4 Methods for transferring customer needs information

Findings from this research show that different methods are used by companies to communicate customer needs information. Results identify a high use of formal written communications (requirement specifications, general reports, market reports and compliance reports) but also reveal that these are not depended upon, and for many attributes, there is extensive use of informal communications (informal meetings and ad hoc communications). The application of other dissemination methods such as creative written communications (theme boards, scheme diagrams, scenarios and metaphors) and the employment of design reviews was also found to be not insignificant in most companies (see section 6.6.5.1, in Chapter 6). These empirical results are an encouraging addendum to the discussions of Bentley (1981) and Bruce *et al.* (1995a). Bentley revealed that, although companies produced formal information, the recipients of the information viewed it mostly with suspicion and gave it little regard. Similarly, Bruce *et al.* (1995a) stated that recipients were not getting the information they would like in the most effective or efficient way. Of course, these things may still be partially true in the companies studied in this research. However, the results do imply that the development of a new product within the companies does not rely purely upon formal written communications. The findings also show that the companies recognise the transfer of information via a number of different means, for many of the different product attributes.

There was considerable use of informal communications by all companies, for all types of product attributes except servicing and warranty and life costs, which were restricted to formal means of information dissemination. This indicates that the companies expected a lot from their informal boundary spanning communications. In fact, for three of the companies, some of the types of attribute information were only communicated via this means. Other researchers also recount that informal information sharing is widely used (Himmelfarb, 1992; Service *et al.*, 1989; Wright, 1999) and that it may possibly be a critical success factor, essential to the successful implementation of projects (Conway, 1995; Norman and Peterson, 1999; Pinto and Pinto, 1990; Service *et al.*, 1989). Although reliance upon such a random form of information dissemination may be inappropriate, causing difficulties even communicating erroneous customer needs information (Conway, 1995; Pugh, 1991).

Design reviews are used for disseminating information on a wide range of different types of product attribute. In fact, in three of the companies, respondents recognised that design review was used for 14 of the attributes (the other company noted its use 7 times). Despite widespread use of design reviews, they were never used as the only information transfer means. This concurs with the previous finding of Araujo *et al.*, (1995) who suggested that the most popular way to communicate design issues was via design review, but also found that many different design methods were used throughout the NPD process.

7.2.5 Who uses customer needs information

Within all of the companies, it is recognised that a number of different groups need to use different types of customer needs information (see section 6.6.3 and 6.6.4 in Chapter 6). Design and R&D are the major recipients of information, as they generally collect less than they use and marketing and sales are often the major suppliers of this information. Although each company has one technical functional that does a lot of the collection (as discussed in section 7.2.1).

For all companies, both technical functions and marketing/ sales functions are involved in the use of customer needs information during some of the same NPD process activities. Also, both of these sets of people use information on similar attributes. This implies that there is a multidisciplinary involvement in the NPD process, where groups are affecting the development of the product. This also suggests that there is much cross-discipline communication to provide the information on the attributes at the appropriate times. This is seen in the findings discussed in section 7.2.4, above on the transfer of information. However, there are differences in the number of activities where there is cross-discipline involvement. Company D only has multi-discipline involvement in 3 NPD process activities. Whereas the other companies have much more extensive overlap of functions using information during the same activities. Interestingly, it is Company D that reports the most number of times where product attributes perform poorly against the competition and this may be linked to the minimal times functional groups work together. Previous research has advocated multi-disciplinary work. Cooper and Kleinschmidt (1995a) recognise it as one of their important factors for product success in the marketplace. This work supports the finding that interdisciplinary involvement is important to product success (Cooper and Kleinschmidt see p69). The need for good relationships between the functions, in a multi-disciplinary environment has also been recognised as important (Hart, 1995; Cooper and Press, 1995), in this research, this might be suggested by the extensive use of different forms of communications in the companies.

7.2.6 When customer needs information is used

A certain amount of customer needs information was reported as being used during the development of the NPD process (see section 6.6.3, in Chapter 6). Interestingly, during no one phase did any company report using information on all types of applicable product attributes, and generally information on only a few attributes was used more than once, across NPD process phases.

As reported in section 6.6.3, for three companies (A, B and C), the largest number of different attributes were used during the development phase of the NPD process. However, Company D used information on almost half as many different attributes as the other companies during the same development phase, and used most different types during the production and launch phase. Company D therefore seems to be reactive, rather than proactive, collecting a larger number of attributes at the same phase in the NPD process than they require. Again, it needs to be noted that Company D is the one with low scores for competitive standing, but with around an 80% market share in a reportedly "stagnant" market. It is therefore possible that the company is purposefully adopting a reactive strategy, as there may be little point in putting capital into innovation where costs may not be recovered (Urban and Hauser, 1988). The results from two of the other companies (A and C) imply that these, too, may be adopting a reactive strategy, all be it less starkly to that of Company D. These two companies do not use many types of customer needs information early on in the NPD process and appear to make marketing and technical assessments based only on cost and risk. Company B, on the other hand, uses 8 different types of customer needs information (40% of applicable types), including technical innovation, which suggests that the company may have a more customer oriented, pro-active strategy (Foxall and Johnston, 1994). The strategy of these companies may not affect the ability of the product to meet the needs of many of their customers, but selecting the most appropriate one and communicating it clearly to the development team may add to product success (Cooper and Kleinschmidt, 1995a).

Chapter 8
Conclusions and considerations for further work

This research project investigated designing for customer needs compliance. It aimed to understand the perceptions which the design team may have of the product in terms of customer needs. It was also an objective to determine how customer needs compliance activities and information transfer methods during NPD affect the final design and, consequently, the *quality* of the product.

Previous chapters in this thesis have explained the basis of the work undertaken during the study, have reported findings of the work and then discussed the findings in terms of the research questions that were formed before the main company studies were carried out. The final chapter of this research thesis details the conclusions found during the study and provides some considerations for further work. In each of the sections, conclusions are drawn as to whether there was evidence to help support or refute each of the three research hypotheses. Further research possibilities and issues are then raised for each of the areas as the research hypotheses are addressed.

8.1 Discussing the research hypotheses

The general research problem for this research was stated as:

How do companies define what the customer wants and what is the role of information management in ensuring customer needs compliance during NPD?

A conceptual model was developed and eight specific research questions were formulated to help make the overall question more manageable. The research questions were quite general, so three research hypotheses were used to provide a basis for the theoretical explanation of what the investigation was about. Each of these research hypotheses is now addressed in turn.

8.2 Differences in product quality

The first research hypothesis anticipated that the definition of *quality* would be born out in the empirical studies:

> To provide product *quality*, each different product offering will aim at a different set of customer's needs. Therefore the importance given to the product's attributes will be different for each product.
>
> (See section 4.3, Chapter 4)

8.2.1 Conclusions for this hypothesis

- From the findings in Chapter 5, and the subsequent discussions in Chapter 6, it can be concluded that there is much evidence for support of this very general hypothesis.

- Specifically, each of the four products that were studied presented very different situations of what the perceived customer needs were for the particular product. It was found that the overall importance (A_i) given to each of the product attributes appeared to be specific to the product and identifiable for each product individually.

- There were some similarities between the overall A_i for some of the product attributes. However, *quality* is about the complete product offering, the totality of characteristics and the way that this is perceived by customers. Therefore, when viewed in this way, it is clear that the overall picture of the relative importance of product attributes is different between the four companies studied.

- It was found that each company in the study had a number of different customers and that these customers were certainly viewed as having differing influences upon the priorities that might be set for the design of a product. That is, each customer had different roles in terms of their relationship(s) with the product and the buying process; they were also perceived as having very different requirements in terms of which product attributes were important to them.

- Results show that different companies perceived different competitive standings (C_i) in the marketplace for each product attribute. Also, that when these competitive positions were assessed in terms of which product attributes were important to the customers (A_i), each company presented a perceptual map of quality that differed between companies.

- There was a difference found between one company and all the others. Company D reported that the attributes of their product were mostly "the same as" ($C_i = 0$) the competition, and that on 5 occasions, (including for some attributes that were seen as important) their product was "somewhat worse" than the competition ($C_i = -1$). This made for a negative overall perception of product *quality*. All other companies reported that the majority of their attributes were "somewhat better than the competition" ($C_i = +1$) and that on at least two occasions in each company, products attributes were reported as being "definitely superior" ($C_i = +2$). The perception of product *quality* in these cases was seen as more positive.

- There appeared to be no relationship between competitive standing (and the implied Q_i) and how well the company was doing in terms of market share. This was due to the types of products investigated and the industries and markets within which they operate. Therefore no measure of "success" can be implied from this research.

8.2.2 Conclusions for the methodology used in this area

- The method of collecting data from respondents relied heavily upon the motivation and interest from the researcher. In order to maintain consistency in collection, the same researcher had to ask the same questions many times (i.e. asking the respondent to fill in a blank form of exactly the same sheet for each of the customers they identified). However, it is believed that in doing this the research method carried more face validity – that each sheet collected data on the items they set out to measure. If the respondent had been asked to fill in only one importance sheet for the total "customer", there would have been great difficulties in producing a valid description of the items that had been attempted to be measured.

- The methodology used to produce A_i and C_i used judgement, when producing the P_{iM} and R_{iM} scores. The reliability of the methodology may therefore be questioned. It is expected that a different researcher applying the same techniques would produce comparable results, if the same approach were taken. However, this has not been verified.

- The equations used for the different aspects of the product attributes were extremely useful, and although the process was long and involved, the methodology that was developed to collect and assimilate the results of this study were found to produce results that could easily be compared both within and between companies.

- The use of competitive standing (C_i) (and the implied Q_i) presented only a limited view of product quality. However, this perception was adjudged to be the most realistic form of understanding a company's perception of the quality of their product. Results may suffer from extreme bias, as methodology texts recount that respondents often find it difficult to view these sorts of issues negatively. Also, although literature report that a five point scale is most suitable where scales are to be integrated, the importance scale used left respondents too few options (especially if they had psychologically ignored the two possible negative responses). The best (and recommended) way to assess product quality is to ask the customer, and probably use a seven or nine point scale. Unfortunately this research did not have the opportunity to do this, so results are all relative to the perceptions of the companies themselves and findings take this restriction into account.

8.2.3 Possible further work in this area

- It is expected that the conclusions from this hypothesis can be generalised. Therefore, further studies using the same methodology are required to investigate whether there may be a pattern in the importance of product attributes (i.e. the A_i scores) for similar products, or whether each product does, indeed, have its own unique set of quality attributes.

- The "quality" of the product was represented only by the company's perception of how well they were doing in terms of competitive standing. Further studies are required to place the findings into the context of what the customers themselves perceive as the quality of the products, as this, by definition should be a more valid measure of *quality*.

- There is a possibility that this research did not capture all of the product attributes that affect the *quality* of the product. This study purposefully did not concern itself with the organisational aspects of the product: deliveries, lead times, flexibility etc. Therefore, new research that does include these aspects of organisational delivered product quality is warranted.

8.3 Differences in perception of product quality

The second hypothesis sought to find possible differences between perceptions in each of the companies in the study:

> There will be differences in the perception of product *quality* between different company groups.
>
> (See section 4.3, Chapter 4)

8.3.1 Conclusions for this hypothesis

- Results from the studies in the four companies found little evidence to support this hypothesis.

- It was difficult to assess groupings within the companies because the respondents did not fall into useable group sizes. In some cases they were spread across groups and therefore the group size was small (one or two respondents), so making any "safe" conclusions about the behaviour of that group was not possible. The other extreme was where there were lots of respondents in one group and none in most of the others. In this case generalisations about the differences between groups were not actually possible.

- Groups were nominal and mutually exclusive. Therefore groups could not be amalgamated to provide valid data analysis between more appropriate size groups.

- It was not deemed appropriate to compile any "master" groups (i.e. all R&D from all companies, all marketing from all companies etc.) as products were totally different and results could in no way be combined with any validity.

8.3.2 Conclusions for the methodology used in this area

- Groups were self reporting and were therefore open to bias in interpretation by both respondent and researcher. The customer involvement groupings were well explained and the management groups offered most respondents no problems. However, the simple list of functional groups was difficult to fill in for many interviewees as they did not see themselves falling neatly into the groups offered to them.

- There would need to have been more people to make any assumptions between groups in each company. Group "quotas" could possibly have been used, although this would have lead to looking for a "senior manager, who never spoke to customers and was from the marketing functional area" to fill all of the quotas, for example. This, obviously would have been very difficult to do. As such, a possible change to the methodology might be fewer, but wider categories for groups, so that some general findings could have been made and then followed up with in-depth interviews, or similar.

8.3.3 Possible further work in this area

- It is still thought that there may be differences between separate groups within many companies that design, manufacture and sell industrial goods. Indications are that certain groups are involved in areas of the process in different ways (see next section) and therefore that perceptions within groups may be different. However, to determine this, a different methodology would need to be constructed.

8.4 The affect of information management

The third hypothesis offered by this research expected that the information systems within each company would make some differences to the companies overall ability to supply the customer with what they needed:

> The customer data and information collection and transfer process in the company will affect customer needs compliance.
>
> (See section 4.3, Chapter 4)

8.4.1 Conclusions for this hypothesis

- This research provides some evidence to suggest that the information systems within the companies studied may affect the customer needs compliance of their product. However, there are confounding variables and problems with determining customer needs compliance, therefore it is possible that the results were obtained for other reasons.

- The company (Company D) that had an overall "poor" quality product (i.e. were perceived as having poor competitive standing in the marketplace) was generally different in many aspects of its information management to the other three companies in terms of involvement of different functional groups in the collection and use of customer needs information and number of attributes collected.

- Specifically, Company D had much less multi-disciplinary involvement in both the collection and use of customer needs information than the other companies through out the NPD process. Fewer functional groups were involved in collecting and using product attribute information during all phases of the NPD process.

- Company D does not have anyone who is specifically labelled "marketing", rather the marketing function is carried out by designers, R&D and sales as required.

- Company D was also reported as using information a lot later than other companies – they often waited until production and launch until they used specific types of information and collected information at the time it was required, rather than having any strategy for data collection earlier in the NPD process. Other companies appeared to take a more pro-active approach.

- Possible confounding variables that may be important in the results obtained include:
  - the reason for involvement in the study (Companies A, B and C may have wanted to provide a good example of a product, Company D may have wanted to find out reasons why their particular product was a problem);
  - the companies and products chosen were not at all random (therefore there is no statistical reason why there should be any differences between the companies or product);
  - choice of NPD strategies (Company D may be purposefully adopting a strategy of low investment in the product because of the market situation, and resources may be used differently in product comparable with those from companies A, B and C);
  - the respondents within Company D did not have a consensus view on whether NPD process activities actually took place (this may have influenced their responses, or may affect the research in totality, as previous research suggests that if a company does not a clearly communicated product development process, then it is likely to have less product success, thus the information systems are only a part of the wider issue).

8.4.2 Conclusions for the methodology used in this area

- An issue raised during the discussion was the possibility of different company cultures. That is, the respondents from Company D were more candid and had fewer problems with declaring problems with their product. Although the purpose of the research was explained in a similar way to each company and respondent, results from the other companies may have suffered from a "halo" effect, with the interviewees wanting to place the company and product in good light. This may have meant that where the true answer was $C_i = -1$, the response offered was $C_i = 0$, which is more favourable for the company. Similarly, respondents may have answered positively to questions, assuming things to be true, even if they did not know whether the group did or did not collect the information. These issues are very difficult to track, but the researcher tried to find out if responses were a reflection of the truth, or just supposition.

- The questionnaire design collected a vast amount of data, in relatively short space of time. The use of this method was extremely successful in terms of time investment for the researcher and the companies.

- As with A_i and C_i, the consensus views on whether a company did or did not use a methods and whether or not a functional group was involved used judgement. Therefore the reliability of the methodology for this area of the research work may also be questioned. As previously stated, it is expected that a different researcher applying the same techniques would produce comparable results, if the same approach were taken. However, again this has not been verified.

8.4.2.1 Possible further work in this area

- These results are only applicable to the companies that were studied. It would be difficult to carry out a generalising study that used the same methodology. However, a different approach could use this work as a basis to study the management of customer needs information that included many more companies.

- Further research is warranted where perceptions are collected using a similar methodology to this, but with support by qualitative methods to discover whether the perceptions of the respondents in companies are very different from the tangible realities of quality reports, customer returns, design review minutes, design specifications and briefs etc.

- This research sought information on the most pertinent collection and dissemination methods, as described by other researchers (and found during the exploratory phase of the research). However, all methods are generally paper based and there is scope for further research to examine the role of other medium in the design process (e.g. computer based methods and tools, such as email and other communications, the internet for information gathering, CAD and CAM for disseminating product characteristics etc.).

8.5 Closing remarks

The general research problem for this research work asked:

How do companies define what the customer wants and what is the role of information management in ensuring customer needs compliance during NPD?

The work carried out during this research found that this general question was difficult to fully answer. Therefore, the research specifically focused upon:

- *how companies perceive customer needs and the role of information management within a company in supplying those needs.*

It was found that companies do define what the customer wants differently between product types. It was also apparent that companies must make priority decisions in terms of which product attributes are important to the generic "customer" and that these may well be based upon the information collection and dissemination process put in place to pass customer needs information.

The model suggested of the NPD process for customer needs compliance (figure 4.2 in Chapter 4), as operationalised through research questions and hypotheses, seems to go some way to explaining the role of perceptions in the NPD process and the involvement of information management to provide a *quality* product.

One of the most important aspects of this research is the development of a unique and thorough methodology which has potential for re-use in other customer needs, company information management and New Product Development research work.

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Appendix A
Interview script for experience surveys

Interview scripts for the experience surveys were necessarily general. They were used to guide the interviewer to ask about particular areas of the respondent's experience of NPD in their company.

The following page presents a set of questions that were used by the interviewer in the experience survey interviews. However, many questions that are not listed here were asked, prompted by the responses given by the interviewees, so that certain lines of enquiry could be followed.

Initial questions for experience surveys:

GENERAL

What is your involvement with the company?

What job do you do? (job title?)

What does this entail?

INVOLVEMENT WITH NEW PRODUCTS

How does your job involve you in the development of new products?

How much time do you spend with NPD?

Is this all on one product, or across a number?

FUNCTIONAL INVOLVEMENT

Who else is involved in product development with you?

Do you have regular contact with them?

Are there any specific things you do together (e.g. visit customers, design reviews, select suppliers etc.).

Is your involvement in the NPD process typical for your job function?

Are there any patterns of involvement for particular job functions?

CUSTOMER INVOLVEMENT

Who gets involved with talking to customers?

How do you communicate with current/ potential customers?

Is this proactive or reactive? Are there any typical patterns of customer involvement?

Do they get involved directly/ indirectly in the design process (e.g. tests/ UFGs etc.).

OTHER CUSTOMER INFORMATION COLLECTION/ DISSEMINATION

Are there any other ways of collecting information about customers?

Are these internal or external sources?

Do all functions get involved with this/ have sight of these types of information?

Are any gut feelings validated by market research?

Is there market research carried out, is this formal or informal?

Who is involved in this?

IMPROVEMENTS

In your opinion (from your experience) are there any good things about the way your company tries to understand and involve the customer?

Are there any things that could do with improvement?

Are there any areas where you could offer suggestions for a different approach?

Appendix B
Tabular prompt sheets for analysis of selected cases

The experience surveys were carried out using a set of prompt tables, that were used as an interview script. The format of tables allowed the researcher to fill in information as she went along.

The full set of prompt tables were 20 pages long, to allow for enough space for hand written notes. The tables in this appendix are therefore condensed for brevity, however no content has been lost.

SECTION I MARKETS

Ia. Markets by Product Type

Product Type	Market Size	Company's Market Share

Ib. Markets by Named Product

Specific Product	Market Size	Market Share

Ic. Market segment characteristics

Product Type	Industry category	Market Segment	Features of Segment

Id. Market segment dynamics

Product	Market dynamics	Company Share dynamics

SECTION II COMPETITION

IIa. Competition from Direct Rival Products, by Product Type

Product Type	Competitors - Direct Rival Products	Company Advantages over Rival	Rival Advantages over Company

IIb. Competition from Direct Rival Products, by Named Product

Specific Product	Competitors - Direct Rival Products	Company Advantages over Rival	Rival Advantages over Company

IIc. Competition from Substitute Products, by Product Type

Product Type	Competitors - Substitute Products	Company Advantages over Substitute	Substitute Advantages over Company

IId. Competition from Substitute Products, by Named Product

Specific Product	Competitors - Substitute Products	Company Advantages over Substitute	Substitute Advantages over Company

IIe. Competition from Possible New Entrant Products, by Product Type

Product Type	Competitors - Possible New Entrant Products	Company Advantages over New Entrant	New Entrant Advantages over Company

IIf. Competition from Possible New Entrant Products, by Named Product

Specific Product	**Competitors - Possible New Entrant Products**	**Company Advantages over New Entrant**	**New Entrant Advantages over Company**

IIg. Competitor Intelligence

Product	**Competitor type**	**What info. collected**	**How info. collected**

SECTION III SUPPLY CHAIN

IIIa. Suppliers Used

Product	**Component**	**Supplier**	**Why use this supplier?**

IIIb. Suppliers & Competitive Forces

Supplier	**Control over supplier**	**Supplier competitive strengths**

SECTION IV EXTERNAL INFLUENCES

Possible Influence	**Particular Product Type**	**Details**
Social		
Technological		
Economical		
Environmental (ecological)		
Political		
Does the company carry-out any research covering these aspects? (market research, publications, HMSO info. etc?)		
Who carries it out?		
To whom does it get reported?		

SECTION V Performance Measures

Va External measures

Product	What measure used?	Rank in market?	Main competition	Place in market?

Vb Internal Measures

Product	Measure	met?	what happens if not met?

Vc Performance Research

Product	Most common industry measure	Company review undertaken?	Independent review undertaken?

Vd Affect of Performance Measures

Product	Which reviews more important?	Are reviews fair or biased?	External affects of reviews	Internal affects of reviews

SECTION VI Products &Orders

VIa Winning Orders by Product Type

Product Type					
Criteria		**Industry Norm**	**Past**	**Present**	**Ideal**
Quality	**Consistency**				
	Capability				
Flexibility	**Volume**				
	Variety				
	Design				
Speed	**Time to Market**				
	Delivery				
Dependability	**Delivery**				
	Finical				
Relationships	**Partnerships**				
	Learning				
Price					
Other criteria?					

VIb Product Qualities by Product Type

Product Type	**Customer Target**	**Benefits required (quality)**

VId Summary of Benefits & features of Product Types

Product Type	**Customer target**	**Benefit required (quality)**	**Atributes/ features offered**

VIf Buyer Competitive Advantages

Product	**Buyer**	**Buyer competitive advantages**	**Relationship**

SECTION VII Product Development

VIIa Product Portfolio

Product type	**Specific Product**	**Launch Date**	**Reason**	**Sales volume**

VIIb NPD Launch Vs Development

	1996	1995	1994	1993
No. of products developed each Yr?				
No. of products launched each Yr?				
When do products "fail"?				
What criteria are used for judging?				

VIIc NPD Strategies

Are there NPD strategies in place/ being developed?	
Who produces them?	
How often are they reviewed?	
Who knows of the strategies?	
Are new products always assessed strategically? (do they need to be?)	
Is the strategy financially/ marketing and technology based?	

SECTION VIII Stakeholders in product design process

VIIIa Internal Stakeholders by product type

Product Type	Stakeholder title/ name	What hold?	Importance

VIIIb Internal Stakeholders by named product

Specific Product	Stakeholder title/ name	What hold?	Importance

VIIIc Other influences

Product	Influence	What hold?	Importance

SECTION IX Company Set-up

IXa Group Structure

IXb Company Structure

IXc Communications

What?	Formal ?	How?	By whom?	To whom?	Source

IXd Culture

Initiative	Initiated by whom?	Affect	Source

Appendix C
Product attribute list

A list of as many applicable product attributes as possible was drawn up for use in the exploratory research. The interviewees were shown the list, which was grouped under the headings shown in this appendix. This appendix also details some of the other researchers who have suggested that these attributes may affect the *quality* of a product. The list was reduced to from 59 attributes in 11 groups to 20 single items (as explained in Chapter 5, section 5.4.5.1) for the pre-test questionnaire (see Appendix D). Eventually, information on 21 attributes was collected (as "customisation" was separated in the final questionnaire, see Appendices E and F).

Groups of "customer needs" characteristics	Origin of characteristic
AESTHETICS	
Colour	Hollins and Pugh, 1996
Fashion	Hollins and Pugh, 1996
Finish	Hollins and Pugh, 1996
Form (appearance)	Pugh (1991); Cooper, 1999
Graphics	Pugh (1991)
Packaging	Hollins and Pugh, 1996 (add-on features, added value); Pugh (1991)
Style	Hollins and Pugh, 1996; Cooper, 1999
CAPITAL COST	
Initial capital outlay	Pugh (1991) (product cost)
Price	Pugh (1991) (product cost)
DESIGN	
Branding	Kotler *et al.*, 1996
Functional design (industrial need)	Kotler *et al.*, 1996;
Marginal differentiation	Kotler *et al.*, 1996; Cooper, 1999
Originality	Kotler *et al.*, 1996
EMOTIONS	
Career enhancement	Hollins and Pugh, 1996 (actually called it "status" and "reputation of company")
Choice	Kotler *et al.*, 1996; Hutt and Speh, 1992
Convenience	Kotler *et al.*, 1996; Hutt and Speh, 1992
Expectations	Kotler *et al.*, 1996; Hutt and Speh, 1992
Familiarity	Hollins and Pugh, 1996
"Features"	Hollins and Pugh, 1996 (add-on features, added value)
Fits in with lifestyle	
Implications of purchase	Hutt and Speh, 1992
Office politics	Pugh, 1991 (just politics)
Perceived risk	Hutt and Speh, 1992
Personal like/ dislike	Hutt and Speh, 1992
(Psychological) annoyance with features	Sanders and McCormick, 1993
Value	Hutt and Speh, 1992; Pugh, 1991; Kotler *et al.*, 1996

ERGONOMICS	
Comfort	Hollins and Pugh, 1996; Sanders and McCormick, 1993
(Ergonomic) annoyance with features	Pugh, 1991; Sanders and McCormick, 1993
Health and safety	Hollins and Pugh, 1996 Pugh, 1991 (safety)
Layout	Sanders and McCormick, 1993
LIFE COSTS	
Consumables	Hollins and Hollins, 1990; Hollins and Pugh, 1996
Continuity of supply and support	Hollins and Hollins, 1990; Hollins and Pugh, 1996 (availability, speed of delivery, effective distribution) (after-sales service network) (servicing and warranty available),
Cost effectiveness over life-time	Hollins and Pugh, 1996 (life in service)
Depreciation	Hutt and Speh, 1992
Labour	Hutt and Speh, 1992
Maintenance costs	Hollins and Hollins, 1990; Hollins and Pugh, 1996 (after sale service network)
Repairs	Hollins and Pugh, 1996
Upgrades possible/ required	Hollins and Hollins, 1990
Useful life	Hollins and Pugh, 1996 (life in service) Pugh, 1991 (life in service AND product life span)
MAINTAINABILITY	
Accessibility	Hollins and Hollins, 1990; Sanders and McCormick, 1993
Down time required	Hollins and Hollins, 1990
Frequency of maintenance	Hollins and Hollins, 1990
Labour – skills/ availability/ specialists needed?	Hollins and Hollins, 1990); Hutt and Speh, 1992
OPERATION	
Ease of use and task fulfilment	Hollins and Pugh, 1996; Sanders and McCormick, 1993
Knowledge/ skill acquisition/ expertise required	Sanders and McCormick, 1993
Manuals	Pugh, 1991 (documentation); Sanders and McCormick, 1993
Training required	Sanders and McCormick, 1993

PERFORMANCE	
Effectiveness (is it achieving intended purpose?)	Pugh, 1991; Hollins and Pugh, 1996
Efficacy (does means work?)	
Efficiency (is added value maximised?)	Hollins and Pugh, 1996 (add-on features, added value)
Power	Hollins and Pugh, 1996 (faster, more range, quieter, accuracy etc.)
PHYSICAL QUALITY	
Dimensions	Pugh, 1991; Hollins and Pugh, 1996
Electrical/ electronic	Pugh, 1991; Hollins and Pugh, 1996
Failures for QA in production and G.R.I. (goods receiving inspection)	Hollins and Pugh, 1996 (conforming to standards)
Mechanical	Pugh, 1991; Hollins and Pugh, 1996
RELIABILITY	
Criticality of failures	Pugh, 1991; Hollins and Pugh, 1996
Down time on failures	Pugh, 1991; Hollins and Pugh, 1996
Durability	Pugh, 1991; Hollins and Pugh, 1996; Hutt and Speh, 1992
M.T.B.F. (mean time between failures)	Pugh, 1991; Hollins and Pugh, 1996

Appendix D
Questionnaire used for pre-test

The questionnaire used for the pre-test includes questions about all of the items listed in Appendix G, and uses the scales developed in Appendix H. After peer review, the questionnaire was administered to four individuals at Company B. The findings from the pre-test were very positive and only a few changes were required to produce the final questionnaire used in the main study (see Appendix E for the list of changes and Appendix F for the full questionnaire used).

The full questionnaire is not presented here. Instead, the sheets that contain questions that were used in the pre-test that were subsequently changed for the final questionnaire are provided. The necessity for this is to show physically the differences in the data collection method for the results from four respondents that used this pre-test questionnaire.

This section asks about your perceptions of the company, generally. Please tick *one* box in answer to each question.

A1. Which one of the following categories do you think best describes your company?

Market driven	☐
Driven by a combination of market & technology	☐
Technology driven	☐

A2. Do you think that the majority of your company's products are aimed at mass markets or more specialised markets?

Mass market	☐
A combination of mass and niche markets	☐
Niche Markets	☐

Please tick *one* box in answer to each group.

A3. How important do you think each of these groups are as a source of new product ideas to your company:

	Definitely not important	Fairly unimportant	Average importance	Fairly important	Extremely important
iternal, company technical departments	☐	☐	☐	☐	☐
iternal, company marketing departments	☐	☐	☐	☐	☐
ompany sales force	☐	☐	☐	☐	☐
ustomers	☐	☐	☐	☐	☐
ompetitors	☐	☐	☐	☐	☐
ppliers	☐	☐	☐	☐	☐
nother industry	☐	☐	☐	☐	☐
search/ academic institutions	☐	☐	☐	☐	☐
mpany employee suggestion scheme	☐	☐	☐	☐	☐
her (please specify)	☐	☐	☐	☐	☐

This section asks for information on how good your products are in comparison with the competition. Please tick *one* box in answer to each attribute.

5. **How well does the product your company produces currently stand in comparison with the competition in the same UK market for each attributes?**

	Definitely Inferior	Somewhat worse	About the same	Somewhat better	Definitely Superior	N/ A
:sthetics of product (form, appearance, colour, ·le, graphics)	☐	☐	☐	☐	☐	☐
:hnical innovation (originality, functional :ign)	☐	☐	☐	☐	☐	☐
ınd (name, image, logo)	☐	☐	☐	☐	☐	☐
›ertise required & ease of installation	☐	☐	☐	☐	☐	☐
ıertise required & ease of use	☐	☐	☐	☐	☐	☐
ntainability of product once in use (down ; required to fix, skills required, ease of ιir)	☐	☐	☐	☐	☐	☐
ntainability of equipment used to install luct (down time required to fix, skills ired, ease of repair)	☐	☐	☐	☐	☐	☐
icing & warranty available	☐	☐	☐	☐	☐	☐
ıbility (durability, MTBF, criticality of re)	☐	☐	☐	☐	☐	☐
of product (price to the customer)	☐	☐	☐	☐	☐	☐
of installation (initial capital outlay to set- · install, cost of tools etc.)	☐	☐	☐	☐	☐	☐
Costs (consumables, depreciation, nuity of supply & support)	☐	☐	☐	☐	☐	☐
ical Quality (QA of product, conformity to nsions/ engineering characteristics)	☐	☐	☐	☐	☐	☐
nical performance (speed, strength, power)	☐	☐	☐	☐	☐	☐
ıomics (annoyance with design features, t of features/ functions)	☐	☐	☐	☐	☐	☐
ıct health & safety	☐	☐	☐	☐	☐	☐
›misation	☐	☐	☐	☐	☐	☐
r risk (acceptability, suitability, feasibility nology or financial)	☐	☐	☐	☐	☐	☐
tiveness (does it achieve intended purpose)	☐	☐	☐	☐	☐	☐

NOTE: ONE OF THESE SHEETS WAS FILLED FOR EACH CUSTOMER

Please tick *one* box in answer to each attribute.

C3. Please evaluate each attribute in terms of how important you think it is to the <u>CUSTOMER</u> of the product by ticking the appropriate box

	Definitely not important	Fairly unimportant	Average importance	Fairly important	Definitely important	N/ A
Aesthetics of product (form, appearance, colour, style, graphics)	☐	☐	☐	☐	☐	☐
Technical innovation (originality, functional design)	☐	☐	☐	☐	☐	☐
Brand (name, image, logo)	☐	☐	☐	☐	☐	☐
Personal preference (like/ dislike)	☐	☐	☐	☐	☐	☐
xpertise required & ease of installation	☐	☐	☐	☐	☐	☐
xpertise required & ease of use	☐	☐	☐	☐	☐	☐
laintainability of product once in use (down ime required to fix, skills required, ease of epair)	☐	☐	☐	☐	☐	☐
laintainability of equipment used to install roduct (down time required to fix, skills quired, ease of repair)	☐	☐	☐	☐	☐	☐
ervicing & warranty available	☐	☐	☐	☐	☐	☐
eliability (durability, MTBF, criticality of ilure)	☐	☐	☐	☐	☐	☐
ost of product (price to the customer)	☐	☐	☐	☐	☐	☐
ost of installation (initial capital outlay to set- or install, cost of tools etc.)	☐	☐	☐	☐	☐	☐
fe Costs (consumables, depreciation, ntinuity of supply & support)	☐	☐	☐	☐	☐	☐
ysical Quality (QA of product, conformity to mensions/ engineering characteristics)	☐	☐	☐	☐	☐	☐
chnical performance (speed, strength, power)	☐	☐	☐	☐	☐	☐
gonomics (annoyance with design features, yout of features/ functions)	☐	☐	☐	☐	☐	☐
oduct health & safety	☐	☐	☐	☐	☐	☐
istomisation	☐	☐	☐	☐	☐	☐
wer risk (acceptability, suitability, feasibility - hnology or financial)	☐	☐	☐	☐	☐	☐
fectiveness (does it achieve intended purpose)	☐	☐	☐	☐	☐	☐

This section discusses the collection of customer needs information. Please tick *all* boxes which are appropriate.

E1. **Which functions in your company do you think are involved in the collection of customer need or preference information during each of the activities - please refer to question D1. for definitions. (tick the appropriate boxes).**

		Who Collects Customer Needs Information?				
During which activities?	N/A	Marketing	Sales	R&D	Design	Manufacturing
Initial Screening	☐	☐	☐	☐	☐	☐
Preliminary market assessment	☐	☐	☐	☐	☐	☐
Preliminary technical assessment	☐	☐	☐	☐	☐	☐
Detailed market study/ market research	☐	☐	☐	☐	☐	☐
Business/ financial analysis	☐	☐	☐	☐	☐	☐
Product development	☐	☐	☐	☐	☐	☐
In-house testing	☐	☐	☐	☐	☐	☐
ustomer tests of product	☐	☐	☐	☐	☐	☐
est market/ trial sell	☐	☐	☐	☐	☐	☐
rial production	☐	☐	☐	☐	☐	☐
re-commercialisation business analysis	☐	☐	☐	☐	☐	☐
roduction start-up	☐	☐	☐	☐	☐	☐
larket launch	☐	☐	☐	☐	☐	☐
ost launch analysis	☐	☐	☐	☐	☐	☐

E2. Which functions do you think collect information during the product development (tick the appropriate boxes).

Customer Needs or Preference Information	***Who Collects This Information?***					
	N/A	Marketing	Sales	R&D	Design	Manufacturing
Aesthetics of product (form, appearance, colour, style, graphics)	☐	☐	☐	☐	☐	☐
Technical innovation (originality, functional design)	☐	☐	☐	☐	☐	☐
Brand (name, image, logo)	☐	☐	☐	☐	☐	☐
Personal preference (like/ dislike)	☐	☐	☐	☐	☐	☐
Expertise required & ease of installation	☐	☐	☐	☐	☐	☐
Expertise required & ease of use	☐	☐	☐	☐	☐	☐
Maintainability of product once in use (down ime required to fix, skills required, ease of epair)	☐	☐	☐	☐	☐	☐
Maintainability of equipment used to install roduct (down time required to fix, skills equired, ease of repair)	☐	☐	☐	☐	☐	☐
ervicing & warranty available	☐	☐	☐	☐	☐	☐
eliability (durability, MTBF, criticality of ailure)	☐	☐	☐	☐	☐	☐
ost of product (price to the customer)	☐	☐	☐	☐	☐	☐
ost of installation (initial capital outlay to set-p or install, cost of tools etc.)	☐	☐	☐	☐	☐	☐
ife Costs (consumables, depreciation, ontinuity of supply & support)	☐	☐	☐	☐	☐	☐
hysical Quality (QA of product, conformity to imensions/ engineering characteristics)	☐	☐	☐	☐	☐	☐
echnical performance (speed, strength, power)	☐	☐	☐	☐	☐	☐
rgonomics (annoyance with design features, yout of features/ functions)	☐	☐	☐	☐	☐	☐
roduct health & safety	☐	☐	☐	☐	☐	☐
lass customisation	☐	☐	☐	☐	☐	☐
ıdividual specification customisation	☐	☐	☐	☐	☐	☐
ower risk (acceptability, suitability, feasibility - chnology or financial)	☐	☐	☐	☐	☐	☐
ffectiveness (does it achieve intended purpose)	☐	☐	☐	☐	☐	☐

This section asks questions about when customer needs information is actually used during the product development process. Please tick *all* boxes which are appropriate.

F1. **Which functions in your company do you think will need to use customer need or preference information during each of the activities - please refer to question D1. for definitions. (tick the appropriate boxes).**

During which activities?	N/A	Marketing	Sales	R&D	Design	Manufacturing
	Who Uses Customer Needs Information?					
Initial Screening	☐	☐	☐	☐	☐	☐
Preliminary market assessment	☐	☐	☐	☐	☐	☐
Preliminary technical assessment	☐	☐	☐	☐	☐	☐
Detailed market study/ market research	☐	☐	☐	☐	☐	☐
Business/ financial analysis	☐	☐	☐	☐	☐	☐
?roduct development	☐	☐	☐	☐	☐	☐
n-house testing	☐	☐	☐	☐	☐	☐
ustomer tests of product	☐	☐	☐	☐	☐	☐
est market/ trial sell	☐	☐	☐	☐	☐	☐
rial production	☐	☐	☐	☐	☐	☐
re-commercialisation business analysis	☐	☐	☐	☐	☐	☐
roduction start-up	☐	☐	☐	☐	☐	☐
larket launch	☐	☐	☐	☐	☐	☐
ost launch analysis	☐	☐	☐	☐	☐	☐

F2. **Which functions do you think use information during the product development (tick the appropriate boxes).**

Customer Needs or Preference Information	N/A	Marketing	Sales	R&D	Design	Manufacturing
	Who Uses This Information?					
Aesthetics of product (form, appearance, colour, style, graphics)	☐	☐	☐	☐	☐	☐
Technical innovation (originality, functional design)	☐	☐	☐	☐	☐	☐
Brand (name, image, logo)	☐	☐	☐	☐	☐	☐
Personal preference (like/ dislike)	☐	☐	☐	☐	☐	☐
Expertise required & ease of installation	☐	☐	☐	☐	☐	☐
xpertise required & ease of use	☐	☐	☐	☐	☐	☐
laintainability of product once in use (down ime required to fix, skills required, ease of epair)	☐	☐	☐	☐	☐	☐
laintainability of equipment used to install roduct (down time required to fix, skills equired, ease of repair)	☐	☐	☐	☐	☐	☐
ervicing & warranty available	☐	☐	☐	☐	☐	☐
eliability (durability, MTBF, criticality of ilure)	☐	☐	☐	☐	☐	☐
ost of product (price to the customer)	☐	☐	☐	☐	☐	☐
ost of installation (initial capital outlay to set- or install, cost of tools etc.)	☐	☐	☐	☐	☐	☐
ife Costs (consumables, depreciation, ntinuity of supply & support)	☐	☐	☐	☐	☐	☐
ysical Quality (QA of product, conformity to mensions/ engineering characteristics)	☐	☐	☐	☐	☐	☐
chnical performance (speed, strength, power)	☐	☐	☐	☐	☐	☐
gonomics (annoyance with design features, yout of features/ functions)	☐	☐	☐	☐	☐	☐
oduct health & safety	☐	☐	☐	☐	☐	☐
ass Customisation	☐	☐	☐	☐	☐	☐
dividual specification customisation	☐	☐	☐	☐	☐	☐
wer risk (acceptability, suitability, feasibility - chnology or financial)	☐	☐	☐	☐	☐	☐
fectiveness (does it achieve intended purpose)	☐	☐	☐	☐	☐	☐

This section asks questions about product design and development tools used to collect, capture and share customer needs information. Please tick *all* boxes which are appropriate.

G1. **Which of these tools do you know of being used to collect information on the needs of the customer? (tick the appropriate boxes).**

	Questionnaire	One-on – One Interviews	User Focus Groups	Observation	Customer specification	None at all	Other means (please specify)
Aesthetics	☐	☐	☐	☐	☐	☐	....
Technical innovation	☐	☐	☐	☐	☐	☐	....
Brand	☐	☐	☐	☐	☐	☐	....
Personal preference	☐	☐	☐	☐	☐	☐	....
Expertise required & ease of installation	☐	☐	☐	☐	☐	☐	....
Expertise required & ease of use	☐	☐	☐	☐	☐	☐	....
Maintainability of product once in use	☐	☐	☐	☐	☐	☐	....
Maintainability of equipment used to install	☐	☐	☐	☐	☐	☐	....
Servicing & warranty	☐	☐	☐	☐	☐	☐	....
Reliability	☐	☐	☐	☐	☐	☐	....
Cost of product	☐	☐	☐	☐	☐	☐	....
Cost of installation	☐	☐	☐	☐	☐	☐	....
Life Costs	☐	☐	☐	☐	☐	☐	....
Physical Quality	☐	☐	☐	☐	☐	☐	....
Technical performance	☐	☐	☐	☐	☐	☐	....
Ergonomics	☐	☐	☐	☐	☐	☐	....
Product health & safety	☐	☐	☐	☐	☐	☐	....
Mass custom.	☐	☐	☐	☐	☐	☐	....
Spec. custom.	☐	☐	☐	☐	☐	☐	....
Lower risk	☐	☐	☐	☐	☐	☐	....
Effectiveness	☐	☐	☐	☐	☐	☐	....

G2. **Which of these tools do you know of being used to capture and review information on the needs of the customer? (tick the appropriate boxes).**

	Reports	Requirement specification	Theme boards	Scheme diagrams	Scenarios	Made tangible by metaphor /analogy	Other means	Never captured
Aesthetics	☐	☐	☐	☐	☐	☐	☐	☐
Technical innovation	☐	☐	☐	☐	☐	☐	☐	☐
Brand	☐	☐	☐	☐	☐	☐	☐	☐
Personal preference	☐	☐	☐	☐	☐	☐	☐	☐
Expertise required & ease of installation	☐	☐	☐	☐	☐	☐	☐	☐
Expertise required & ease of use	☐	☐	☐	☐	☐	☐	☐	☐
Maintainability of product once in use	☐	☐	☐	☐	☐	☐	☐	☐
Maintainability of equipment used to install product	☐	☐	☐	☐	☐	☐	☐	☐
Servicing & warranty	☐	☐	☐	☐	☐	☐	☐	☐
Reliability	☐	☐	☐	☐	☐	☐	☐	☐
Cost of product	☐	☐	☐	☐	☐	☐	☐	☐
Cost of installation	☐	☐	☐	☐	☐	☐	☐	☐
Life Costs	☐	☐	☐	☐	☐	☐	☐	☐
Physical Quality	☐	☐	☐	☐	☐	☐	☐	☐
Technical performance	☐	☐	☐	☐	☐	☐	☐	☐
Ergonomics	☐	☐	☐	☐	☐	☐	☐	☐
Product health & safety	☐	☐	☐	☐	☐	☐	☐	☐
Mass custom.	☐	☐	☐	☐	☐	☐	☐	☐
Spec custom.	☐	☐	☐	☐	☐	☐	☐	☐
Lower risk	☐	☐	☐	☐	☐	☐	☐	☐
Effectiveness	☐	☐	☐	☐	☐	☐	☐	☐

G3. **Which of these tools do you know of being used to transfer information on the needs of the customer? (tick the appropriate boxes).**

	Reports	Requirement specification	Theme boards	Scheme diagrams	Scenarios	Made tangible by metaphor /analogy	Other means	Never captured
Aesthetics	☐	☐	☐	☐	☐	☐	☐	☐
Technical innovation	☐	☐	☐	☐	☐	☐	☐	☐
Brand	☐	☐	☐	☐	☐	☐	☐	☐
Personal preference	☐	☐	☐	☐	☐	☐	☐	☐
Expertise required & ease of installation	☐	☐	☐	☐	☐	☐	☐	☐
Expertise required & ease of use	☐	☐	☐	☐	☐	☐	☐	☐
Maintainability of product once in use	☐	☐	☐	☐	☐	☐	☐	☐
Maintainability of equipment used to install product	☐	☐	☐	☐	☐	☐	☐	☐
Servicing & warranty	☐	☐	☐	☐	☐	☐	☐	☐
Reliability	☐	☐	☐	☐	☐	☐	☐	☐
Cost of product	☐	☐	☐	☐	☐	☐	☐	☐
Cost of installation	☐	☐	☐	☐	☐	☐	☐	☐
Life Costs	☐	☐	☐	☐	☐	☐	☐	☐
Physical Quality	☐	☐	☐	☐	☐	☐	☐	☐
Technical performance	☐	☐	☐	☐	☐	☐	☐	☐
Ergonomics	☐	☐	☐	☐	☐	☐	☐	☐
Product health & safety	☐	☐	☐	☐	☐	☐	☐	☐
Mass custom.	☐	☐	☐	☐	☐	☐	☐	☐
Spec custom.	☐	☐	☐	☐	☐	☐	☐	☐
Lower risk	☐	☐	☐	☐	☐	☐	☐	☐
Effectiveness	☐	☐	☐	☐	☐	☐	☐	☐

This section asks questions about product design and development methods used to help the company comply with customer needs. Please tick *all* boxes which are appropriate.

H1. **Which of these communication methods do you know of being used to help the company ensure compliance with customer needs during product development?**

	Informal meetings	Compliance reports	Market surveys	Reports containing graphs/ tables	Design review	None at all	Other means (please specify)
Aesthetics	☐	☐	☐	☐	☐	☐	....
Technical innovation	☐	☐	☐	☐	☐	☐	....
Brand	☐	☐	☐	☐	☐	☐	....
Personal preference	☐	☐	☐	☐	☐	☐	....
Expertise required & ease of installation	☐	☐	☐	☐	☐	☐	....
Expertise required & ease of use	☐	☐	☐	☐	☐	☐	....
Maintainability of product in use	☐	☐	☐	☐	☐	☐	....
Maintainability of equipment used to install product	☐	☐	☐	☐	☐	☐	....
Servicing & warranty	☐	☐	☐	☐	☐	☐	....
Reliability	☐	☐	☐	☐	☐	☐	....
Cost of product	☐	☐	☐	☐	☐	☐	....
Cost of installation	☐	☐	☐	☐	☐	☐	....
Life Costs	☐	☐	☐	☐	☐	☐	....
Physical Quality	☐	☐	☐	☐	☐	☐	....
Technical performance	☐	☐	☐	☐	☐	☐	....
Ergonomics	☐	☐	☐	☐	☐	☐	....
Product health & safety	☐	☐	☐	☐	☐	☐	....
Mass custom	☐	☐	☐	☐	☐	☐	....
Spec. custom.	☐	☐	☐	☐	☐	☐	....
Lower risk	☐	☐	☐	☐	☐	☐	....
Effectiveness	☐	☐	☐	☐	☐	☐	....

H2. How often are you aware of these specific design methods being used by the company during product development?

	Used in the past - but not now.	Never	Sometimes	Frequently	Always	May use something similar	Don't know what this is
Benchmarking competitor products	☐	☐	☐	☐	☐	☐	☐
Brainstorming	☐	☐	☐	☐	☐	☐	☐
Competitor analysis	☐	☐	☐	☐	☐	☐	☐
Compliance reports	☐	☐	☐	☐	☐	☐	☐
Cost analysis	☐	☐	☐	☐	☐	☐	☐
Critical path analysis	☐	☐	☐	☐	☐	☐	☐
Design catalogues	☐	☐	☐	☐	☐	☐	☐
Design for assembly	☐	☐	☐	☐	☐	☐	☐
Design for manufacture	☐	☐	☐	☐	☐	☐	☐
Design mock-ups	☐	☐	☐	☐	☐	☐	☐
Design of experiments	☐	☐	☐	☐	☐	☐	☐
Design review	☐	☐	☐	☐	☐	☐	☐
Engineering drawing to BS308	☐	☐	☐	☐	☐	☐	☐
Evaluation matrices	☐	☐	☐	☐	☐	☐	☐
Failure mode and effects	☐	☐	☐	☐	☐	☐	☐
Fault tree analysis	☐	☐	☐	☐	☐	☐	☐
Finite Element Analysis	☐	☐	☐	☐	☐	☐	☐
ishbone (Ishikawa) diagrams	☐	☐	☐	☐	☐	☐	☐
unctional analysis	☐	☐	☐	☐	☐	☐	☐
azard analysis	☐	☐	☐	☐	☐	☐	☐
iterature searching	☐	☐	☐	☐	☐	☐	☐
larket surveys	☐	☐	☐	☐	☐	☐	☐
laterial selection	☐	☐	☐	☐	☐	☐	☐
lorphological charts	☐	☐	☐	☐	☐	☐	☐
eeds analysis	☐	☐	☐	☐	☐	☐	☐
Objective trees	☐	☐	☐	☐	☐	☐	☐
areto analysis	☐	☐	☐	☐	☐	☐	☐
atent searching	☐	☐	☐	☐	☐	☐	☐
roduct design brief	☐	☐	☐	☐	☐	☐	☐
roduct design specification	☐	☐	☐	☐	☐	☐	☐

H2. Cont. **How often are you aware of these specific design methods being used by the company during product development?**

	Used in the past - but not now.	Never	Sometimes	Frequently	Always	May use something similar	Don't know what this is
Project milestones	☐	☐	☐	☐	☐	☐	☐
Quality function deployment	☐	☐	☐	☐	☐	☐	☐
Rapid prototyping	☐	☐	☐	☐	☐	☐	☐
Risk analysis	☐	☐	☐	☐	☐	☐	☐
Robust engineering (Taguchi)	☐	☐	☐	☐	☐	☐	☐
Simulation	☐	☐	☐	☐	☐	☐	☐
Simultaneous engineering or CE	☐	☐	☐	☐	☐	☐	☐
Statistical protocol	☐	☐	☐	☐	☐	☐	☐
S-W-O-T	☐	☐	☐	☐	☐	☐	☐
Value analysis	☐	☐	☐	☐	☐	☐	☐

Please would you answer the questions in the following section about yourself.

X1. Which one of the following categories best describes your job function?

R&D	☐
Project design	☐
Marketing	☐
Sales	☐
Manufacturing	☐
Other: Please specify	☐

X2. Job Title ....

X3. Which one of the following categories best describes your level of management ?

No management responsibilities	☐
Some functional/ product management responsibilities	☐
Functional manager	☐
Product manager	☐
Senior manager	☐
Director	☐
Other: Please specify	☐

X4. How many years have you been working for this company?

Less than 1 year	☐
1-2 years	☐
2-3 years	☐
3-4 years	☐
4-5 years	☐
Over 5 years	☐

Appendix E
Changes made to questionnaire

This appendix lists the changes that were made to the questionnaire used in the pre-test (as described in Appendix D), to produce the final questionnaire (presented in full in Appendix F).

The changes that were required between the questionnaire used in the pre-test and the final questionnaire used for the main were:

Emphasis on question wording added;

Unnecessary instructions and introductory page removed, as the researcher explained these to the interviewee to put them at ease and "break the ice";

Changes to questions:

A3 add "Don't know" as a response, add "legislation/ regulations" as an item.

B5 add "Don't know" as a response.

B5 and C3 divide "customisation" into "mass customisation" and "individual customisation".

E1/2 and F1/2 move "N/A" to end of response list. Add "other" as a response, after "Manufacturing". Add underlined heading above response boxes.

G1 remove the word "interviews" after "one-on-one" (as not always an "interview"). Add "Don't know of any means" as a response.

G2 reword the question to indicate capture, presentation and dissemination. Add "Don't know of any means used".

G3 removed from final survey (G2 included the intention of the question).

H1 Add "Ad hoc comms" as a response. Remove "Market survey" as a response. Change "Reports containing graphs and charts" to read "market reports". Add "Don't know of any means used".

H2 remove this question, as not required to provide information to study, also most respondents do not have the ability to answer this question in an interview – they need to refer to documentation to provide reliable response.

X2 Add new question which includes grouping according to involvement with customers (and renumber pre-test X2. to "X1.2).

X4 (new version) Change number of years working for the company to a single number response, rather than category response.

Appendix F
Final version of questionnaire used in the main study

This appendix includes the full questionnaire used for the main study. It was administered by the interviewer, but was filled in by each respondent themselves. The interviewer then checked for possible anomalies before proceeding to the next sheet.

REF ....

This section asks about your perceptions of the company, generally. Please tick *one* box in answer to each question.

A1. Which one of the following categories do you think best describes your company?

Market driven	☐
Driven by a combination of market & technology	☐
Technology driven	☐

A2. Do you think that the majority of your company's products are aimed at mass markets or more specialised markets?

Mass market	☐
A combination of mass and niche markets	☐
Niche Markets	☐

Please tick *one* box in answer to each group.

A3. **How important <u>do you think</u> each of these groups are as A SOURCE OF NEW PRODUCT IDEAS to your company:**

	Definitely not important	Fairly unimportant	Average importance	Fairly important	Definately important	Don't know
nternal, company technical departments	☐	☐	☐	☐	☐	☐
nternal, company marketing departments	☐	☐	☐	☐	☐	☐
ompany sales force	☐	☐	☐	☐	☐	☐
ustomers	☐	☐	☐	☐	☐	☐
ompetitors	☐	☐	☐	☐	☐	☐
uppliers	☐	☐	☐	☐	☐	☐
nother industry	☐	☐	☐	☐	☐	☐
esearch/ academic institutions	☐	☐	☐	☐	☐	☐
ompany employee suggestion scheme	☐	☐	☐	☐	☐	☐
egislation/ regulations	☐	☐	☐	☐	☐	☐
ther (please specify)	☐	☐	☐	☐	☐	☐

REF ....

We are asking for details of your perceptions of how new products are developed in your company. We would therefore like you to pick one generic product type and then make all responses relative to that product type.

B1. The generic product type chosen is

....

<u>Please use the same generic product type when answering questions in the rest of this questionnaire .</u>

Please tick *one* box in answer to each question.

B2. How many years has your company been producing this type of product?

Less than 1 year	☐
2 - 3 years	☐
4 - 5 years	☐
5 - 10 years	☐
10 - 20 years	☐
Over 20 years	☐
Don't know	☐

B3. Do you think THIS TYPE OF PRODUCT is aimed at mass markets or more specialised markets?

Mass market	☐
A combination of mass and niche markets	☐
Niche Markets	☐

B4. When the company started the latest design of this product, what type of development was it?

New to the world	A new product that created an entirely new market.	☐
New to the company	A new product that, for the first time, allowed the company to enter an established market.	☐
Additions to existing product lines	A new product that **supplements** the company's established product lines.	☐
Improvements in/ revisions to existing products	A new product that provides improved performance or greater perceived value to **replace** existing products	☐
Repositionings	An existing product that was targeted to new markets or market segments.	☐
Cost reductions	A new product that provides similar performance at a lower cost.	☐

REF ....

This section asks for information on how good your products are in comparison with the competition. Please tick *one* box in answer to each attribute.

5. **How well does the product your company produces <u>currently stand</u> in comparison with the competition in the SAME UK MARKET for each attributes?**

	Definitely Inferior	Somewhat worse	About the same	Somewhat better	Definitely Superior	N/ A	Don't know
sthetics of product (form, appearance, colour, le, graphics)	☐	☐	☐	☐	☐	☐	☐
:hnical innovation (originality, functional ign)	☐	☐	☐	☐	☐	☐	☐
ınd (name, image, logo)	☐	☐	☐	☐	☐	☐	☐
›ertise required & ease of installation	☐	☐	☐	☐	☐	☐	☐
›ertise required & ease of use	☐	☐	☐	☐	☐	☐	☐
intainability of product once in use (down : required to fix, skills required, ease of iir)	☐	☐	☐	☐	☐	☐	☐
ntainability of equipment used to install luct (down time required to fix, skills iired, ease of repair)	☐	☐	☐	☐	☐	☐	☐
icing & warranty available	☐	☐	☐	☐	☐	☐	☐
ability (durability, MTBF, criticality of ıre)	☐	☐	☐	☐	☐	☐	☐
: of product (price to the customer)	☐	☐	☐	☐	☐	☐	☐
of installation (initial capital outlay to set-r install, cost of tools etc.)	☐	☐	☐	☐	☐	☐	☐
Costs (consumables, depreciation, inuity of supply & support)	☐	☐	☐	☐	☐	☐	☐
ical Quality (QA of product, conformity to nsions/ engineering characteristics)	☐	☐	☐	☐	☐	☐	☐
ınical performance (speed, strength, power)	☐	☐	☐	☐	☐	☐	☐
nomics (annoyance with design features, ıt of features/ functions)	☐	☐	☐	☐	☐	☐	☐
uct health & safety	☐	☐	☐	☐	☐	☐	☐
s customisation	☐	☐	☐	☐	☐	☐	☐
idual specification customisation	☐	☐	☐	☐	☐	☐	☐
er risk (acceptability, suitability, feasibility hnology or financial)	☐	☐	☐	☐	☐	☐	☐
:tiveness (does it achieve intended purpose)	☐	☐	☐	☐	☐	☐	☐

REF ....

There is, almost certainly, more than one "customer" for the finished product. We would like you to list those people who are your customers: think about the end user, the person who makes the financial decision, the installer, the retailer and others who may influence the purchase decision.

C1. Please give details of each type of person you consider as a customer of the FINISHED PRODUCT (Put only one type of person in each section, if more than one "End user" use "Other 1, 2 & 3" as necessary).

End User

Buyer (the person who has financial control of the purchase),

Installer

Retailer

Maintainer

Other 1

Other 2

Other 3

Please use the same definitions for each of these types of customer throughout the rest of the questionnaire.

C2. Which customers do you think are the most important to satisfy when designing and developing the product? (Please place a ranking next to each of them, using 1 as the most important).

End User	
Buyer	
Installer	
Retailer	
Maintainer	
Other 1	
Other 2	
Other 3	

REF ....

NOTE: ONE OF THESE SHEETS WAS FILLED FOR EACH CUSTOMER

Please tick *one* box in answer to each attribute.

C3. **Please evaluate each attribute in terms of how important you think it is to the <u>CUSTOMER</u> of the product by ticking the appropriate box**

	Definitely not important	Fairly unimportant	Average importance	Fairly important	Definitely important	N/ A
Aesthetics of product (form, appearance, colour, style, graphics)	☐	☐	☐	☐	☐	☐
Technical innovation (originality, functional design)	☐	☐	☐	☐	☐	☐
Brand (name, image, logo)	☐	☐	☐	☐	☐	☐
Personal preference (like/ dislike)	☐	☐	☐	☐	☐	☐
Expertise required & ease of installation	☐	☐	☐	☐	☐	☐
Expertise required & ease of use	☐	☐	☐	☐	☐	☐
Maintainability of product once in use (down ime required to fix, skills required, ease of epair)	☐	☐	☐	☐	☐	☐
Maintainability of equipment used to install roduct (down time required to fix, skills equired, ease of repair)	☐	☐	☐	☐	☐	☐
ervicing & warranty available	☐	☐	☐	☐	☐	☐
eliability (durability, MTBF, criticality of ailure)	☐	☐	☐	☐	☐	☐
ost of product (price to the customer)	☐	☐	☐	☐	☐	☐
ost of installation (initial capital outlay to set-p or install, cost of tools etc.)	☐	☐	☐	☐	☐	☐
ife Costs (consumables, depreciation, ontinuity of supply & support)	☐	☐	☐	☐	☐	☐
hysical Quality (QA of product, conformity to imensions/ engineering characteristics)	☐	☐	☐	☐	☐	☐
echnical performance (speed, strength, power)	☐	☐	☐	☐	☐	☐
rgonomics (annoyance with design features, yout of features/ functions)	☐	☐	☐	☐	☐	☐
roduct health & safety	☐	☐	☐	☐	☐	☐
lass customisation	☐	☐	☐	☐	☐	☐
ndividual specification customisation	☐	☐	☐	☐	☐	☐
ower risk (acceptability, suitability, feasibility - chnology or financial)	☐	☐	☐	☐	☐	☐
ffectiveness (does it achieve intended purpose)	☐	☐	☐	☐	☐	☐

REF ....

This section discusses the collection of customer needs information. Please tick *one* box in answer to each activity.

D1. Which of the following activities <u>do you recognise</u> as taking place during the product development process?

Activity		Yes	No	Don't know
PRE-DEVELOPMENT				
Initial Screening	The initial go/ no go decision where it is first decided to allocate funds to the proposed new product idea.	☐	☐	☐
Preliminary market assessment	An initial, preliminary, but non-scientific, market assessment; a first and quick look at the market.	☐	☐	☐
Preliminary technical assessment	An initial, preliminary appraisal of the technical merits and difficulties of the project.	☐	☐	☐
Detailed market study/ market research	Market research, involving a reasonable sample of respondents, a formal design and a consistent data collection procedure.	☐	☐	☐
Business/ financial analysis	A financial or business analysis leading to a go/ no go decision prior to product development and the development of market and/ or business objectives.	☐	☐	☐
DEVELOPMENT				
Product development	The actual design and development of the product including concept generation and embodiment resulting in e.g. a prototype, simulation or sample product.	☐	☐	☐
In-house testing	Testing the product in-house, in the lab or under controlled conditions (as opposed to in the field or with customers).	☐	☐	☐
Customer tests of product	Testing the product under real life conditions e.g. with customers and/ or in the field.	☐	☐	☐
Test market/ trial sell	A test market or trial sell of the product - trying to sell the product but to a limited or test set of customers.	☐	☐	☐
Trial production	A trial production run to test the production facilities.	☐	☐	☐
Pre-commercialisation business analysis	A financial or business and appraisal of objectives, following product development but prior to full scale launch.	☐	☐	☐
PRODUCTION & LAUNCH				
Production start-up	The start-up of full scale or commercial production.	☐	☐	☐
Market launch	The launch of the product, on a full scale and/ or commercial basis with an identifiable set of marketing activities specific to this product.	☐	☐	☐
POST LAUNCH				
Post launch analysis	Market research and business or financial appraisal of how the product is achieving market and/ or business objectives.	☐	☐	☐

REF ....

This section discusses the collection of customer needs information. Please tick *all* boxes which are appropriate.

E1. **Which functions in your company <u>do you think</u> are INVOLVED IN THE COLLECTION of customer need or preference information during each of the activities - please refer to question D1. for definitions. (tick the appropriate boxes).**

<u>During which activities?</u>	***<u>Who Collects Customer Needs Information?</u>***						
	Marketing	Sales	R&D	Design	Manufacturing	Other	N/A
Initial Screening	☐	☐	☐	☐	☐	☐	☐
Preliminary market assessment	☐	☐	☐	☐	☐	☐	☐
Preliminary technical assessment	☐	☐	☐	☐	☐	☐	☐
Detailed market study/ market research	☐	☐	☐	☐	☐	☐	☐
Business/ financial analysis	☐	☐	☐	☐	☐	☐	☐
Product development	☐	☐	☐	☐	☐	☐	☐
In-house testing	☐	☐	☐	☐	☐	☐	☐
Customer tests of product	☐	☐	☐	☐	☐	☐	☐
Test market/ trial sell	☐	☐	☐	☐	☐	☐	☐
Trial production	☐	☐	☐	☐	☐	☐	☐
Pre-commercialisation business analysis	☐	☐	☐	☐	☐	☐	☐
Production start-up	☐	☐	☐	☐	☐	☐	☐
Market launch	☐	☐	☐	☐	☐	☐	☐
ost launch analysis	☐	☐	☐	☐	☐	☐	☐

REF ....

E2. **Which functions <u>do you think</u> COLLECT INFORMATION during the product development (tick the appropriate boxes).**

<u>Who Collects This Information?</u>

<u>Customer Needs or Preference Information</u>	Marketing	Sales	R&D	Design	Manufacturing	Other	N/A
Aesthetics of product (form, appearance, colour, style, graphics)	☐	☐	☐	☐	☐	☐	☐
Technical innovation (originality, functional design)	☐	☐	☐	☐	☐	☐	☐
Brand (name, image, logo)	☐	☐	☐	☐	☐	☐	☐
Personal preference (like/ dislike)	☐	☐	☐	☐	☐	☐	☐
Expertise required & ease of installation	☐	☐	☐	☐	☐	☐	☐
Expertise required & ease of use	☐	☐	☐	☐	☐	☐	☐
Maintainability of product once in use (down time required to fix, skills required, ease of repair)	☐	☐	☐	☐	☐	☐	☐
Maintainability of equipment used to install product (down time required to fix, skills required, ease of repair)	☐	☐	☐	☐	☐	☐	☐
Servicing & warranty available	☐	☐	☐	☐	☐	☐	☐
Reliability (durability, MTBF, criticality of failure)	☐	☐	☐	☐	☐	☐	☐
Cost of product (price to the customer)	☐	☐	☐	☐	☐	☐	☐
Cost of installation (initial capital outlay to set-up or install, cost of tools etc.)	☐	☐	☐	☐	☐	☐	☐
Life Costs (consumables, depreciation, continuity of supply & support)	☐	☐	☐	☐	☐	☐	☐
Physical Quality (QA of product, conformity to dimensions/ engineering characteristics)	☐	☐	☐	☐	☐	☐	☐
Technical performance (speed, strength, power)	☐	☐	☐	☐	☐	☐	☐
Ergonomics (annoyance with design features, layout of features/ functions)	☐	☐	☐	☐	☐	☐	☐
Product health & safety	☐	☐	☐	☐	☐	☐	☐
Mass customisation	☐	☐	☐	☐	☐	☐	☐
Individual specification customisation	☐	☐	☐	☐	☐	☐	☐
Lower risk (acceptability, suitability, feasibility - technology or financial)	☐	☐	☐	☐	☐	☐	☐
Effectiveness (does it achieve intended purpose)	☐	☐	☐	☐	☐	☐	☐

REF ....

E3. **When <u>do you think</u> customer needs information is CAPTURED FOR USE ON A SPECIFIC PROJECT? (tick the appropriate boxes).**

<u>Customer Needs or Preference Information</u>	***<u>When is This Collected?</u>***					
	Never Captured	pre-development	development	production & launch	post launch	Don't know
Aesthetics of product (form, appearance, colour, style, graphics)	☐	☐	☐	☐	☐	☐
Technical innovation (originality, functional design)	☐	☐	☐	☐	☐	☐
Brand (name, image, logo)	☐	☐	☐	☐	☐	☐
Personal preference (like/ dislike)	☐	☐	☐	☐	☐	☐
Expertise required & ease of installation	☐	☐	☐	☐	☐	☐
Expertise required & ease of use	☐	☐	☐	☐	☐	☐
Maintainability of product once in use (down time required to fix, skills required, ease of repair)	☐	☐	☐	☐	☐	☐
Maintainability of equipment used to install product (down time required to fix, skills required, ease of repair)	☐	☐	☐	☐	☐	☐
Servicing & warranty available	☐	☐	☐	☐	☐	☐
Reliability (durability, MTBF, criticality of failure)	☐	☐	☐	☐	☐	☐
Cost of product (price to the customer)	☐	☐	☐	☐	☐	☐
Cost of installation (initial capital outlay to set-up or nstall, cost of tools etc.)	☐	☐	☐	☐	☐	☐
ife Costs (consumables, depreciation, continuity of upply & support)	☐	☐	☐	☐	☐	☐
hysical Quality (QA of product, conformity to imensions/ engineering characteristics)	☐	☐	☐	☐	☐	☐
echnical performance (speed, strength, power)	☐	☐	☐	☐	☐	☐
rgonomics (annoyance with design features, layout of atures/ functions)	☐	☐	☐	☐	☐	☐
roduct health & safety	☐	☐	☐	☐	☐	☐
lass customisation	☐	☐	☐	☐	☐	☐
idividual specification customisation	☐	☐	☐	☐	☐	☐
ower risk (acceptability, suitability, feasibility - chnology or financial)	☐	☐	☐	☐	☐	☐
ffectiveness (does it achieve intended purpose)	☐	☐	☐	☐	☐	☐

REF ....

This section asks questions about when customer needs information is actually used during the product development process. Please tick *all* boxes which are appropriate.

F1. **Which functions in your company do you think will NEED TO USE customer need or preference information during each of the activities - please refer to question D1. for definitions. (tick the appropriate boxes).**

Who Uses Customer Needs Information?

During which activities?	Marketing	Sales	R&D	Design	Manufacturing	Other	N/A
Initial Screening	☐	☐	☐	☐	☐	☐	☐
Preliminary market assessment	☐	☐	☐	☐	☐	☐	☐
Preliminary technical assessment	☐	☐	☐	☐	☐	☐	☐
Detailed market study/ market research	☐	☐	☐	☐	☐	☐	☐
Business/ financial analysis	☐	☐	☐	☐	☐	☐	☐
Product development	☐	☐	☐	☐	☐	☐	☐
In-house testing	☐	☐	☐	☐	☐	☐	☐
Customer tests of product	☐	☐	☐	☐	☐	☐	☐
Test market/ trial sell	☐	☐	☐	☐	☐	☐	☐
Trial production	☐	☐	☐	☐	☐	☐	☐
Pre-commercialisation business analysis	☐	☐	☐	☐	☐	☐	☐
Production start-up	☐	☐	☐	☐	☐	☐	☐
Market launch	☐	☐	☐	☐	☐	☐	☐
Post launch analysis	☐	☐	☐	☐	☐	☐	☐

REF ....

F2. **Which functions <u>do you think</u> USE INFORMATION during the product development (tick the appropriate boxes).**

Customer Needs or Preference Information	***Who Uses This Information?*** Marketing	Sales	R&D	Design	Manufacturing	Other	N/A
Aesthetics of product (form, appearance, colour, style, graphics)	☐	☐	☐	☐	☐	☐	☐
Technical innovation (originality, functional design)	☐	☐	☐	☐	☐	☐	☐
Brand (name, image, logo)	☐	☐	☐	☐	☐	☐	☐
Personal preference (like/ dislike)	☐	☐	☐	☐	☐	☐	☐
Expertise required & ease of installation	☐	☐	☐	☐	☐	☐	☐
Expertise required & ease of use	☐	☐	☐	☐	☐	☐	☐
Maintainability of product once in use (down ime required to fix, skills required, ease of epair)	☐	☐	☐	☐	☐	☐	☐
Maintainability of equipment used to install roduct (down time required to fix, skills equired, ease of repair)	☐	☐	☐	☐	☐	☐	☐
ervicing & warranty available	☐	☐	☐	☐	☐	☐	☐
eliability (durability, MTBF, criticality of ailure)	☐	☐	☐	☐	☐	☐	☐
ost of product (price to the customer)	☐	☐	☐	☐	☐	☐	☐
ost of installation (initial capital outlay to set-p or install, cost of tools etc.)	☐	☐	☐	☐	☐	☐	☐
ife Costs (consumables, depreciation, ontinuity of supply & support)	☐	☐	☐	☐	☐	☐	☐
hysical Quality (QA of product, conformity to imensions/ engineering characteristics)	☐	☐	☐	☐	☐	☐	☐
echnical performance (speed, strength, power)	☐	☐	☐	☐	☐	☐	☐
rgonomics (annoyance with design features, yout of features/ functions)	☐	☐	☐	☐	☐	☐	☐
roduct health & safety	☐	☐	☐	☐	☐	☐	☐
lass Customisation	☐	☐	☐	☐	☐	☐	☐
ndividual specification customisation	☐	☐	☐	☐	☐	☐	☐
ower risk (acceptability, suitability, feasibility - chnology or financial)	☐	☐	☐	☐	☐	☐	☐
ffectiveness (does it achieve intended purpose)	☐	☐	☐	☐	☐	☐	☐

F3. **When do you think customer needs information is USED? (tick the appropriate boxes).**

When is This Used?

Customer Needs or Preference Information	Never Used	pre-development	development	production & launch	post launch	Don't know
Aesthetics of product (form, appearance, colour, style, graphics)	☐	☐	☐	☐	☐	☐
Technical innovation (originality, functional design)	☐	☐	☐	☐	☐	☐
Brand (name, image, logo)	☐	☐	☐	☐	☐	☐
Personal preference (like/ dislike)	☐	☐	☐	☐	☐	☐
Expertise required & ease of installation	☐	☐	☐	☐	☐	☐
Expertise required & ease of use	☐	☐	☐	☐	☐	☐
Maintainability of product once in use (down time required to fix, skills required, ease of repair)	☐	☐	☐	☐	☐	☐
Maintainability of equipment used to install product (down time required to fix, skills required, ease of repair)	☐	☐	☐	☐	☐	☐
Servicing & warranty available	☐	☐	☐	☐	☐	☐
Reliability (durability, MTBF, criticality of failure)	☐	☐	☐	☐	☐	☐
Cost of product (price to the customer)	☐	☐	☐	☐	☐	☐
Cost of installation (initial capital outlay to set-up or install, cost of tools etc.)	☐	☐	☐	☐	☐	☐
Life Costs (consumables, depreciation, continuity of supply & support)	☐	☐	☐	☐	☐	☐
Physical Quality (QA of product, conformity to dimensions/ engineering characteristics)	☐	☐	☐	☐	☐	☐
Technical performance (speed, strength, power)	☐	☐	☐	☐	☐	☐
Ergonomics (annoyance with design features, layout of features/ functions)	☐	☐	☐	☐	☐	☐
Product health & safety	☐	☐	☐	☐	☐	☐
Mass customisation	☐	☐	☐	☐	☐	☐
Individual specification customisation	☐	☐	☐	☐	☐	☐
Lower risk (acceptability, suitability, feasibility - technology or financial)	☐	☐	☐	☐	☐	☐
Effectiveness (does it achieve intended purpose)	☐	☐	☐	☐	☐	☐

REF ....

This section asks questions about product design and development tools used to collect, capture and share customer needs information. Please tick *all* boxes which are appropriate.

G1. Which of these tools <u>do you know</u> of being used to COLLECT INFORMATION on the needs of the customer? (tick the appropriate boxes).

	Questionnaire	One-on - One	User Focus Groups	Observation	Customer specification	None at all	Other means (please specify)	Don't know of any means
Aesthetics	☐	☐	☐	☐	☐	☐	....	☐
Technical innovation	☐	☐	☐	☐	☐	☐	....	☐
Brand	☐	☐	☐	☐	☐	☐	....	☐
Personal preference	☐	☐	☐	☐	☐	☐	....	☐
Expertise required & ease of installation	☐	☐	☐	☐	☐	☐	....	☐
Expertise required & ease of use	☐	☐	☐	☐	☐	☐	....	☐
Maintainability of product once in use	☐	☐	☐	☐	☐	☐	....	☐
Maintainability of equipment used to install	☐	☐	☐	☐	☐	☐	....	☐
Servicing & warranty	☐	☐	☐	☐	☐	☐	....	☐
Reliability	☐	☐	☐	☐	☐	☐	....	☐
Cost of product	☐	☐	☐	☐	☐	☐	....	☐
Cost of installation	☐	☐	☐	☐	☐	☐	....	☐
Life Costs	☐	☐	☐	☐	☐	☐	....	☐
Physical Quality	☐	☐	☐	☐	☐	☐	....	☐
Technical performance	☐	☐	☐	☐	☐	☐	....	☐
Ergonomics	☐	☐	☐	☐	☐	☐	....	☐
Product health & safety	☐	☐	☐	☐	☐	☐	....	☐
Mass custom.	☐	☐	☐	☐	☐	☐	....	☐
Spec. custom.	☐	☐	☐	☐	☐	☐	....	☐
Lower risk	☐	☐	☐	☐	☐	☐	....	☐
Effectiveness	☐	☐	☐	☐	☐	☐	....	☐

G2. **Which of these tools do you know of being used to CAPTURE, PRESENT, DISSEMINATE OR REVIEW information on the needs of the customer? (tick the appropriate boxes).**

	Reports	Requirement specification	Theme boards	Scheme diagrams	Scenarios	Made tangible by metaphor /analogy	Other means	Never captured	Don't know of any means used
Aesthetics	☐	☐	☐	☐	☐	☐	☐	☐	☐
Technical innovation	☐	☐	☐	☐	☐	☐	☐	☐	☐
Brand	☐	☐	☐	☐	☐	☐	☐	☐	☐
Personal preference	☐	☐	☐	☐	☐	☐	☐	☐	☐
Expertise required & ease of installation	☐	☐	☐	☐	☐	☐	☐	☐	☐
Expertise required & ease of use	☐	☐	☐	☐	☐	☐	☐	☐	☐
Maintainability of product once in use	☐	☐	☐	☐	☐	☐	☐	☐	☐
Maintainability of equipment used to install product	☐	☐	☐	☐	☐	☐	☐	☐	☐
Servicing & warranty	☐	☐	☐	☐	☐	☐	☐	☐	☐
Reliability	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cost of product	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cost of installation	☐	☐	☐	☐	☐	☐	☐	☐	☐
Life Costs	☐	☐	☐	☐	☐	☐	☐	☐	☐
Physical Quality	☐	☐	☐	☐	☐	☐	☐	☐	☐
Technical performance	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ergonomics	☐	☐	☐	☐	☐	☐	☐	☐	☐
Product health & safety	☐	☐	☐	☐	☐	☐	☐	☐	☐
Mass custom.	☐	☐	☐	☐	☐	☐	☐	☐	☐
Spec custom.	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lower risk	☐	☐	☐	☐	☐	☐	☐	☐	☐
Effectiveness	☐	☐	☐	☐	☐	☐	☐	☐	☐

REF ....

This section asks questions about product design and development methods used to help the company comply with customer needs. Please tick *all* boxes which are appropriate.

H1. **Which of these COMMUNICATION METHODS <u>do you know</u> of being used to help the company ensure compliance with customer needs during product development?**

	Informal meetings	Ad hoc comms.	Compliance reports	Market reports	Design review	None at all	Other means (please specify)	Don't know of any means used
Aesthetics	☐	☐	☐	☐	☐	☐	....	☐
Technical innovation	☐	☐	☐	☐	☐	☐	....	☐
Brand	☐	☐	☐	☐	☐	☐	....	☐
Personal preference	☐	☐	☐	☐	☐	☐	....	☐
Expertise required & ease of installation	☐	☐	☐	☐	☐	☐	....	☐
Expertise required & ease of use	☐	☐	☐	☐	☐	☐	....	☐
Maintainability of product in use	☐	☐	☐	☐	☐	☐	....	☐
Maintainability of equipment used to install product	☐	☐	☐	☐	☐	☐	....	☐
Servicing & warranty	☐	☐	☐	☐	☐	☐	....	☐
Reliability	☐	☐	☐	☐	☐	☐	....	☐
Cost of product	☐	☐	☐	☐	☐	☐	....	☐
Cost of installation	☐	☐	☐	☐	☐	☐	....	☐
Life Costs	☐	☐	☐	☐	☐	☐	....	☐
Physical Quality	☐	☐	☐	☐	☐	☐	....	☐
Technical performance	☐	☐	☐	☐	☐	☐	....	☐
Ergonomics	☐	☐	☐	☐	☐	☐	....	☐
Product health & safety	☐	☐	☐	☐	☐	☐	....	☐
Mass custom	☐	☐	☐	☐	☐	☐	....	☐
Spec. custom.	☐	☐	☐	☐	☐	☐	....	☐
Lower risk	☐	☐	☐	☐	☐	☐	....	☐
Effectiveness	☐	☐	☐	☐	☐	☐	....	☐

REF ....

Please would you answer the questions in the following section about yourself.

X1. Which one of the following categories best describes your job function?

R&D ☐
Project design ☐
Marketing ☐
Sales ☐
Manufacturing ☐
Other: Please specify .... ☐

X1.2. **Job Title** ....

X2. Which one of the following categories best describes your level of involvement with customers ?

I have never spoken to customers ☐
I have spoken to customers in the past, but not on recent projects ☐
I occasionally converse with customers, out of interest ☐
I occasionally converse with customers, on specific issues ☐
I regularly converse with customers on general issues ☐
I regularly converse with customers, specifically to solve problems ☐
A major part of my job is to converse with customers ☐

X3. Which one of the following categories best describes your level of management ?

No management responsibilities ☐
Some functional/ product management responsibilities ☐
Functional manager ☐
Product manager ☐
Senior manager ☐
Director ☐
Other: Please specify .... ☐

X4. How many years have you been working for this company?

☐ years

Please answer the questions in the following section, to give a background to the company.

Y1. How many employees are there in your company & division the product was developed in?

	COMPANY	DIVISION
Less than 100		
100-250		
251-500		
501-1000		
More than 1000		

Y2. What was the turnover for your company & division for these years?

	COMPANY		DIVISION	
	94/95	95/96	94/95	95/96
Less than £1m				
£1m - £1.9m				
£2m - £4.9m				
£5m - £9.9m				
£10m - £19.9m				
£20m - £49.9m				
£50m - £74.9m				
£75m - £100m				
£100m - £299.9m				
More than £300m				

Y3. What was the profit (before interest & tax) for your company & division for these years?

	COMPANY		DIVISION	
	94/95	95/96	94/95	95/96
Less than £1m				
£1m - £1.9m				
£2m - £4.9m				
£5m - £9.9m				
£10m - £19.9m				
£20m - £49.9m				
£50m - £74.9m				
£75m - £100m				
£100m - £299.9m				
More than £300m				

Y3. What percentage of the TURNOVER was spent on Research & Development?

	94/95	95/96
Less than 1%		
1 - 2%		
2 - 3%		
4 - 5%		
6 - 7%		
8 - 9%		
More than 10%		

Appendix G
Item definition for the questionnaire.

Two tables are presented in appendix G. Table G.1 provides a list of items required, as derived from the considering the information required (developed in table 5.1 in Chapter 5, section 5.4.1). The second table is linked to first using the reference numbers. In table G.2, measurement items, response formats and selected references are displayed.

The table G.2 is linked to table G.1. Table G.2 explains items used in the questionnaire and provides references and sources of discussion found in the main body of the Thesis.

Table G.1 Items required for the questionnaire

Information	Items required	Link to Table G.2
Importance of product attributes to customers.		
Name all customer types	Customer types	1
Rank order the importance of each customer	-	
Assign importance level to product attributes	Product attributes	2
	Importance scale	3
Current competitive standing of products.		
Assign competitive standing to product attributes	Product attributes	2a
	Competitive superiority scale	4
Group characteristics.		
Name respondent's functional group	Functional groups	5
Respondent's job title	-	
Relatively how much customer involvement	Customer involvement groups	6
Name respondent's management level group	Management level groups	7
Specify number of years at company	-	
Who collects product attributes information.		
Select any of the functions that collects each of the product attribute	Functional groups	5
	Product attributes	2
Who collects customer information and when.		
Select any of the functions that collect customer needs information during each of the NPD activities	Functional groups	5
	NPD activities	8

Continued….

.... Table G.1 continued from previous page.

Information	Items required	Link to Table G.2
When product attribute information is collected.		
Select all of the times during the NPD process phases when each of the product attributes is collected	NPD process phases	8a
	product attributes	2
How information on product attributes is collected.		
Select any of the customer needs information collection methods for each of the product attributes	Collection methods	9
	Product attributes	2
How information on product attributes is transferred/ communicated.		
Select any of the customer needs information transfer methods for each of the product attributes	Transfer methods	10
	Product attributes	2
Select any of the customer needs information communication methods for each product attribute	Communication methods	10a
	Product attributes	2
Who uses product attribute information.		
Select any of the functions that uses each of the product attribute	Functional groups	5
	Product attributes	2
Who uses customer information and when.		
Select any of the functions that uses customer needs information during each of the NPD activities	Functional groups	5
	NPD activities	8
When product attribute information is used.		
Select all of the times during the NPD process phases when each of the product attributes is used	NPD process phases	8a
	Product attributes	2

Continued....

... Table G.1 continued from previous page.

Information	Items required	Link to Table G.2
Product characteristics.		
Name specific product to be described in the questionnaire	-	
Relatively how long product has been produced	Length of time for product groups	11
Assign market types for product	Market types	12
Company characteristics.		
Assign market types for company	Market types	12
Assign market drivers for company	Market drivers	13
Relatively how many employees	Number of employees groups	14
Relatively how much turnover	Turnover groups	15
Relatively how much profit	Profit groups	16
NPD characteristics.		
Relatively how much for R&D	R&D budget groups	17
Assign importance level to sources of new product ideas	Sources of new product ideas	18
	Importance scale	3
Select whether NPD activities take place at the company	NPD activities	8

Table G.2 Item definition for questionnaire

Link to Table G.1	Items required	Scale items used
1	Customer types	Respondent was prompted to fill in own customers appropriate to the type of product (e.g. "financial controllers", "head of production", "driver" etc.). Realising from the literature review in section 2.2.1, that it was difficult to identify a set of exhaustive customer types, it was decided not to force the respondent into one way of thinking. Therefore prompts were simply "end user", "buyer", "installer" and "retailer". The researcher later categorised the customers into types before data analysis. (Webster and Wind, 1972; Jobber, 1998; Wilson *et al.,* 1996; Owen and Hills, 1996). See Chapter 2, section 2.2.1.2 and Chapter 3 section 3.5.1.
2	Product attributes	See Appendix C and Chapter 5.
2a	Product attributes	These 20 items are the same as for **2**, above, with the exception of "personal preference". This scale item was not included because it is not realistic to give an opinion on the competitive superiority of "personal preference" for competing products.
3	Importance scale	Response in the form of a 5 point interval scale. See Chapter 5, section 5.4.5.2. Noted from Churchill, 1995 and Clipson, 1990.
4	Competitive superiority scale	Response in the form of a 5 point interval scale. See Chapter 5, section 5.4.5.2. Noted from Churchill, 1995 and Clipson, 1990.
5	Functional groups	5 nominal groups on the questionnaire. But "other" allowed for retrospective grouping to include 3 others. Griffin and Page, 1993; Pugh and Morely, 1988.
6	Customer involvement groups	7 nominal groups as determined by exploratory and pre-test.
7	Management level groups	6 nominal groups on the questionnaire. Original groups suggested Pugh and Morely, 1988 were expanded to include "mixed" managers

8	NPD activities	14 activities. Used by Cooper and Kleinschmidt (1986) in their research into NPD activities.
8a	NPD process phases	The 14 activities, as used by the researchers above, were split into 4 phases (Cooper and Kleinschmidt, 1986).
9	Collection methods	5 most applicable methods, as found from exploratory and Araujo *et al.*, 1995 and others
10	Transfer methods	6 most applicable methods, as found from exploratory and Araujo *et al.*, 1995 and others (QFD not asked, as had already established that this method was not used).
10a	Communication methods	5 most applicable methods, as found from exploratory and Araujo *et al.*, 1995 and others
11	Length of time for product groups	7 point ordinal scale used, as respondents not expected to know the exact number of years. Question suggested by Story, 1999.
12	Market types	3 point interval scale (technology – market driven). Suggested by Holt *et al.*, 1984; Jobber 1998; Ulrich and Eppinger 1995; Story, 1999.
13	Market drivers	3 point interval scale (technology – market driven). Suggested by Holt *et al.*, 1984; Jobber 1998; Ulrich and Eppinger 1995; Story, 1999.
14	Number of employees groups	Background information, only asked of appropriate personnel. Question suggested by Story, 1999.
15	Turnover groups	Background information, only asked of appropriate personnel. Question suggested by Story, 1999.
16	Profit groups	Background information, only asked of appropriate personnel. Question suggested by Story, 1999.
17	R&D budget groups	Background information, only asked of appropriate personnel. Question suggested by Story, 1999.
18	Sources of new product ideas	11 possible sources of idea. Expanded after pre-test interview. Question suggested by Story, 1999.

Appendix H
Scale development for final questionnaire

This appendix presents individual tables that show how the final questionnaire design and scales were defined by the information required by the research questions. The types of scales used, the number of variables and the corresponding question numbers in the final questionnaire are all included in the tables.

Importance of product attributes to customers.			
Question content: This set of questions try to find out what the respondent thinks are important product attributes to customers. The question must first ask who are the customers anyway? And how important are they to the company? The first question needs to be open-ended (but prompted) as no information is available on customers before the interviews. Each respondent then needs to evaluate each product attribute for each customer.			
Information	Scales used	Variables	Question
Name all customer types	Nominal (open-ended)	Open-ended	C1
Rank order the importance of each customer	Ordinal (rank answers to above question)	Open-ended	C2
Assign importance level to 21 product attributes	Interval (5 point scale, definitely not important to definitely important – plus *N/A*)	21	One of C3 for each customer

Current competitive standing of products.			
Question content: Because product quality is relative, a comparison of products against one another is wanted. An opinion is required on how well a specific product compares with the market as a whole.			
Information	Scales used	Variables	Question
Assign competitive standing to 20 product attributes	Interval (5 point scale, definitely inferior to definitely superior – plus *Don't know* and *N/A*)	20	B5

Group characteristics.			
Question content: It is important to find out what kinds of groupings there may be within the company, as these may be found to influence the responses during data analysis. Function, level of management, involvement with customers and number of years at the company are applicable to this research.			
Information	Scales used	Variables	Question
Name respondent's functional group	Nominal (6 functional categories - including *Other*)	1	X1
Respondent's job title	Nominal (open-ended)	1	X1
Relatively how much customer involvement	Ordinal (7 involvement categories)	1	X2
Name respondent's management level group	Nominal (7 management levels – including *Other*)	1	X3
Specify number of years at company	Ratio (value in years)	1	X4

Who collects product attributes information.			
Question content: An opinion is required from each respondent as to what groups collect customer needs information for each of the product attributes. It is only possible to know about functions as groups, because respondents will not be aware of how many years other people have been at the company, or their involvement with customers etc.			
Information	Scales used	Variables	Question
Select any of the 8 functions that collects each of the 21 product attribute	Dichotomous (check/ no check)	189 (includes *N/A*)	E2

Who collects customer information and when.			
Question content: An opinion is required from each respondent on what groups (functional only) collect information during the different stages of the NPD process.			
Information	Scales used	Variables	Question
Select any of the 8 functions that collect customer needs information during each of the 14 NPD activities	Dichotomous (check/ no check)	126 (includes *N/A*)	E1

When product attribute information is collected.			
Question content: To complement the two queries above, an opinion is required on what types of product attribute information is collected during the different stages of the NPD process.			
Information	Scales used	Variables	Question
Select all of the times during the 4 NPD process phases when each of the 21product attributes is collected	Dichotomous (check/ no check)	126 (includes *Never captured* and *Don't know*)	E3

How information on product attributes is collected.			
Question content: This question gains an overview of the different tools that the respondent knows are used to collect customer needs information. The respondent should be allowed to state that they "don't know" about particular tools.			
Information	Scales used	Variables	Question
Select any of the 5 customer needs information collection methods for each of the 21 product attributes	Dichotomous (check/ no check) (Open-ended nominal for *Other*)	189 (includes *None at all*, *Other* and *don't know*)	G1

How information on product attributes is transferred/ communicated.			
Question content: This question gains an overview of the different tools and communications methods that the respondent knows are used to transfer customer needs information. The respondent should be allowed to state that they "don't know" about particular tools or methods.			
Information	Scales used	Variables	Question
Select any of the 6 customer needs information transfer methods for each of the 21 product attributes	Dichotomous (check/ no check)	189 (includes *Never captured*, *Other* and *Don't know*)	G2
Select any of the 5 customer needs information communication methods for each product attribute	Dichotomous (check/ no check)	189 (includes *None at all*, *Other* and *Don't know*)	H1

Who uses product attribute information.			
Question content: The respondent should offer an opinion on what groups use customer needs information for each of the product attributes.			
Information	Scales used	Variables	Question
Select any of the 8 functions that uses each of the 21 product attribute	Dichotomous (check/ no check)	189 (includes *N/A*)	F2

Who uses customer information and when.			
Question content: An opinion is required from each respondent on what groups (functional only) use information during the different stages of the NPD process.			
Information	Scales used	Variables	Question
Select any of the 8 functions that uses customer needs information during each of the 14 NPD activities	Dichotomous (check/ no check)	126 (includes *N/A*)	F1

When product attribute information is used.			
Question content: Further to the two queries above, an opinion is required on what types of product attribute information is used during the different stages of the NPD process.			
Information	Scales used	Variables	Question
Select all of the times during the 4 NPD process phases when each of the 21product attributes is used	Dichotomous (check/ no check)	126 (includes *Never captured* and *Don't know*)	F3

Product characteristics.			
Question content: To gain background for the study, the respondent should be asked about the particular product which they are offering opinions on (what it is, how long the company has been producing it and the market its aimed at).			
Information	Scales used	Variables	Question
Name specific product to be described in the questionnaire	Nominal (open-ended)	1	B1
Relatively how long product has been produced	Ordinal (6 year group categories)	1	B2
Assign market types for product	Ordinal (3 point scale, mass market to niche market)	1	B3

Company characteristics.			
Question content: Opinions on the company position and simple company qualifiers should be collected. Only suitable respondents will be asked for some information, as they are facts known by higher management only.			
Information	Scales used	Variables	Question
Assign market drivers for company	Ordinal (3 point scale, market driven to technologically driven)	1	A1
Assign market types for company	Ordinal (3 point scale, mass market to niche market)	1	A2
Relatively how many employees	Ordinal (5 employee group categories)	2	Y1
Relatively how much turnover	Ordinal (9 turnover group categories)	4	Y2
Relatively how much profit	Ordinal (9 profit group categories)	4	Y3

NPD characteristics.			
Question content: Sources of new product ideas, NPD activities undertaken by the company and R&D budget are enough information to gain a general idea of NPD.			
Information	Scales used	Variables	Question
Relatively how much for R&D	Ordinal (7 R&D budget group categories)	2	Y4
Assign importance level to 11 sources of new product ideas (including "other source" option).	Interval (5 point scale, definitely not important to definitely important – plus *Don't know*)	11	A3
Select whether 14 NPD activities take place at the company	Multichotomous (yes/ no/ don't know)	14	D1

Appendix I
Producing A_i – the affecting of using customer weightings K_M

This appendix discusses the differences that may have occurred in the results, if no customer weighting (K_M) had been used throughout this research.

Figures I.1, I.2 and I.3, show the difference that using a weighting on customers makes to the overall importance of attributes. Z_i is the total for each product attribute's importance, before any weighting (K_M) was added. However, A_i was used in all calculations for this research. It is taken to be the importance of each attribute, because it does take into account the importance given to each customer (K_M).

There are no major implications from applying customer weightings. A_i is not very different to Z_i in absolute or relative terms. One of the reasons for this is that the customer needs were collected on a 5 point importance scale. As many of the respondents believed most of the attributes would be at least of "average importance", they had only two scale points to choose from, which turned out not to be enough to provide discrimination for the respondent. As a consequence, marginal differences between customer needs were not collected. However, there are some differences in absolute terms and in the order of the importance of attributes (e.g. "Health and safety" is 7th for Z_i, but is 4th using A_i). These differences reflect reality – that health and safety is probably more likely to be viewed around 4th by the design team, because their most important customer has a high regard for health and safety.

Zi for Company A	
72	Effectiveness
65	Reliability
51	Install Expertise
50	Technical Performance
50	Risk
49	Technical Innovation
46	Health & Safety
42	Life Costs
42	Ergonomics
41	Personal Preference
39	Aesthetics
39	Product Cost
38	Install Maintenance
37	Install Cost
34	Use Expertise
32	Physical Quality
29	Mass Customisation
28	Brand
12	Specific Customisation
N/A	Use Maintenance
N/A	Service & Warranty

Ai for Company A	
74	Effectiveness
66	Reliability
55	Install Expertise
51	Health & Safety
50	Technical Performance
49	Risk
49	Technical Innovation
47	Personal Preference
43	Ergonomics
41	Life Costs
38	Product Cost
36	Aesthetics
36	Install Maintenance
35	Install Cost
35	Physical Quality
34	Use Expertise
29	Mass Customisation
24	Brand
11	Specific Customisation
0	Use Maintenance
0	Service & Warranty

Figure I.1 The influence of customer weighting (Km) as shown by Zi and Ai for Company A.

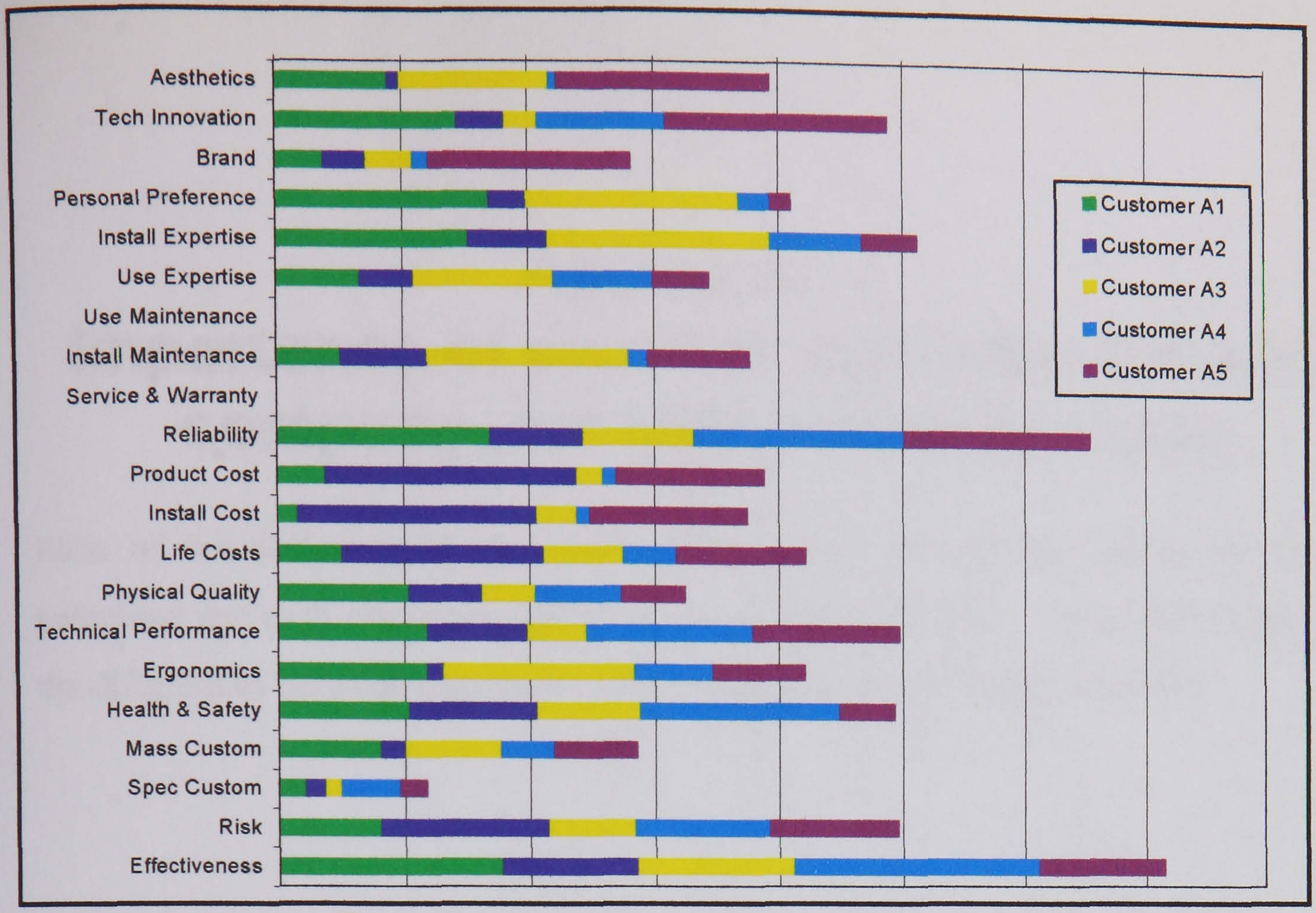

Figure I.2 Z_i: Importance of product attributes for Company A, *without* customer weightings applied.

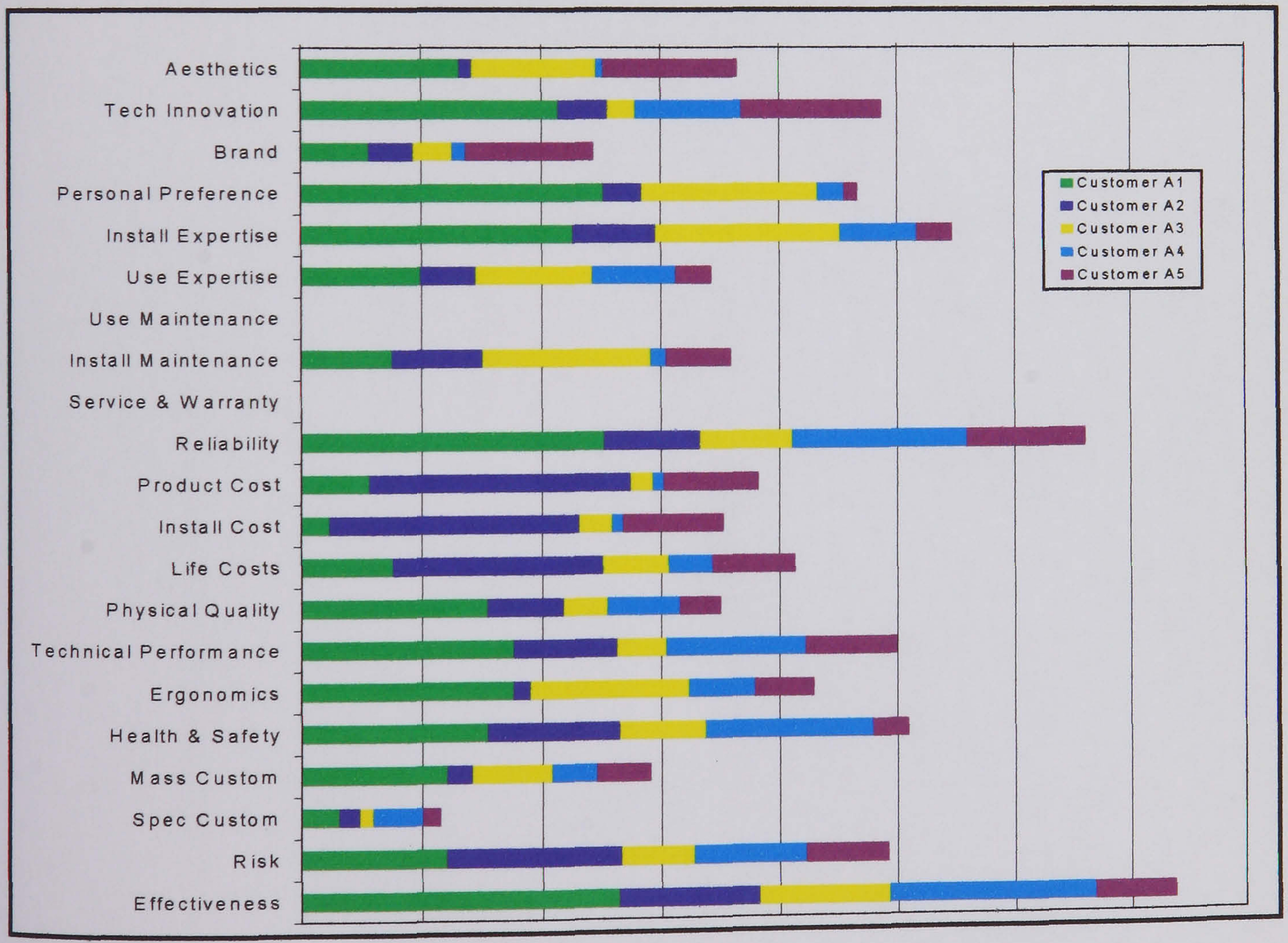

Figure I.3 A_i: Importance of product attributes for Company A, *with* customer weightings (K_M) applied.

Appendix J
Importance of product attributes for each company, for each customer type.

Each of the following 4 bar charts presents the unweighted results for the Z_{iM} perceived for each customer against each product attribute. These bar charts show the differences between customer types and their customer needs priorities

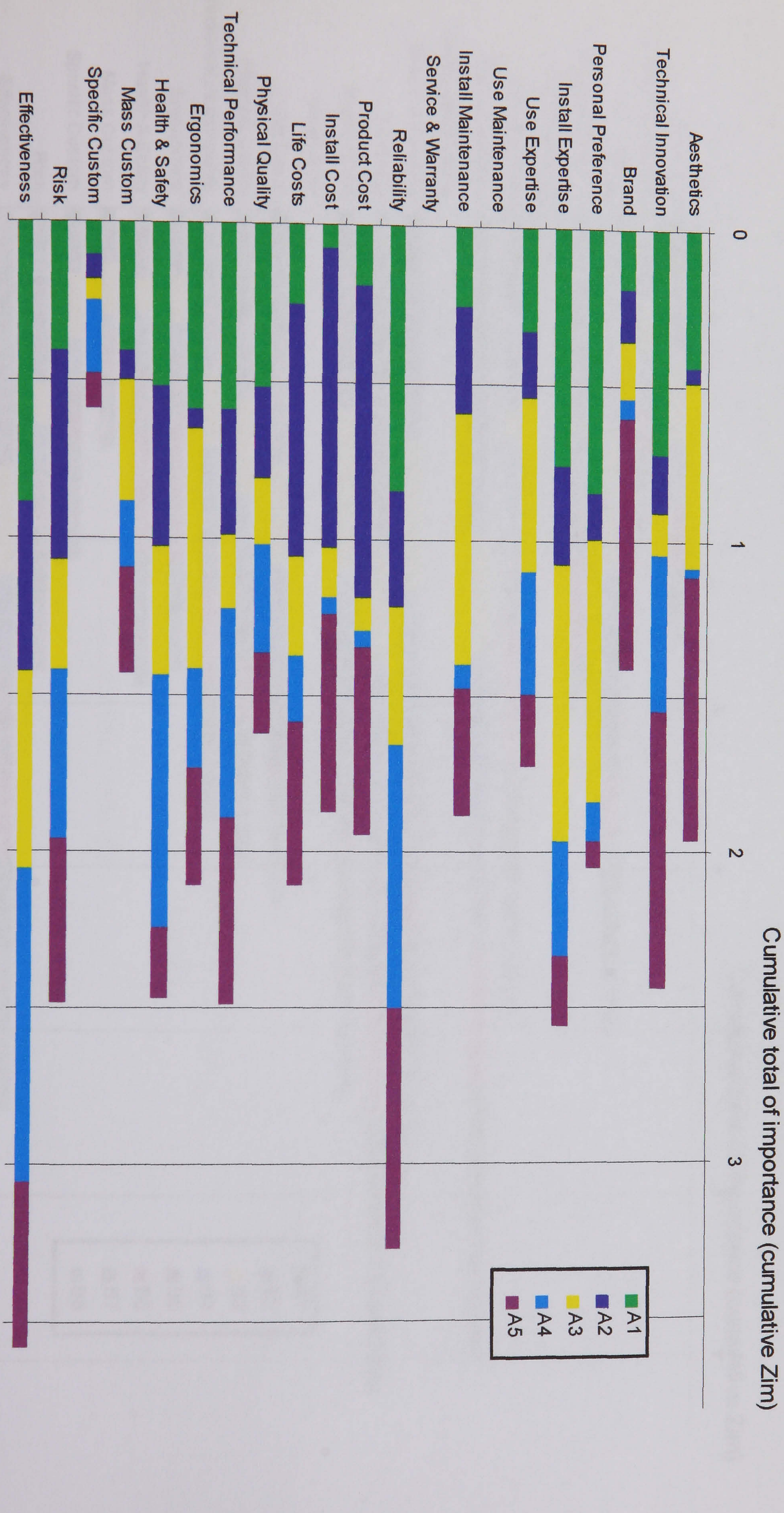

Figure J.1 Company A: Importance of each product attribute to different customer types (Z_{iM})

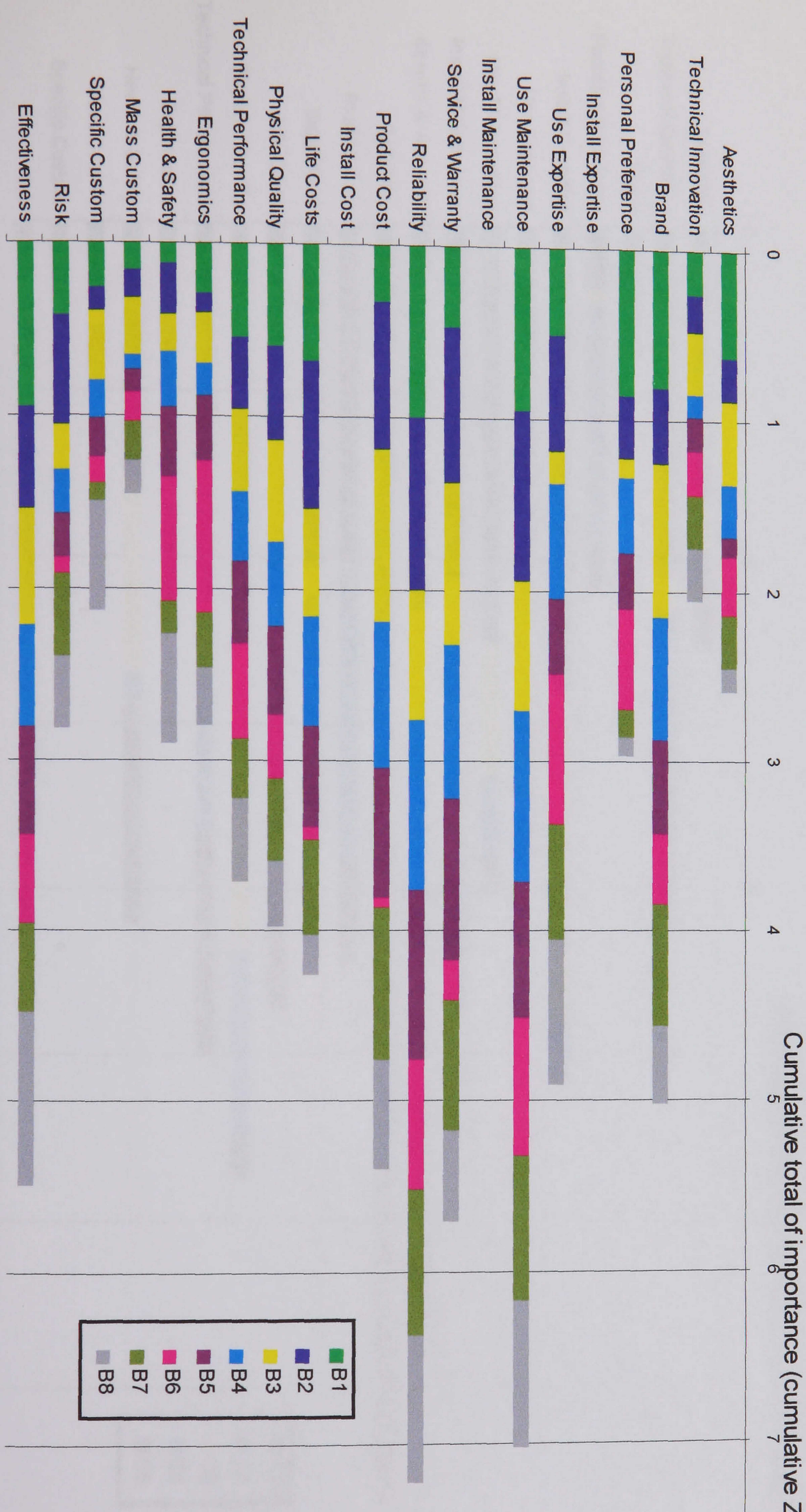

Figure J.2 Company B: Importance of each product attribute to different customer types (Z_{iM})

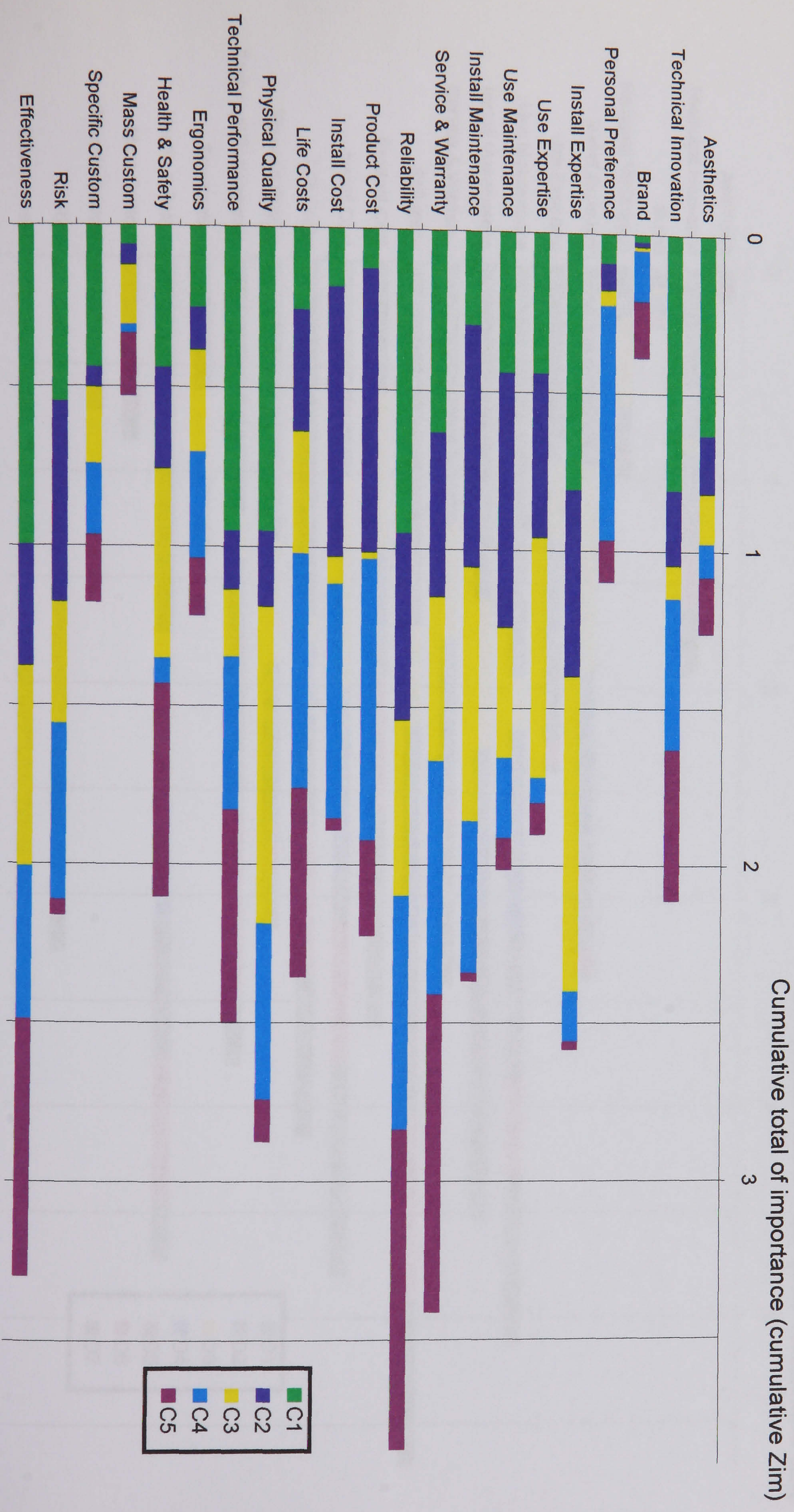

Figure J.3 Company C: Importance of each product attribute to different customer types (Z_{iM})

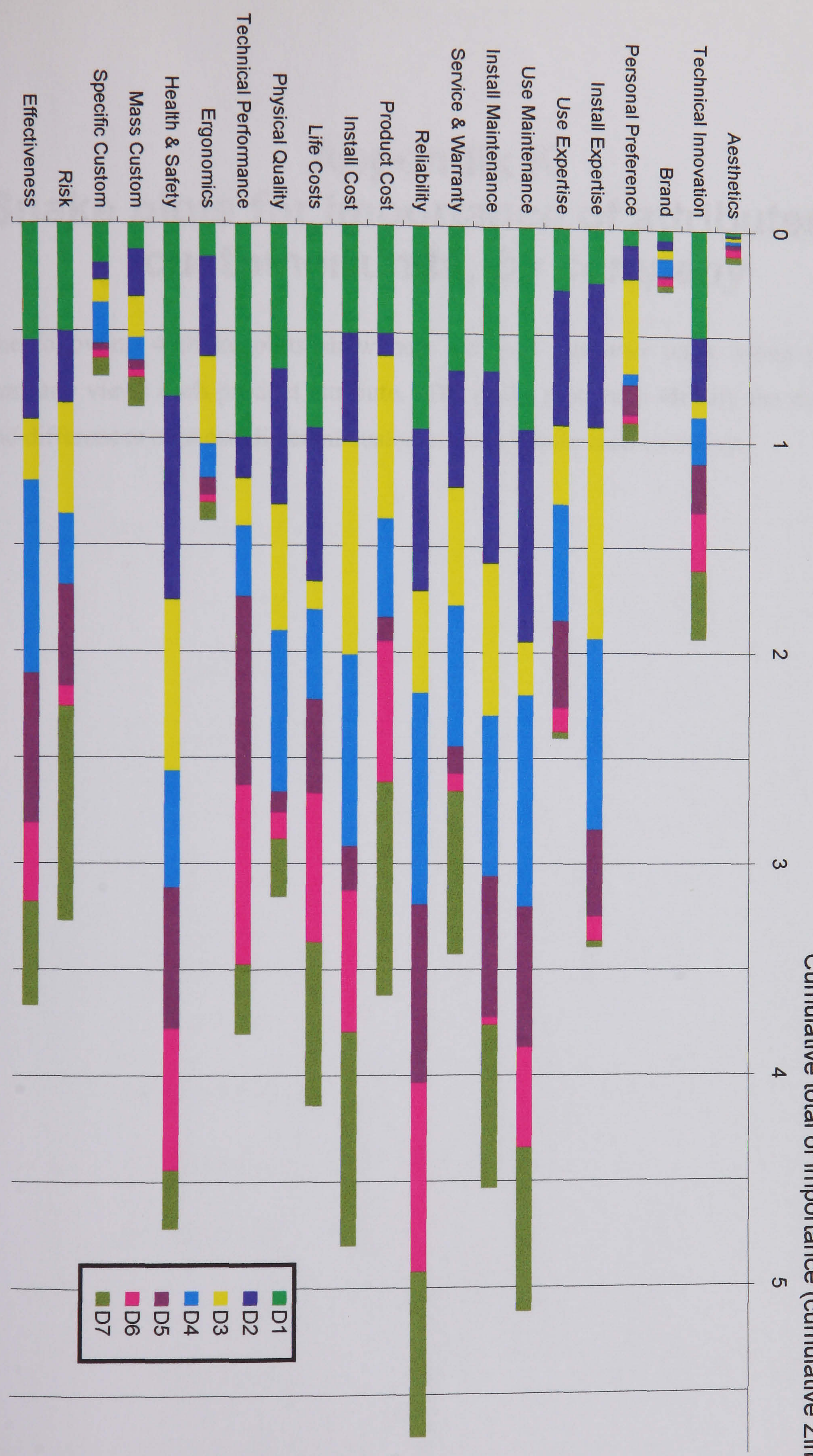

Figure J.4 Company D: Importance of each product attribute to different customer types (Z_{iM})

Appendix K
Snake plots for importance of attributes for customer units, *by company*

The following 4 snake plots show how different customer units within the same company views each product attribute. The snake plots help identify the similarities and differences between different customer units within each company.

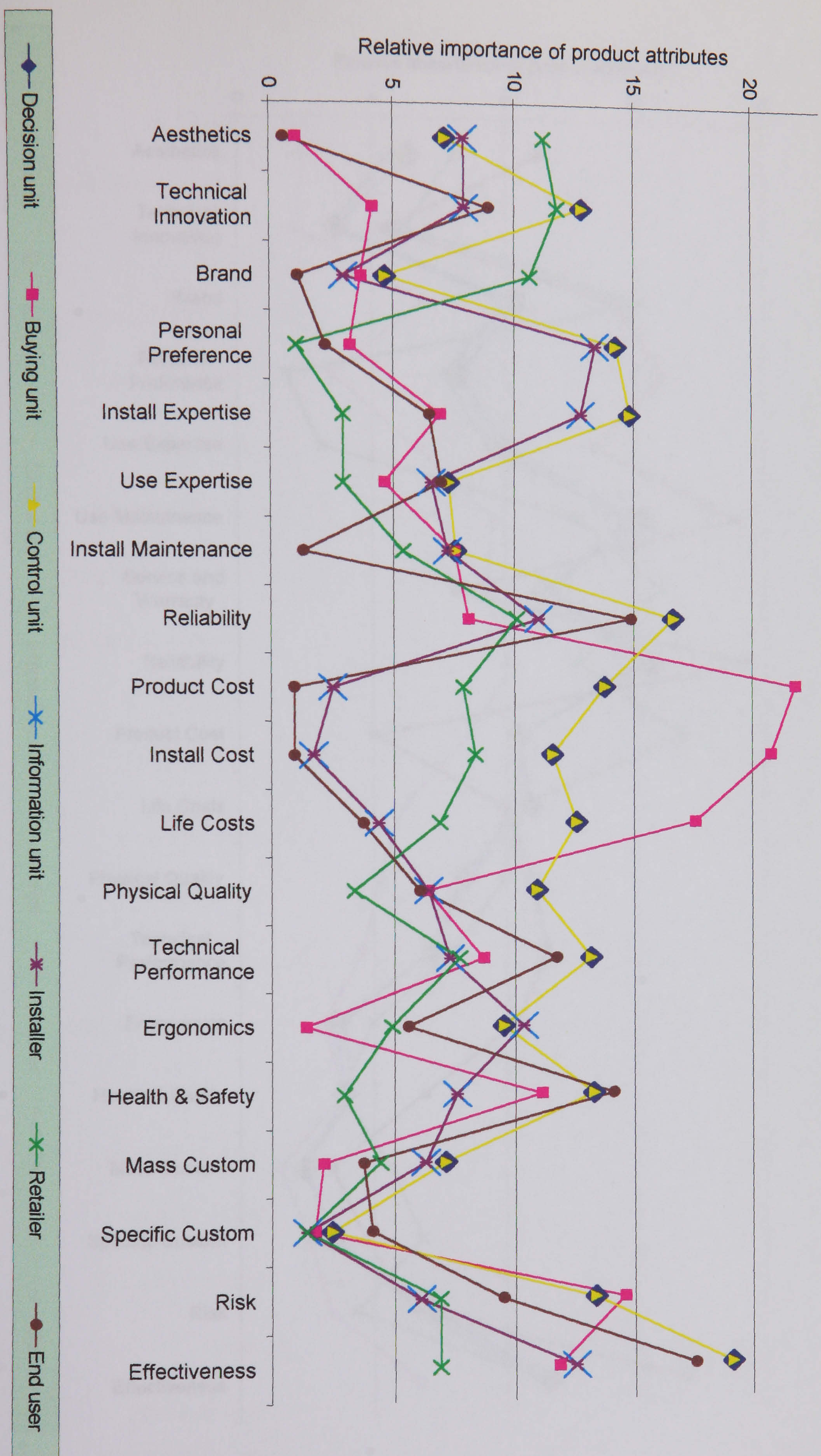

Figure K.1 Company A: Snake plot of the importance of attributes to customer units

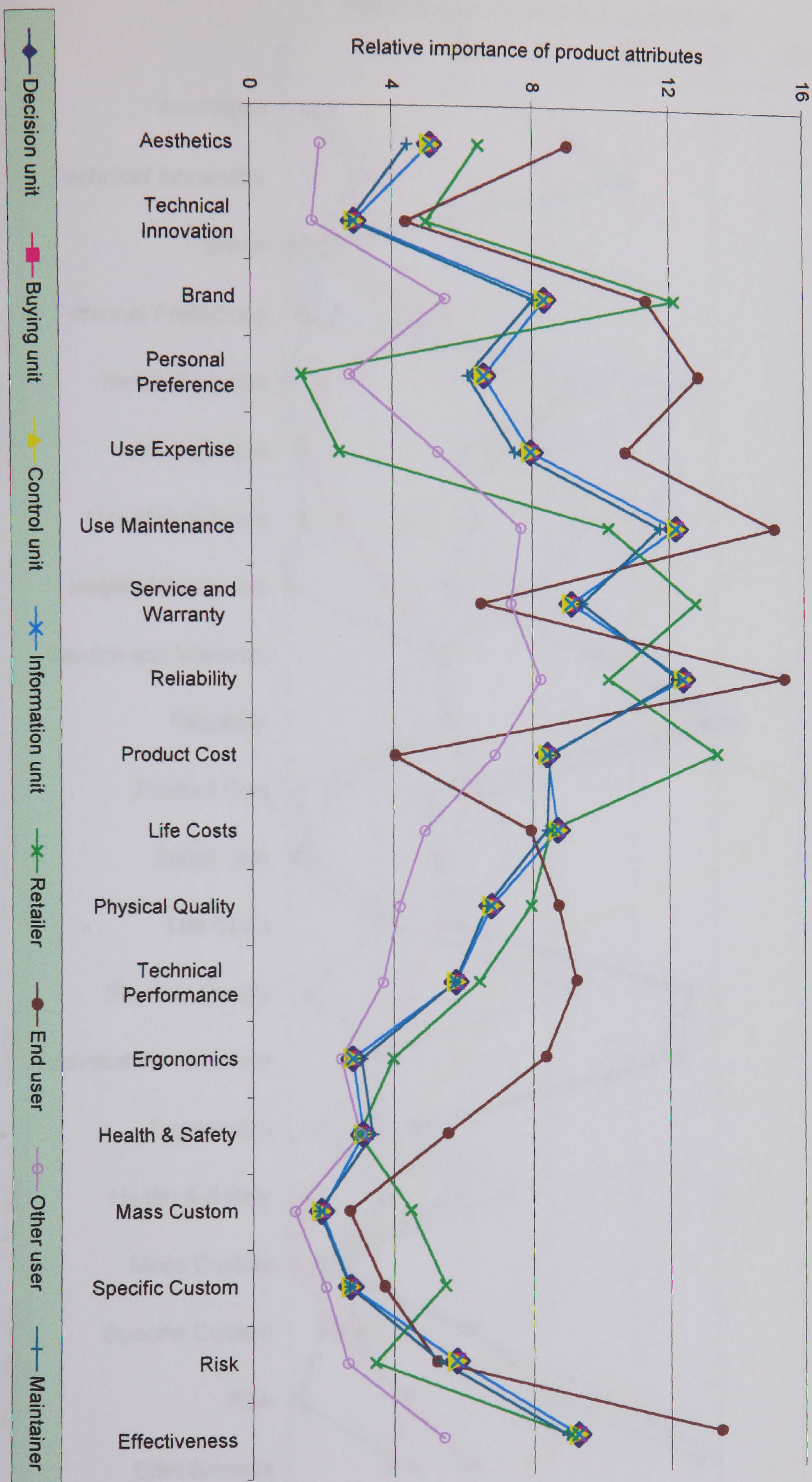

Figure K.2 Company B: Snake plot of the importance of attributes to customer units

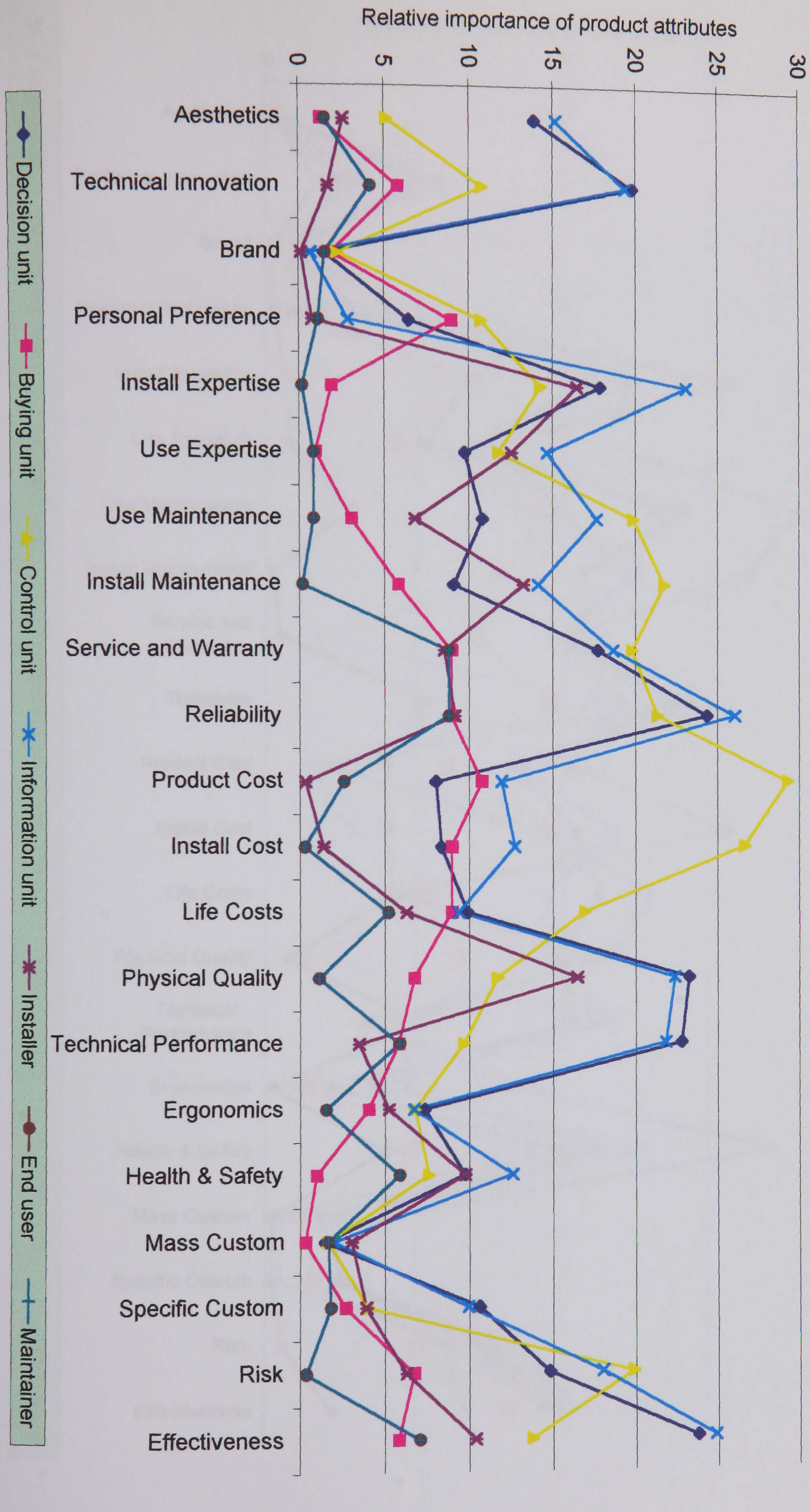

Figure K.3 Company C: Snake plot of the importance of attributes to customer units

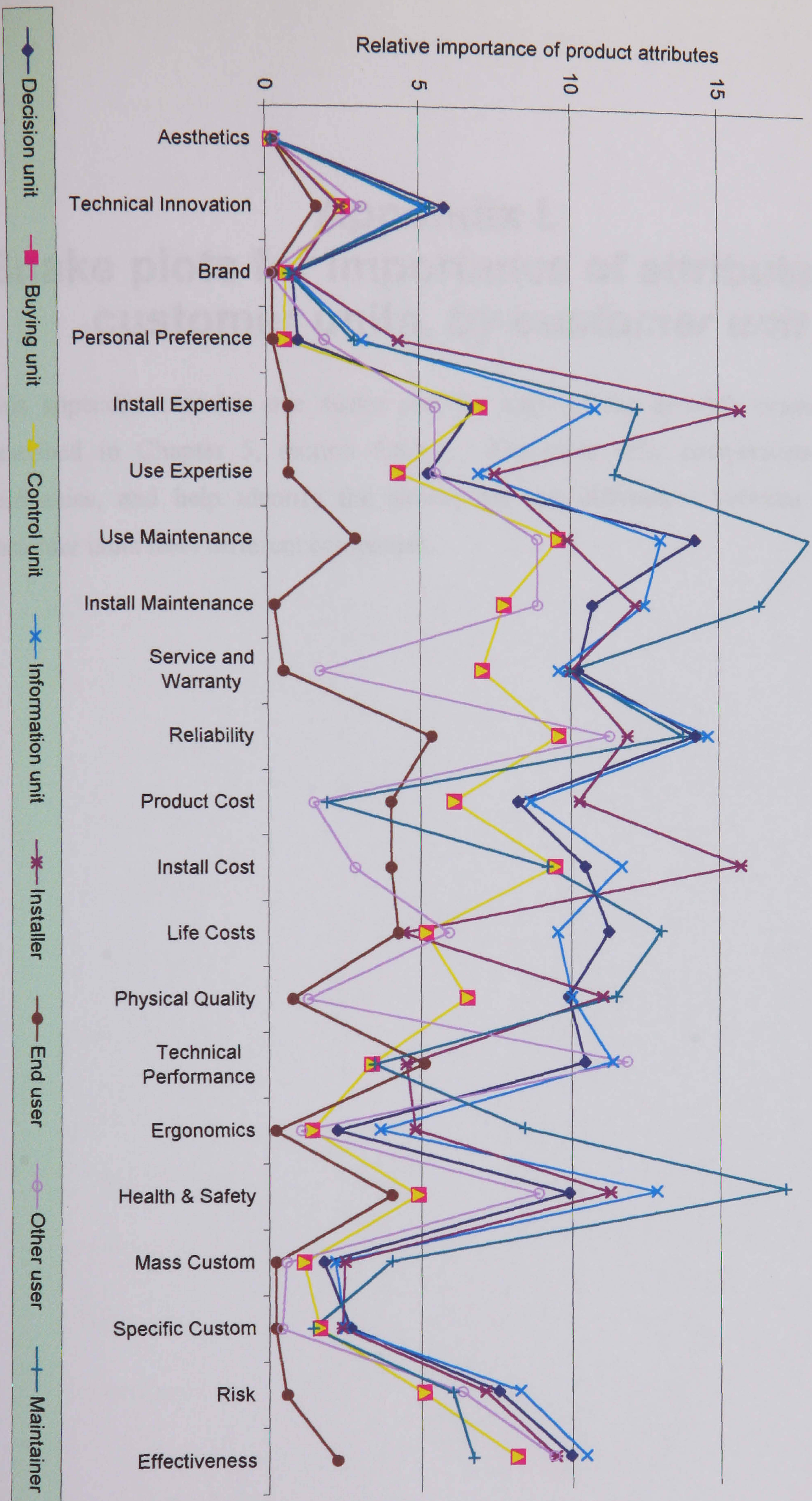

Figure K.4 Company D: Snake plot of the importance of attributes to customer units

Appendix L
Snake plots for importance of attributes for customer units, *by customer unit*

This appendix contains one snake plot for each of the possible customer units described in Chapter 5, section 5.6.3.1. The plots offer comparisons between companies, and help identify the similarities and differences between the same customer units from different companies.

Figure L.1 Decision unit trends for importance of product attributes (Z_{iM})

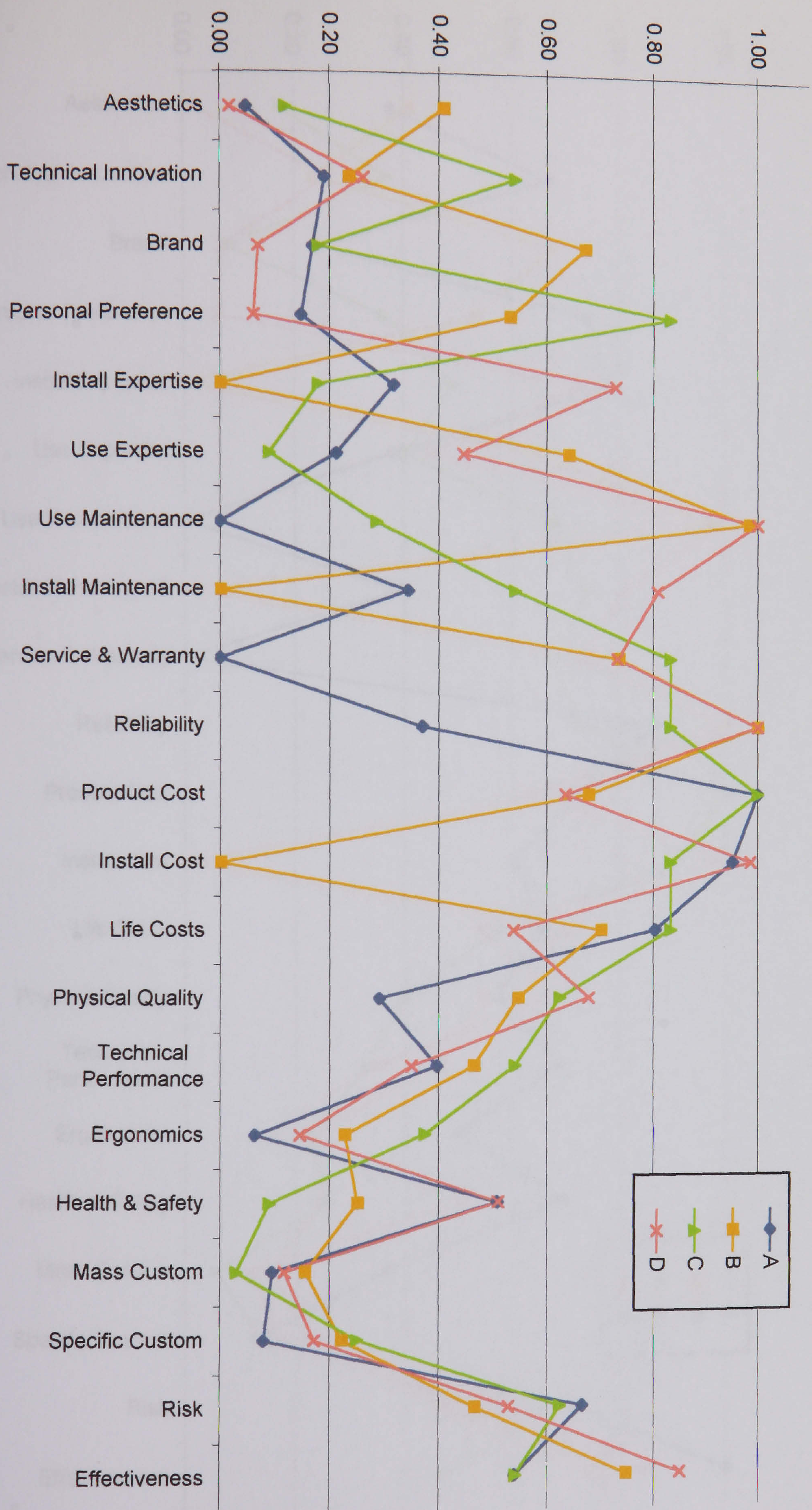

Figure L.2 Buying unit trends for importance of product attributes (Z_{iM})

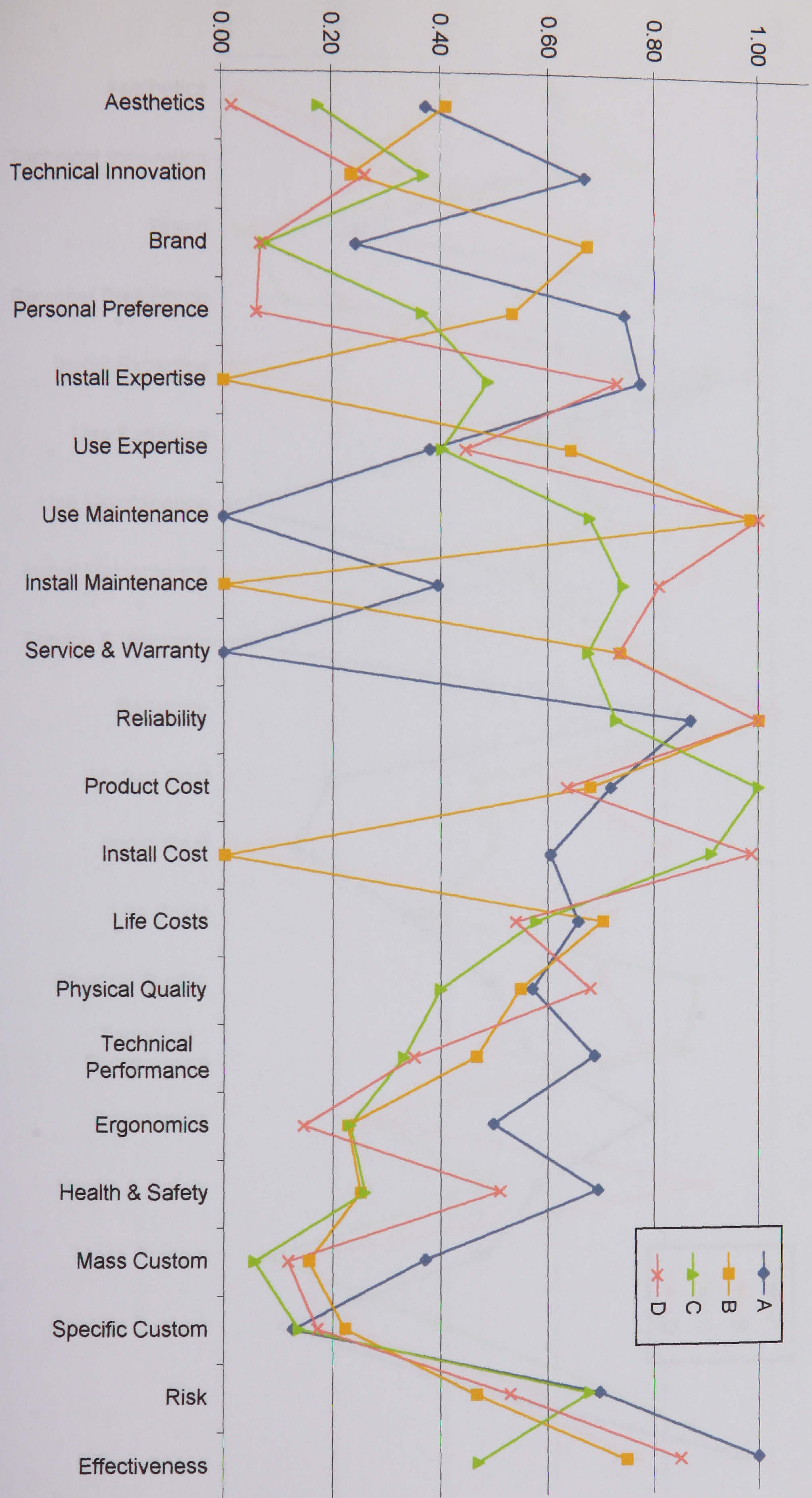

Figure L.3 Control unit trends for importance of product attributes (Z_{iM})

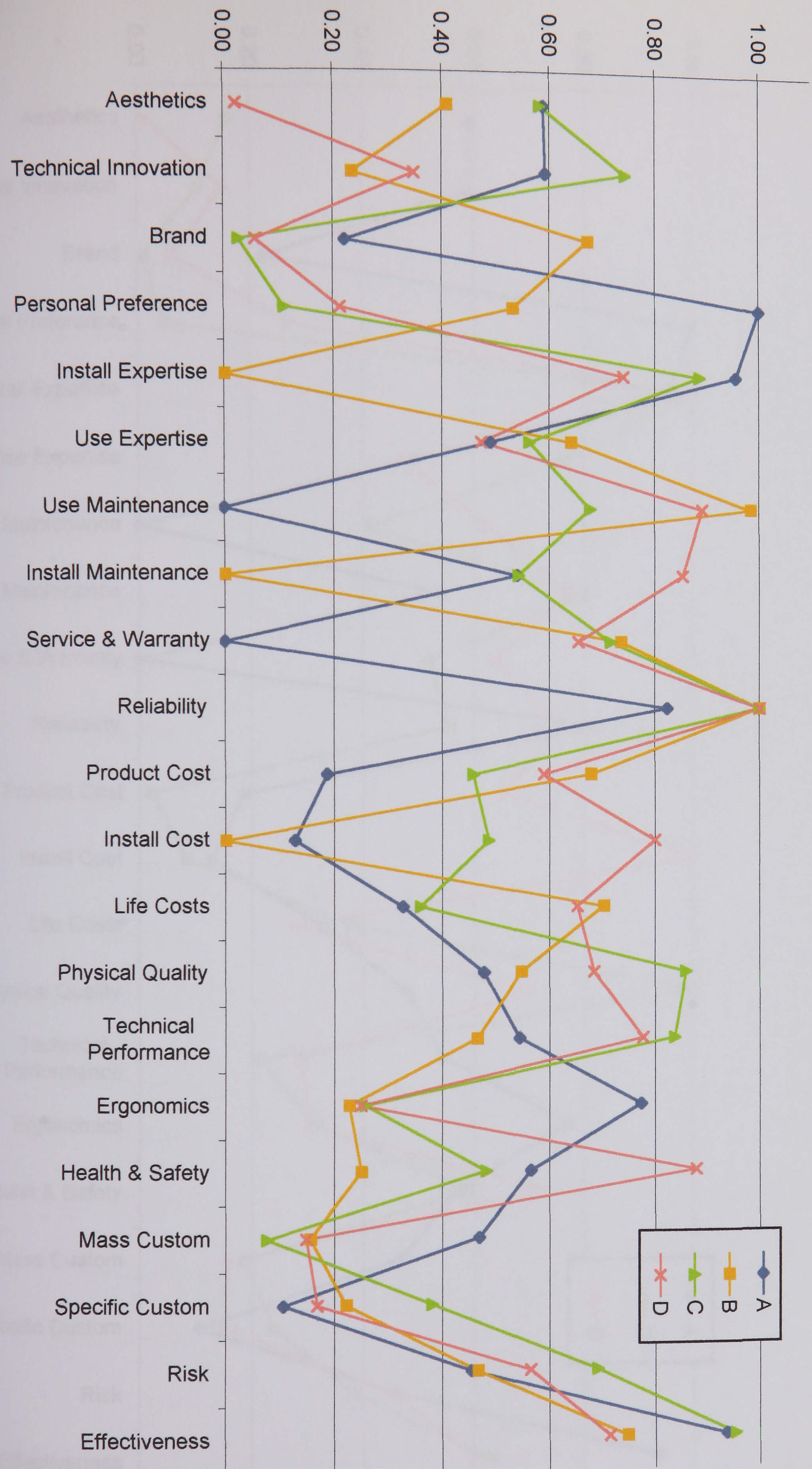

Figure L.4 Information unit trends for importance of product attributes (Z_{iM})

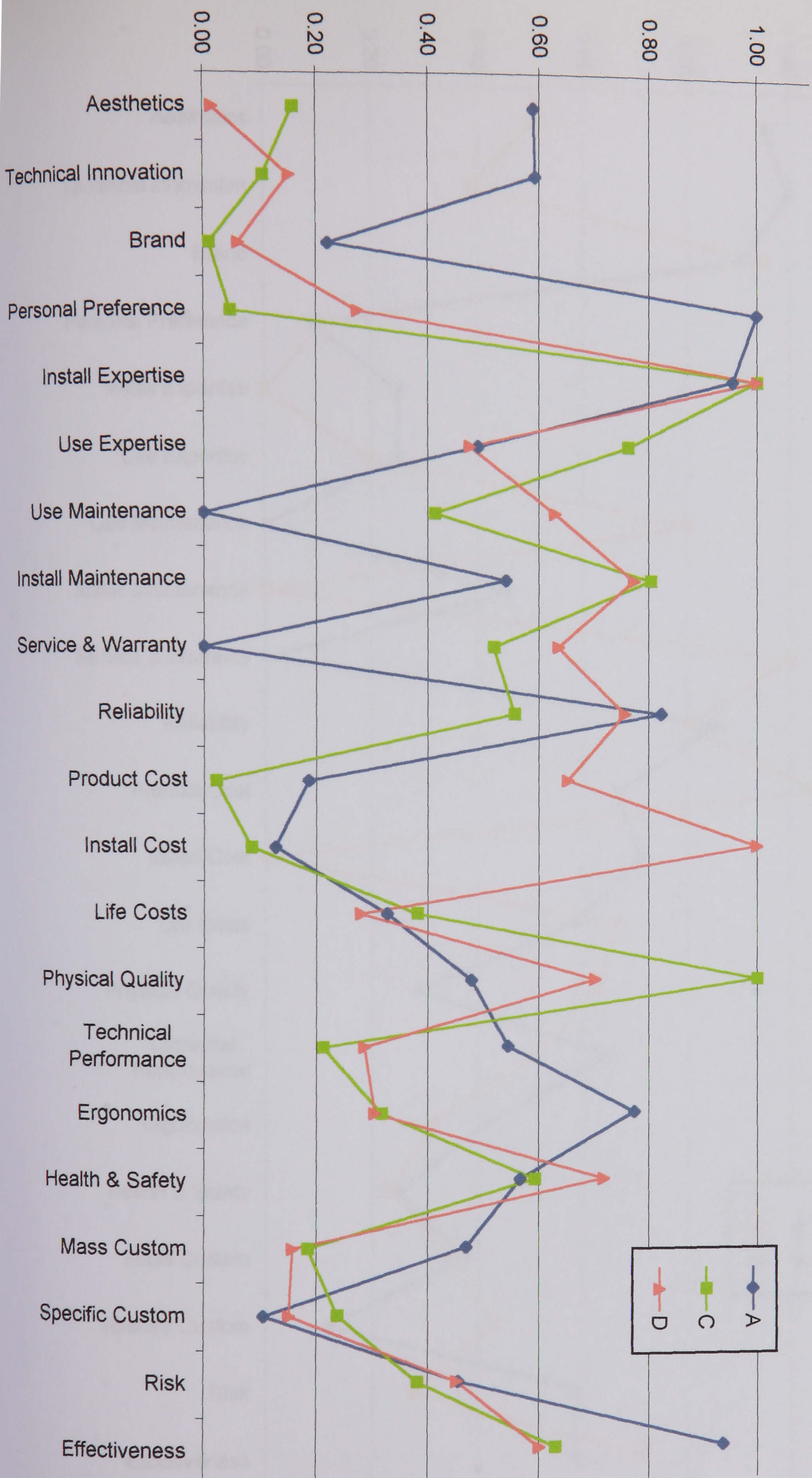

Figure L.5 Installer unit trends for importance of product attributes (Z_{iM})

Figure L.6 Retailer trends for importance of product attributes (Z_{iM})

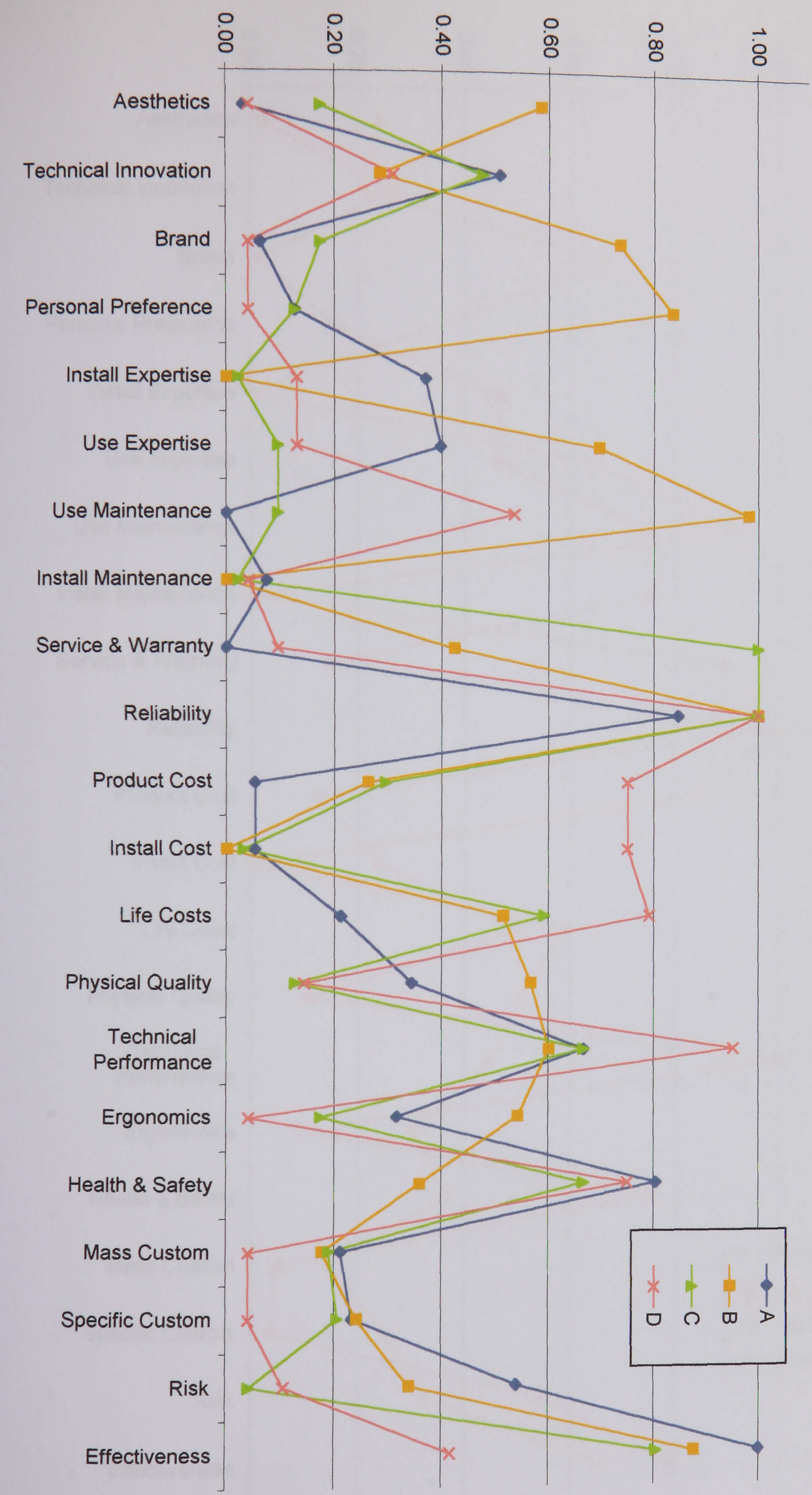

Figure L.7 End user trends for importance of product attributes (Z_{iM})

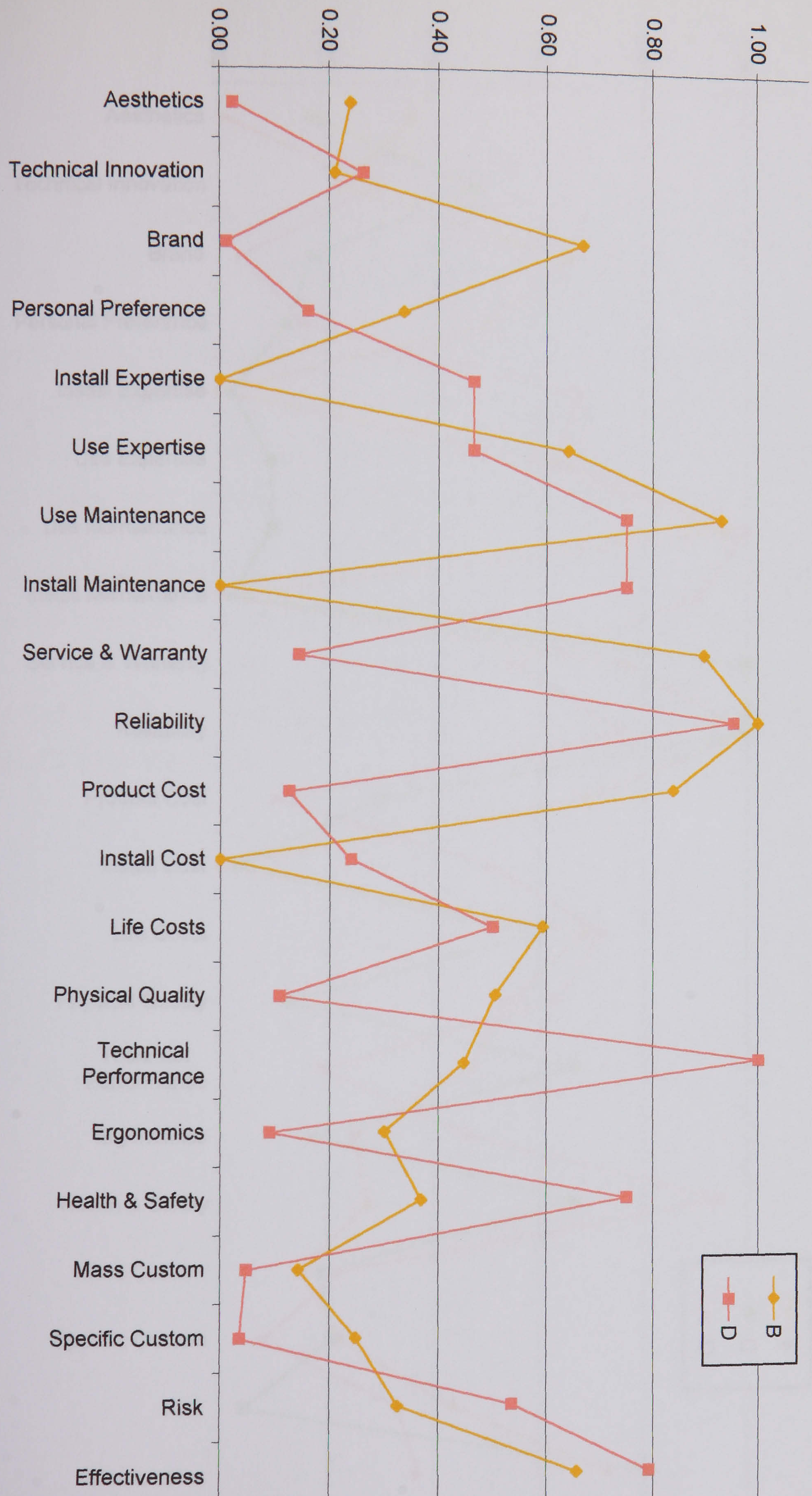

Figure L.8 Other user trends for importance of product attributes (Z_{iM})

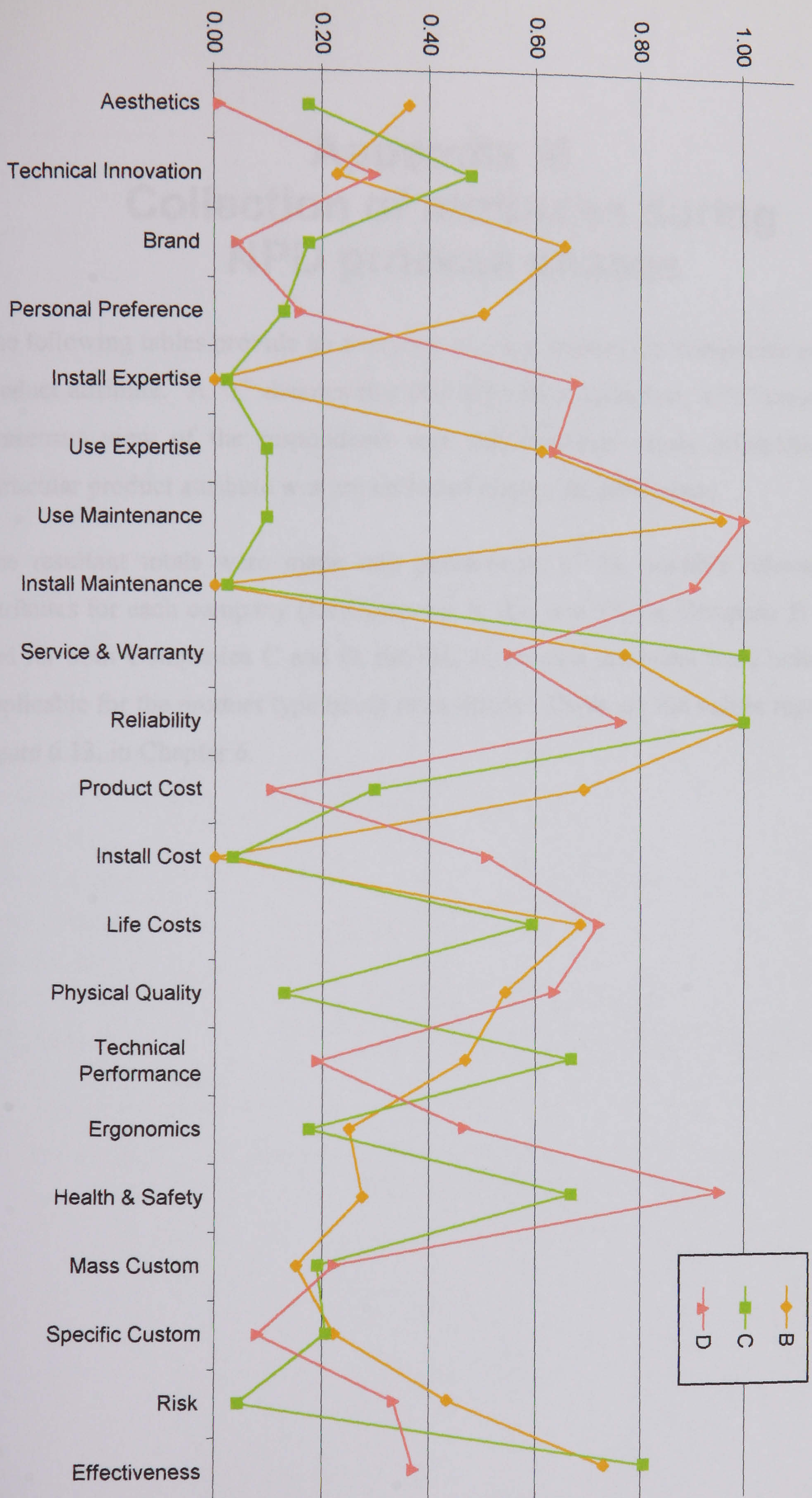

Figure L.9 Maintainer trends for importance of product attributes (Z_{iM})

Appendix M
Collection of attributes during NPD process phases

The following tables provide an overview of when each of the companies collect each product attribute. A "1" denotes that this attribute is collected, a "0" means that the consensus view of the respondents was that customer needs information on the particular product attribute was not collected during the NPD phase.

The resultant totals were made into percentages of the possible relevant product attributes for each company (for Company A, this was 19, for Company B is was 18, and for both Companies C and D, the full 21 product attributes were believed to be applicable for the product type being researched). These are the values represented in figure 6.13, in Chapter 6.

Company A	Never collected	Pre-development	During development	Production and launch	Post-launch
Aesthetics	0	1	1	0	0
Tech Innovation	0	1	1	0	0
Brand	0	0	0	1	0
Personal Preference	0	1	1	0	0
Install Expertise	0	1	1	0	0
Use Expertise	1	0	0	0	0
Use Maintenance	N/A	0	0	0	0
Install Maintenance	0	0	1	0	0
Service & Warranty	N/A	0	0	0	0
Reliability	0	1	1	0	1
Product Cost	0	1	0	1	0
Install Cost	0	1	1	1	0
Life Costs	0	0	1	1	1
Physical Quality	0	0	1	1	0
Technical Performance	0	1	1	0	0
Ergonomics	0	0	1	0	1
Health & Safety	0	0	1	0	0
Mass Custom	0	1	0	0	0
Spec Custom	0	0	0	0	1
Risk	0	1	1	0	0
Effectiveness	0	1	1	1	1
Totals	**1**	**11**	**14**	**6**	**5**

Figure M.1 **Company A: The collection of product attributes during NPD process phases**

Company B	Never collected	Pre-development	During development	Production and launch	Post-launch
Aesthetics	0	1	1	0	0
Tech Innovation	0	1	1	0	0
Brand	0	1	1	0	0
Personal Preference	0	1	1	0	1
Install Expertise	N/A	0	0	0	0
Use Expertise	0	0	1	1	1
Use Maintenance	0	0	1	0	1
Install Maintenance	N/A	0	0	0	0
Service & Warranty	0	0	0	1	0
Reliability	0	0	1	1	1
Product Cost	0	1	1	1	0
Install Cost	N/A	0	0	0	0
Life Costs	0	0	0	0	1
Physical Quality	0	0	1	1	1
Technical Performance	0	1	1	0	0
Ergonomics	0	1	1	1	1
Health & Safety	0	0	1	1	0
Mass Custom	0	1	0	1	1
Spec Custom	0	1	0	0	1
Risk	0	0	1	0	0
Effectiveness	0	0	1	1	1
Totals	**0**	**9**	**14**	**9**	**10**

Figure M.2 **Company B: The collection of product attributes during NPD process phases**

Company C	Never collected	Pre-development	During development	Production and launch	Post-launch
Aesthetics	0	0	1	0	0
Tech Innovation	0	1	1	0	0
Brand	1	0	0	0	0
Personal Preference	0	0	1	0	0
Install Expertise	0	0	1	0	0
Use Expertise	0	0	1	0	0
Use Maintenance	0	0	1	0	0
Install Maintenance	0	0	1	0	0
Service & Warranty	0	0	1	0	0
Reliability	0	0	0	0	1
Product Cost	0	1	1	1	1
Install Cost	0	1	1	1	1
Life Costs	1	0	0	0	0
Physical Quality	0	1	0	0	0
Technical Performance	0	1	1	0	0
Ergonomics	0	0	1	0	0
Health & Safety	0	0	1	0	0
Mass Custom	1	0	0	0	0
Spec Custom	0	1	1	0	0
Risk	0	0	1	0	0
Effectiveness	0	0	1	0	0
Totals	**3**	**6**	**16**	**2**	**3**

Figure M.3 Company C: The collection of product attributes during NPD process phases

Company D	Never collected	Pre-development	During development	Production and launch	Post-launch
Aesthetics	1	0	0	0	0
Tech Innovation	0	1	1	0	0
Brand	0	0	0	1	0
Personal Preference	0	0	1	0	0
Install Expertise	0	1	1	1	0
Use Expertise	0	0	1	1	0
Use Maintenance	0	0	1	1	0
Install Maintenance	0	0	0	1	0
Service & Warranty	0	0	1	1	0
Reliability	0	0	1	0	0
Product Cost	0	1	0	0	0
Install Cost	0	1	0	0	0
Life Costs	0	0	0	0	1
Physical Quality	0	0	1	1	0
Technical Performance	0	1	1	0	0
Ergonomics	0	0	1	1	0
Health & Safety	0	0	1	0	0
Mass Custom	0	0	1	1	0
Spec Custom	0	1	1	1	0
Risk	0	0	1	0	0
Effectiveness	0	0	1	0	1
Totals	3	6	15	10	2

Figure M.4 **Company D: The collection of product attributes during NPD process phases**

Appendix N
Use of attributes during NPD process phases

The following tables provide an overview of when each of the companies use product attribute. A “1” denotes that this attribute is used, a “0” means that the consensus view of the respondents was that customer needs information on the particular product attribute was not used during the NPD phase.

The resultant totals were made into percentages of the possible relevant product attributes for each company (for Company A, this was 19, for Company B is was 18, and for both Companies C and D, the full 21 product attributes were believed to be applicable for the product type being researched). These are the values represented in figure 6.16, in Chapter 6.

Company A	Never used	Pre-development	During development	Production and launch	Post-launch
Aesthetics	0	0	1	0	0
Tech Innovation	0	0	1	0	0
Brand	0	0	0	1	0
Personal Preference	0	0	1	0	0
Install Expertise	0	0	1	0	0
Use Expertise	0	0	1	0	0
Use Maintenance	N/A	0	0	0	0
Install Maintenance	0	0	1	0	0
Service & Warranty	N/A	0	0	0	0
Reliability	0	0	1	0	1
Product Cost	0	1	0	1	0
Install Cost	0	0	1	1	0
Life Costs	0	0	1	1	1
Physical Quality	0	0	1	1	0
Technical Performance	0	0	1	0	1
Ergonomics	0	0	1	0	0
Health & Safety	0	0	1	0	0
Mass Custom	0	0	1	0	0
Spec Custom	0	0	0	0	1
Risk	0	1	1	1	1
Effectiveness	0	0	1	0	1
Totals	1	2	16	6	6

Figure N.1 **Company A: The use of product attributes during NPD process phases**

Company B	Never used	Pre-development	During development	Production and launch	Post-launch
Aesthetics	0	1	1	1	0
Tech Innovation	0	1	1	1	0
Brand	0	0	1	1	1
Personal Preference	0	1	1	0	0
Install Expertise	N/A	0	0	0	0
Use Expertise	0	0	1	1	0
Use Maintenance	0	0	1	1	1
Install Maintenance	N/A	0	0	0	0
Service & Warranty	0	0	0	0	0
Reliability	0	1	1	0	1
Product Cost	0	0	0	1	0
Install Cost	N/A	0	0	0	0
Life Costs	0	0	1	0	1
Physical Quality	0	0	1	1	1
Technical Performance	0	1	1	1	1
Ergonomics	0	1	1	1	1
Health & Safety	0	1	1	0	0
Mass Custom	0	0	1	1	1
Spec Custom	0	0	1	1	1
Risk	0	1	1	0	0
Effectiveness	0	0	1	1	1
Totals	0	8	16	12	10

Figure N.2 Company B: The use of product attributes during NPD process phases

Company C	Never used	Pre-development	During development	Production and launch	Post-launch
Aesthetics	0	0	1	0	0
Tech Innovation	0	0	1	0	0
Brand	1	0	0	0	0
Personal Preference	0	0	1	0	0
Install Expertise	0	0	1	0	0
Use Expertise	0	0	1	0	0
Use Maintenance	0	0	1	0	0
Install Maintenance	0	0	0	1	1
Service & Warranty	0	0	1	0	0
Reliability	0	0	1	1	0
Product Cost	0	1	1	1	1
Install Cost	0	0	1	0	0
Life Costs	0	0	1	0	0
Physical Quality	0	0	1	0	0
Technical Performance	0	0	1	1	0
Ergonomics	0	0	1	0	0
Health & Safety	0	0	1	1	0
Mass Custom	0	0	1	0	0
Spec Custom	0	0	1	0	0
Risk	0	0	1	0	0
Effectiveness	0	0	1	1	1
Totals	1	2	19	6	3

Figure N.3 **Company C: The use of product attributes during NPD process phases**

Company D	Never used	Pre-development	During development	Production and launch	Post-launch
Aesthetics	0	0	1	1	0
Tech Innovation	0	0	1	0	0
Brand	0	0	0	1	0
Personal Preference	0	0	0	1	0
Install Expertise	0	0	1	0	0
Use Expertise	0	0	1	1	0
Use Maintenance	0	0	0	1	0
Install Maintenance	0	0	0	1	1
Service & Warranty	0	0	0	1	0
Reliability	0	0	0	0	1
Product Cost	0	0	0	1	0
Install Cost	0	0	0	1	0
Life Costs	0	0	0	1	1
Physical Quality	0	0	1	1	0
Technical Performance	0	0	1	0	0
Ergonomics	0	0	1	1	0
Health & Safety	0	0	1	0	0
Mass Custom	0	0	1	1	0
Spec Custom	0	1	0	1	1
Risk	0	1	0	0	0
Effectiveness	0	0	1	1	0
Totals	0	2	10	15	4

Figure N.4 **Company D: The use of product attributes during NPD process phases**

Appendix O
Recognition of NPD process activities

This appendix provides the results to question D.1 on the questionnaire. It presents bar charts that show how well recognised each of the NPD processes are in each company. The maximum value in each chart is the total number of respondents that answered this question in each company.

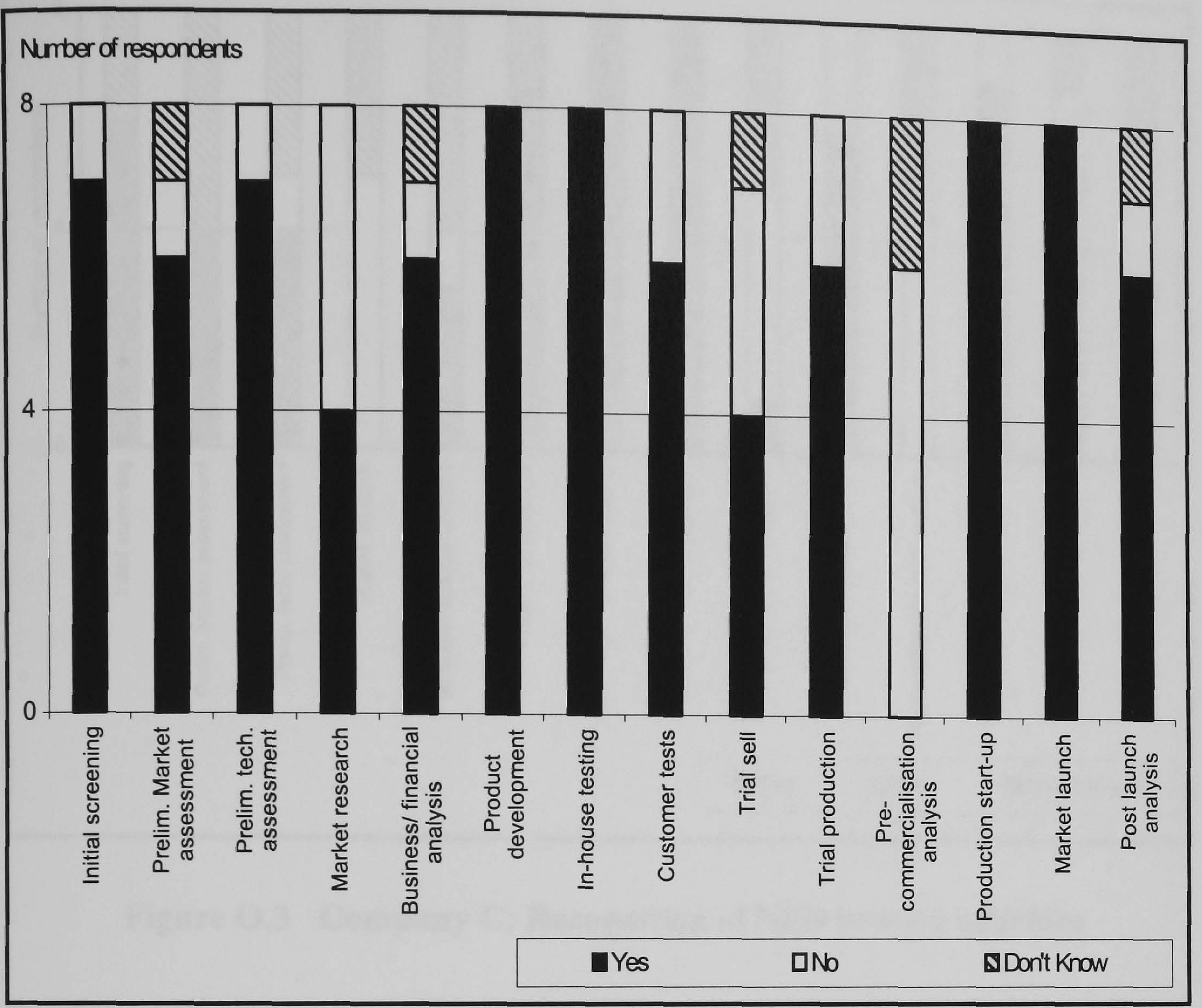

Figure O.1 Company A: Recognition of NPD process activities

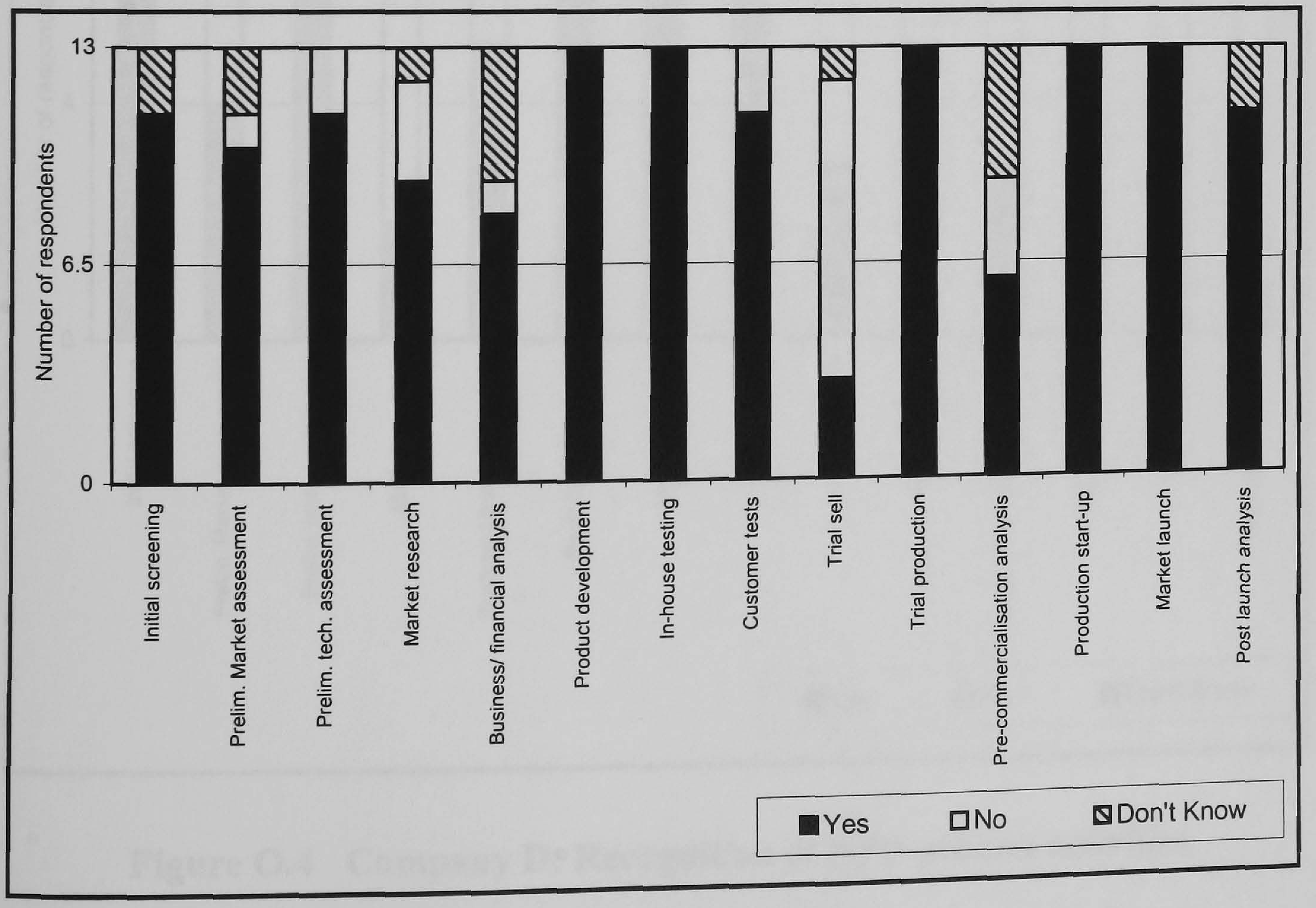

Figure O.2 Company B: Recognition of NPD process activities

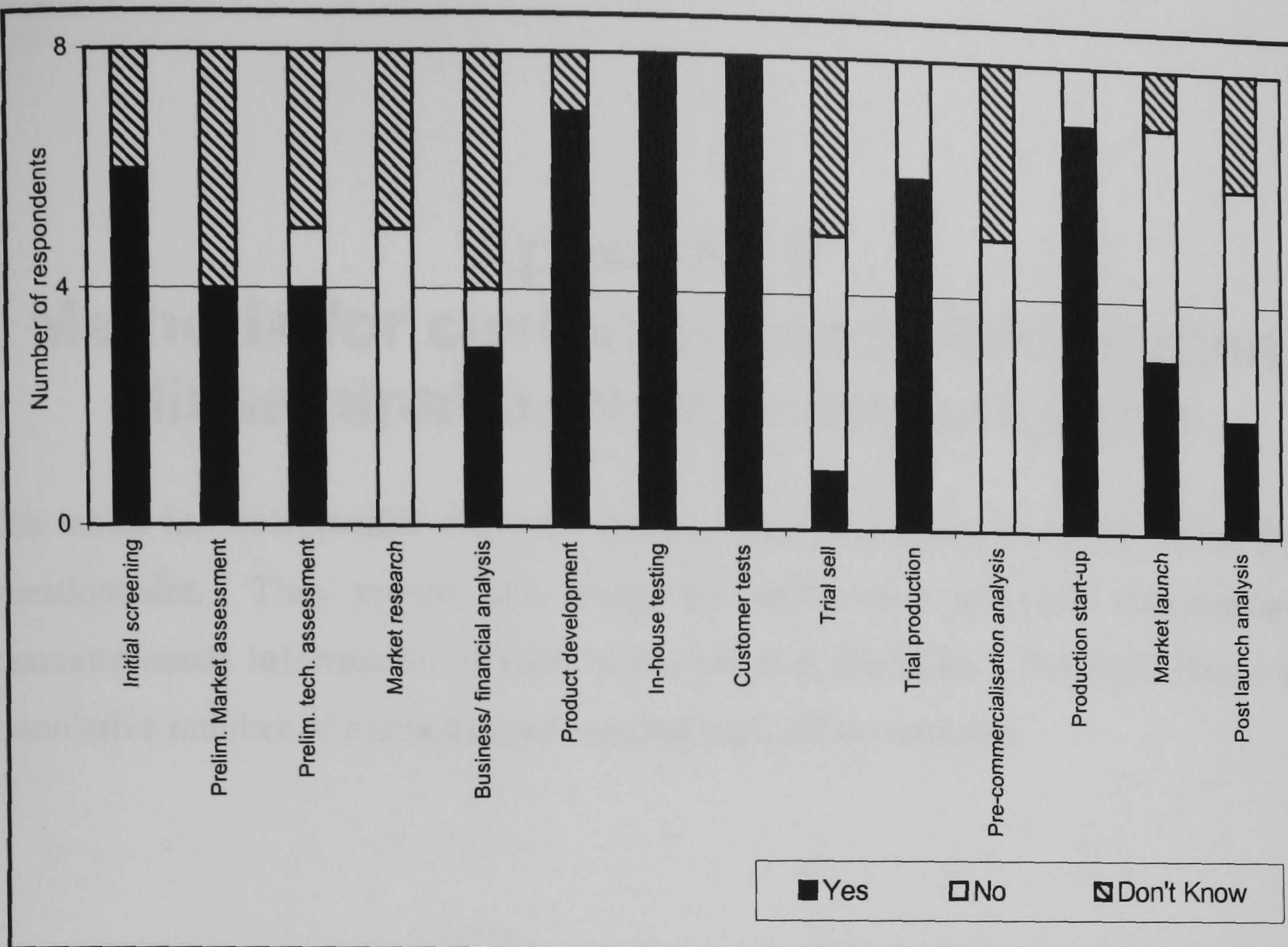

Figure O.3 Company C: Recognition of NPD process activities

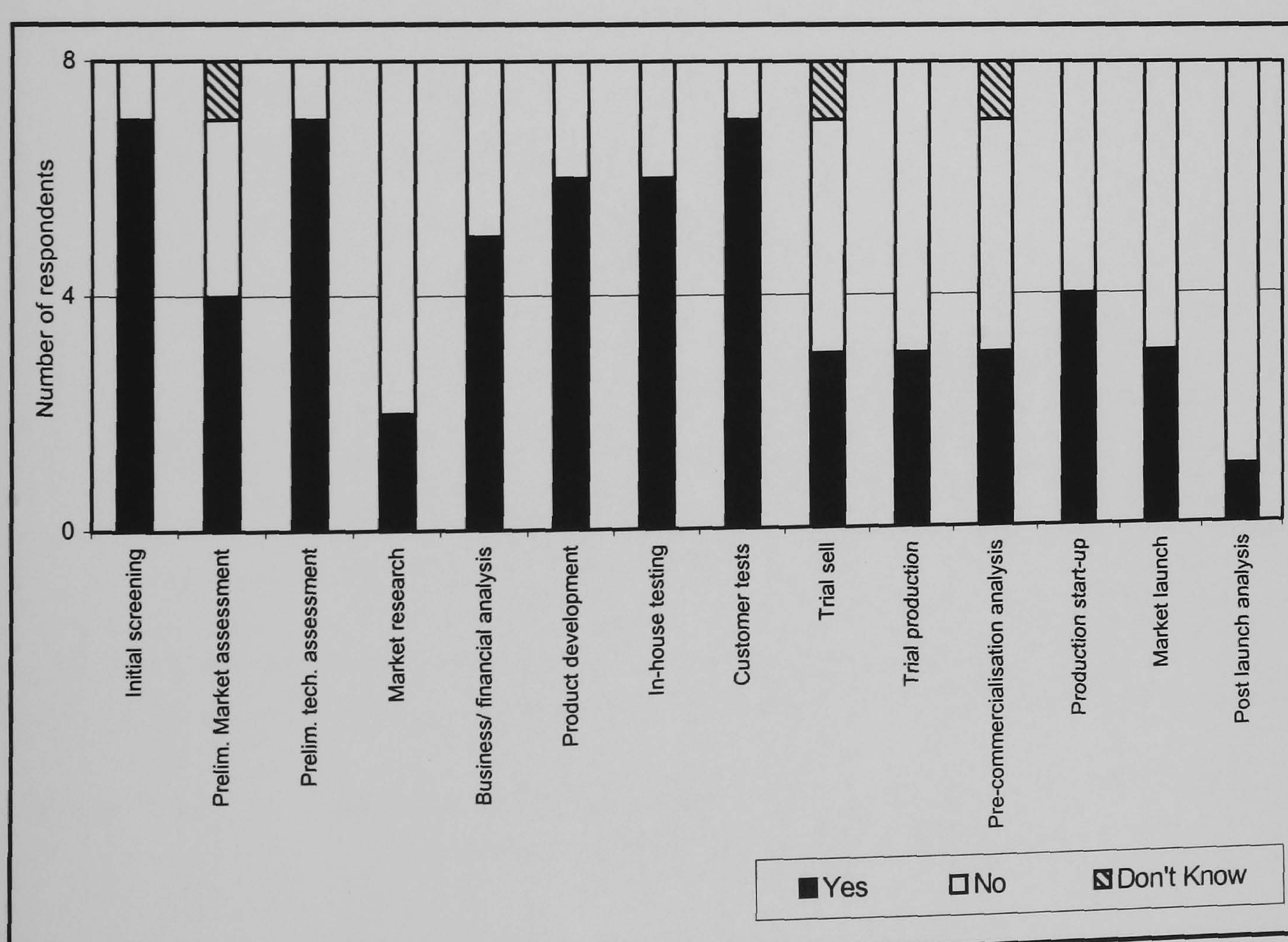

Figure O.4 Company D: Recognition of NPD process activities

Appendix P
Methods for customer needs information dissemination and communication

The tables in this appendix show the results from questions G2 and H1 on the final questionnaire. They present the means by which each company communicates customer needs information of each of the product attributes. The scale shows the cumulative number of methods used, against each of the attributes.

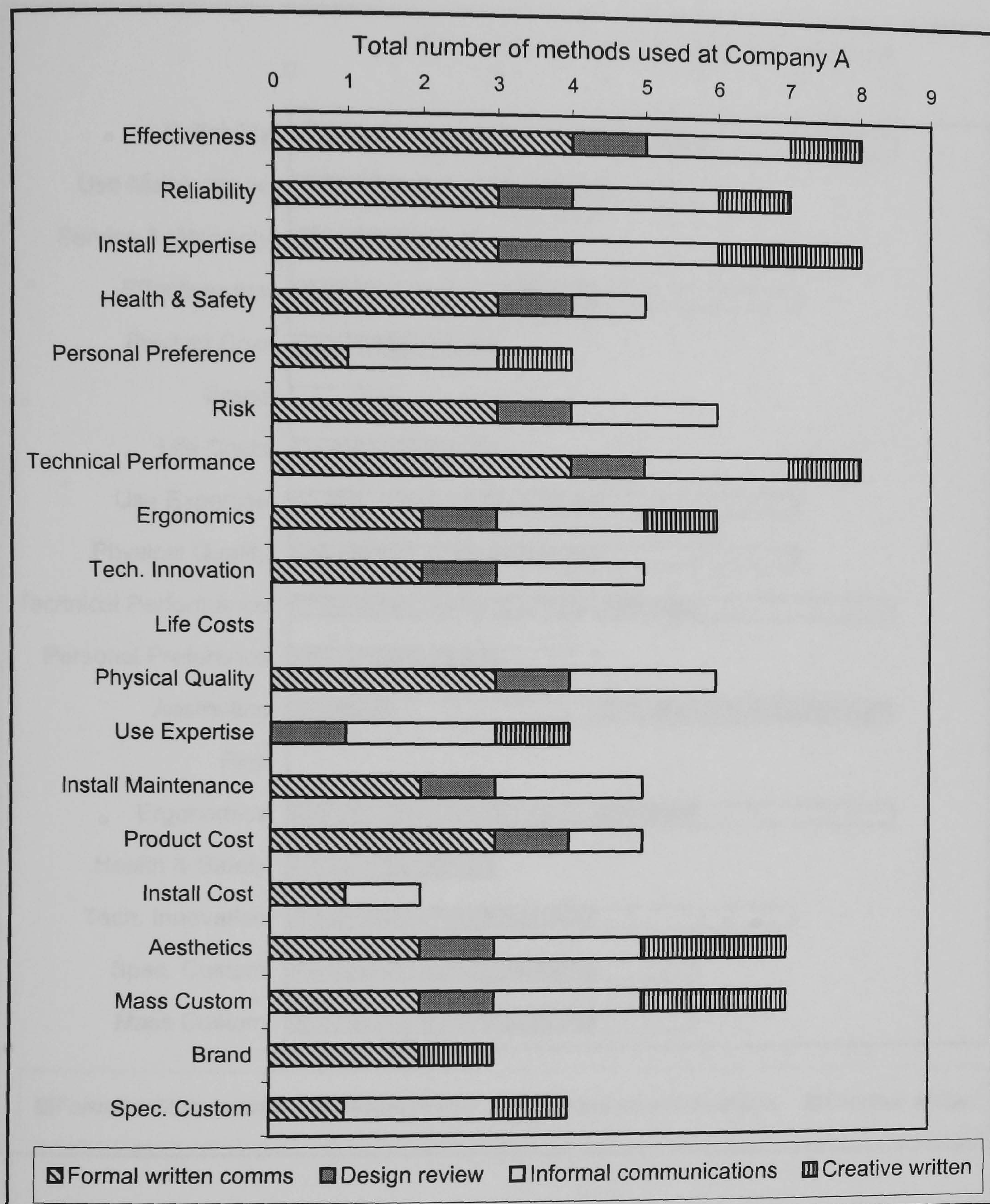

Figure P.1 **Company A: Information dissemination and communications means in order of A_i for Company A**

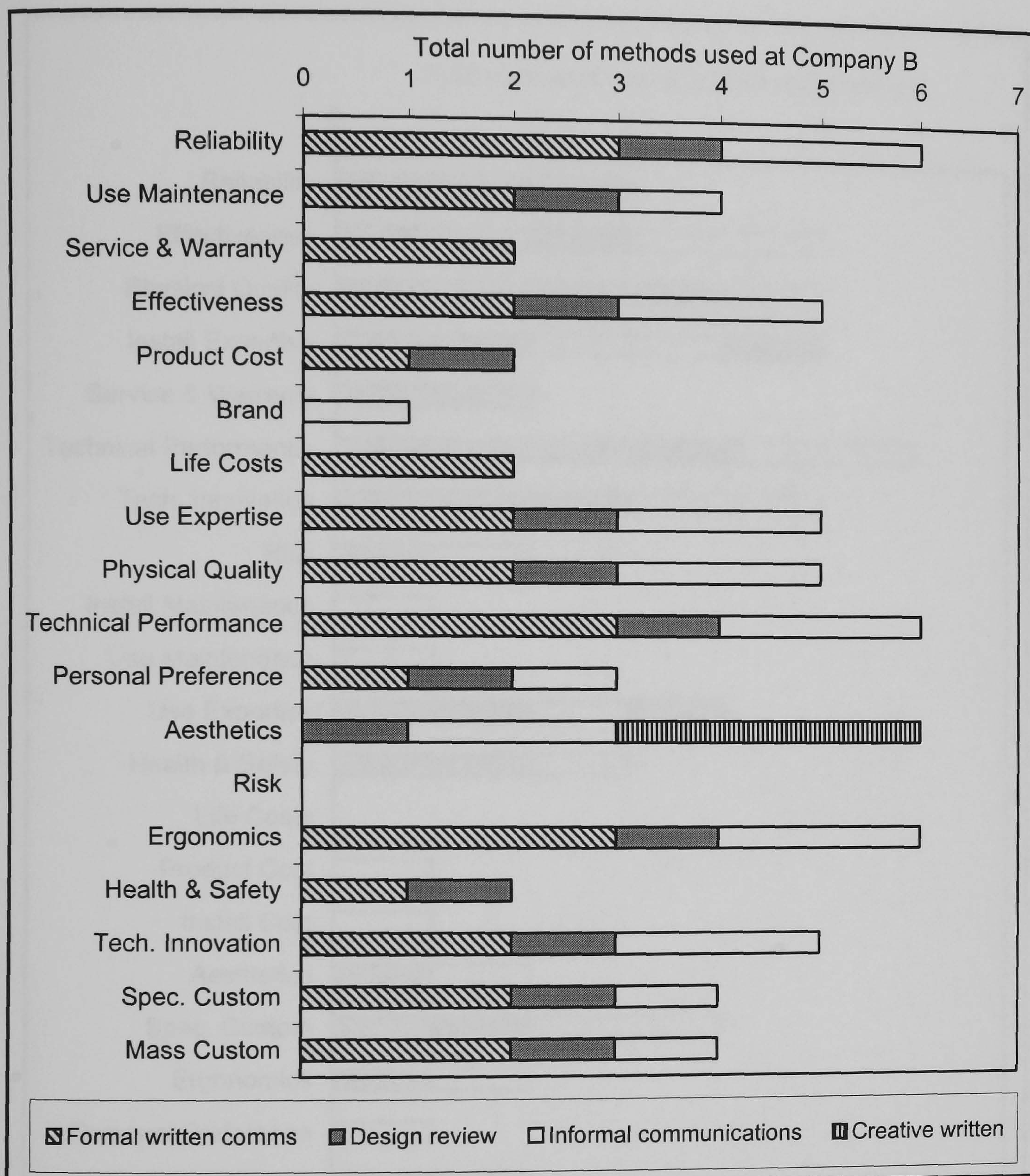

Figure P.2 **Company B: Information dissemination and communications means in order of A_i for Company B**

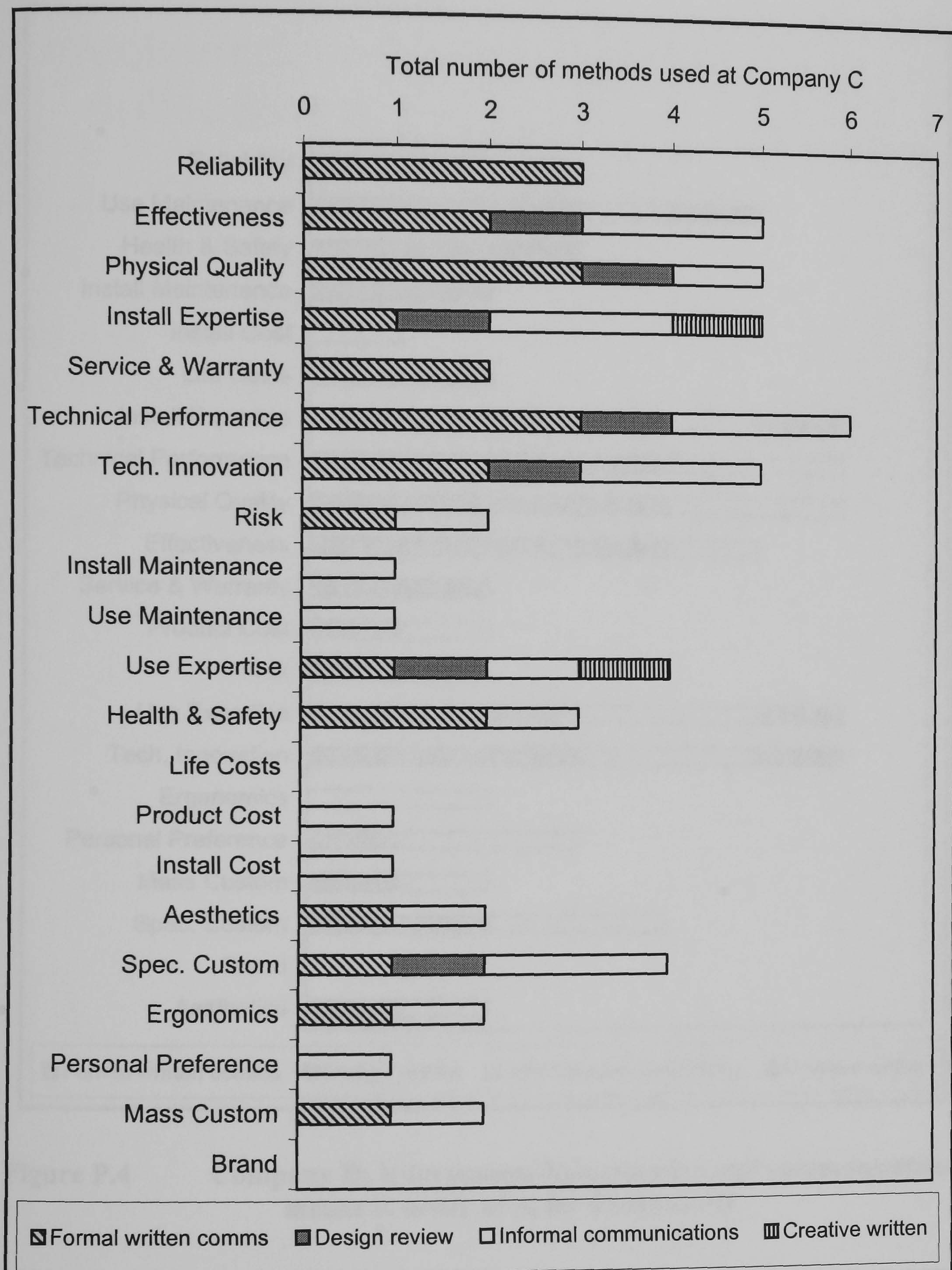

Figure P.3 **Company C: Information dissemination and communications means in order of A_i for Company C**

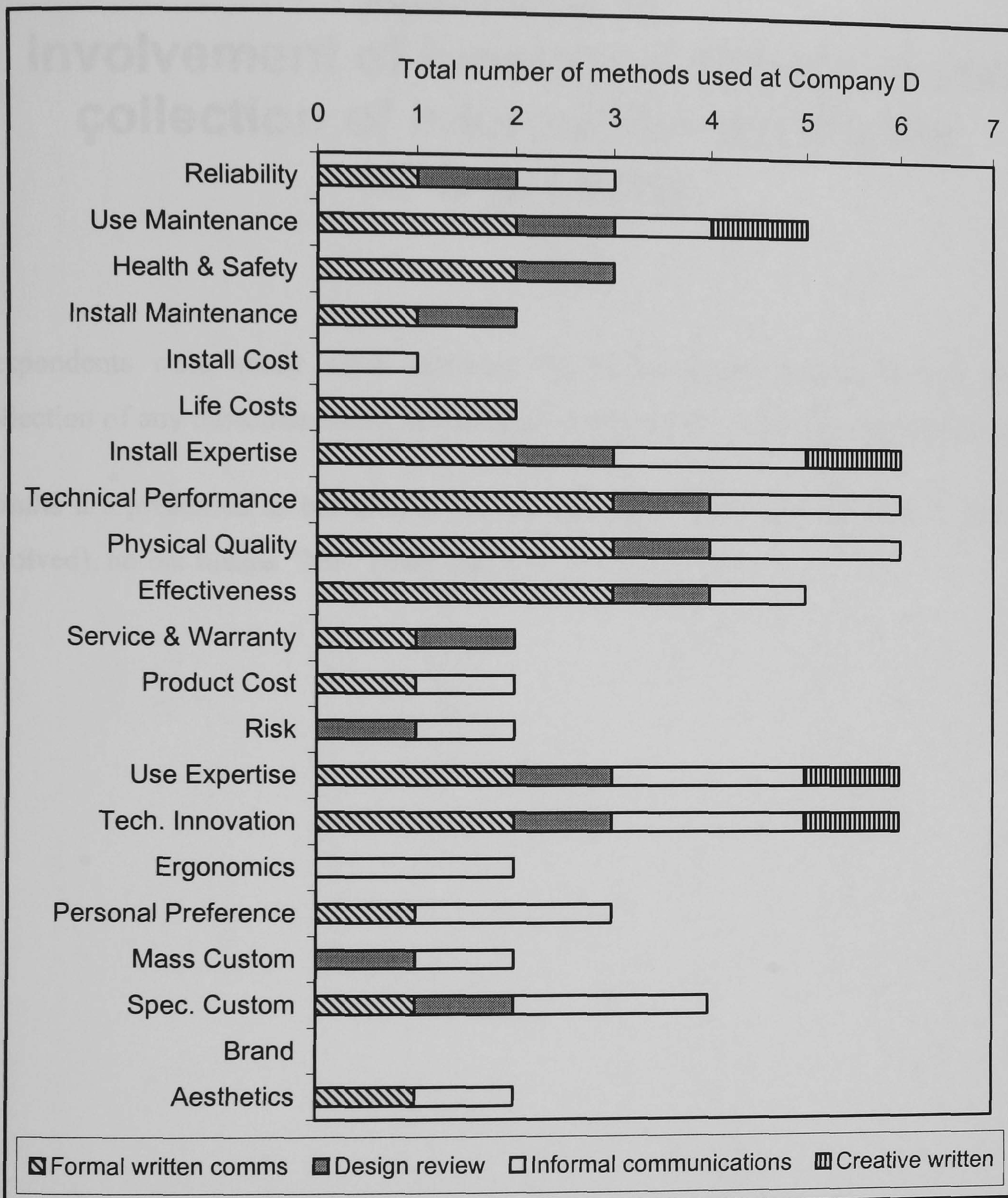

Figure P.4 **Company D: Information dissemination and communications means in order of A_i for Company D**

Appendix Q
Involvement of functional groups in the collection of information during the NPD process

Respondents were asked when different functional groups were involved in the collection of any customer needs information (question E1 on the final questionnaire).

Results are presented as bar charts. A bar indicates "Yes" (the functional group is involved), no bar means "No" (they are not).

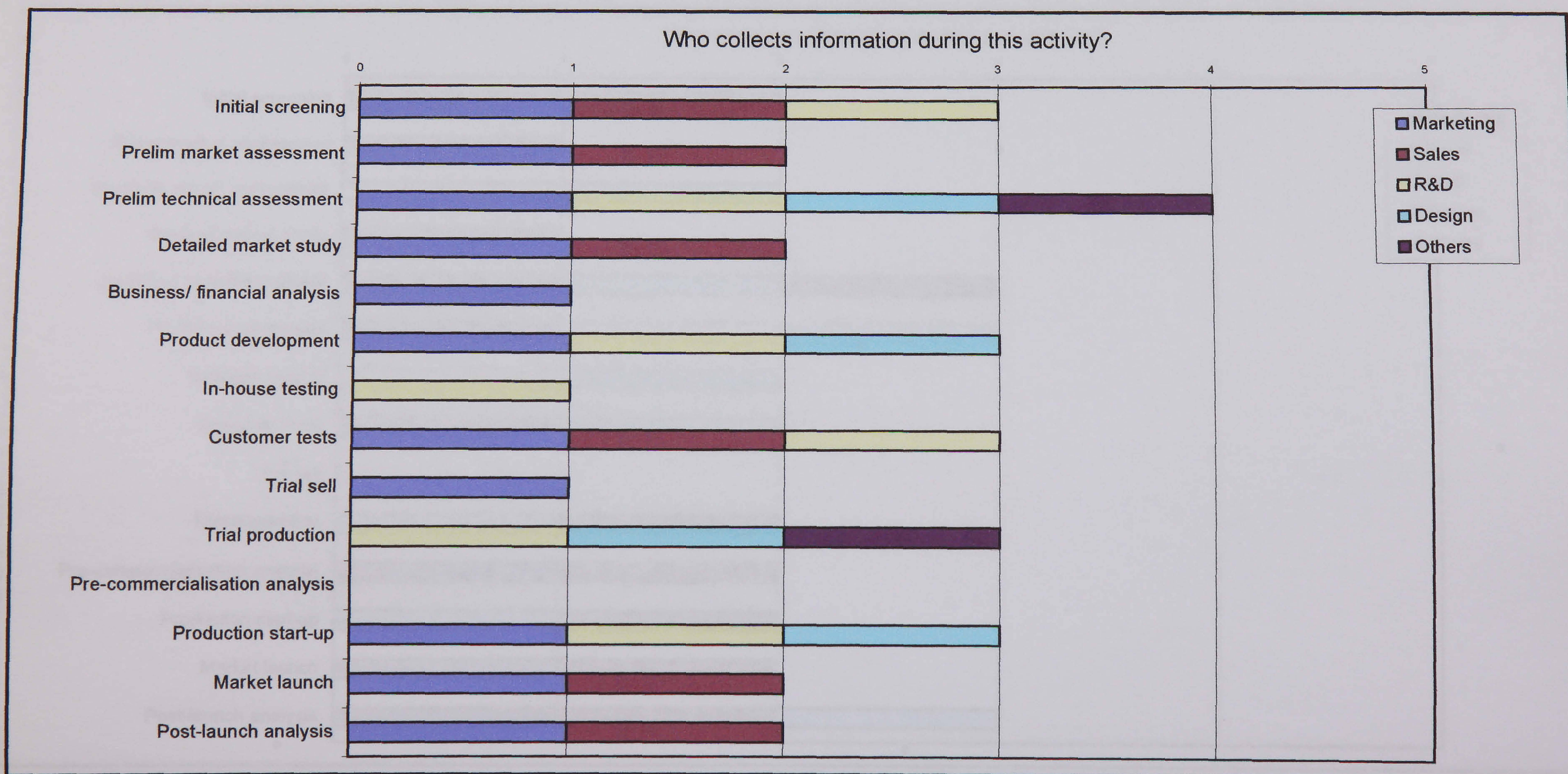

Figure Q.1 <u>Company A:</u> Involvement of each functional group in the *collection* of information during the different NPD process activities

(N.B. Only manufacturing was named as an "other" for Company A).

Figure Q.2 **<u>Company B:</u>** **Involvement of each functional group in the *collection* of information during the different NPD process activities**

(N.B. Manufacturing and service were named as "others" for Company B).

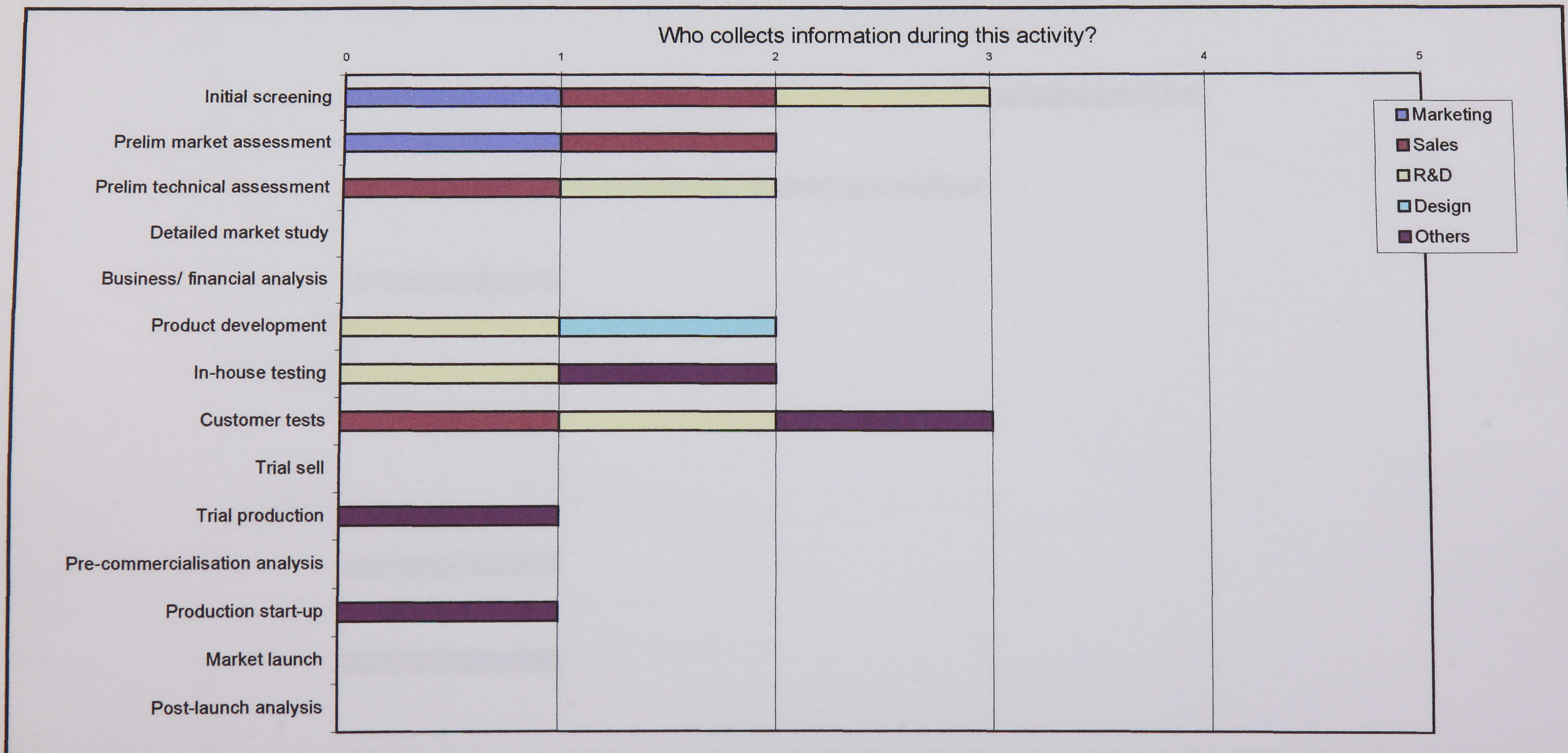

Figure Q.3 **Company C:** **Involvement of each functional group in the *collection* of information during the different NPD process activities**

(N.B. Manufacturing and quality were named as "others" for Company C).

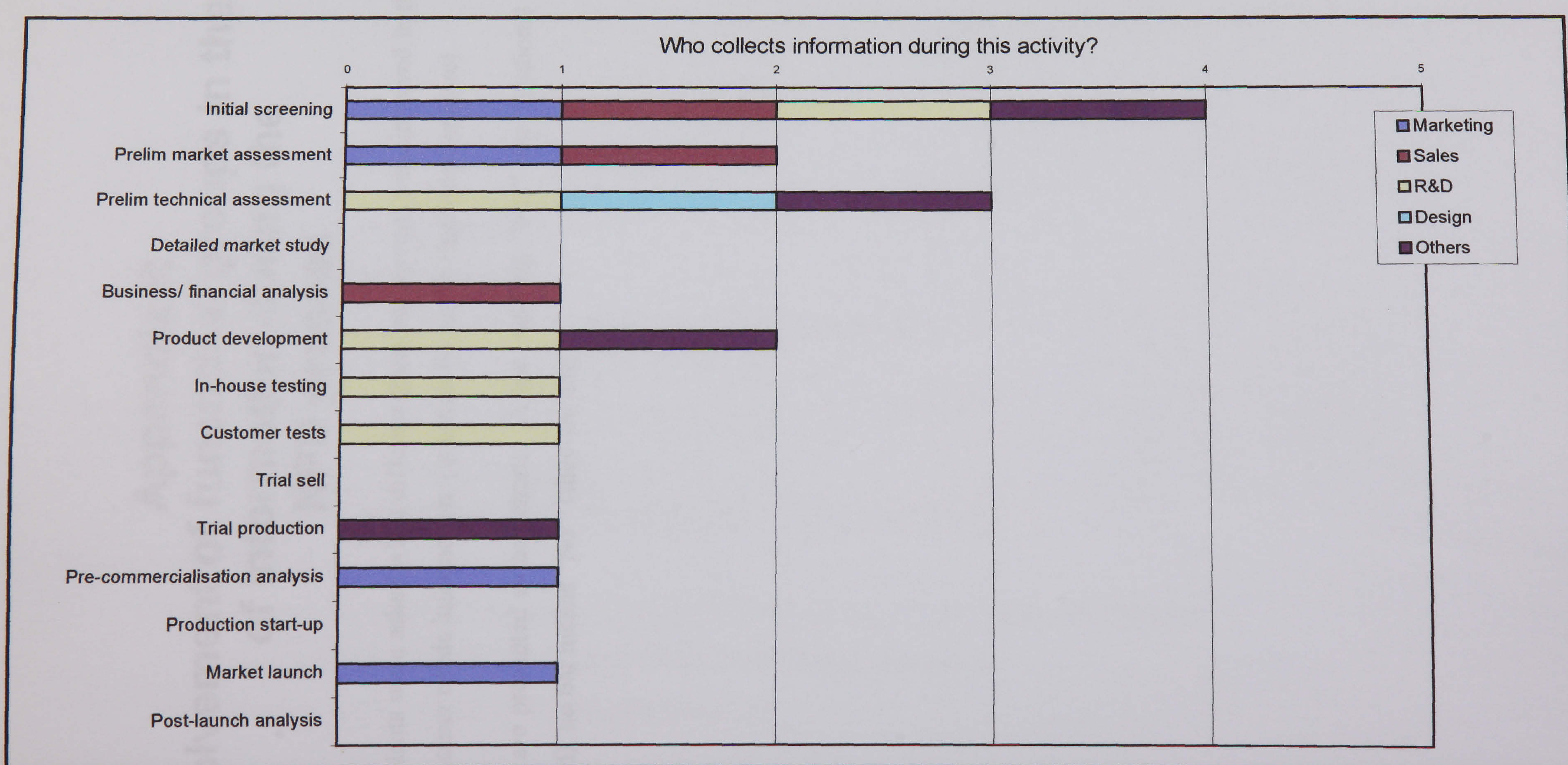

Figure Q.4 **<u>Company D:</u>** **Involvement of each functional group in the *collection* of information during the different NPD process activities**

(N.B. Manufacturing and finance were named as "others" for Company D).

Appendix R
Involvement of functional groups in the use of information during the NPD process

Respondents were asked when different functional groups were involved in the use of any customer needs information (question F1 on the final questionnaire).

Results are presented as bar charts. A bar indicates "Yes" (the functional group is involved), no bar means "No" (they are not).

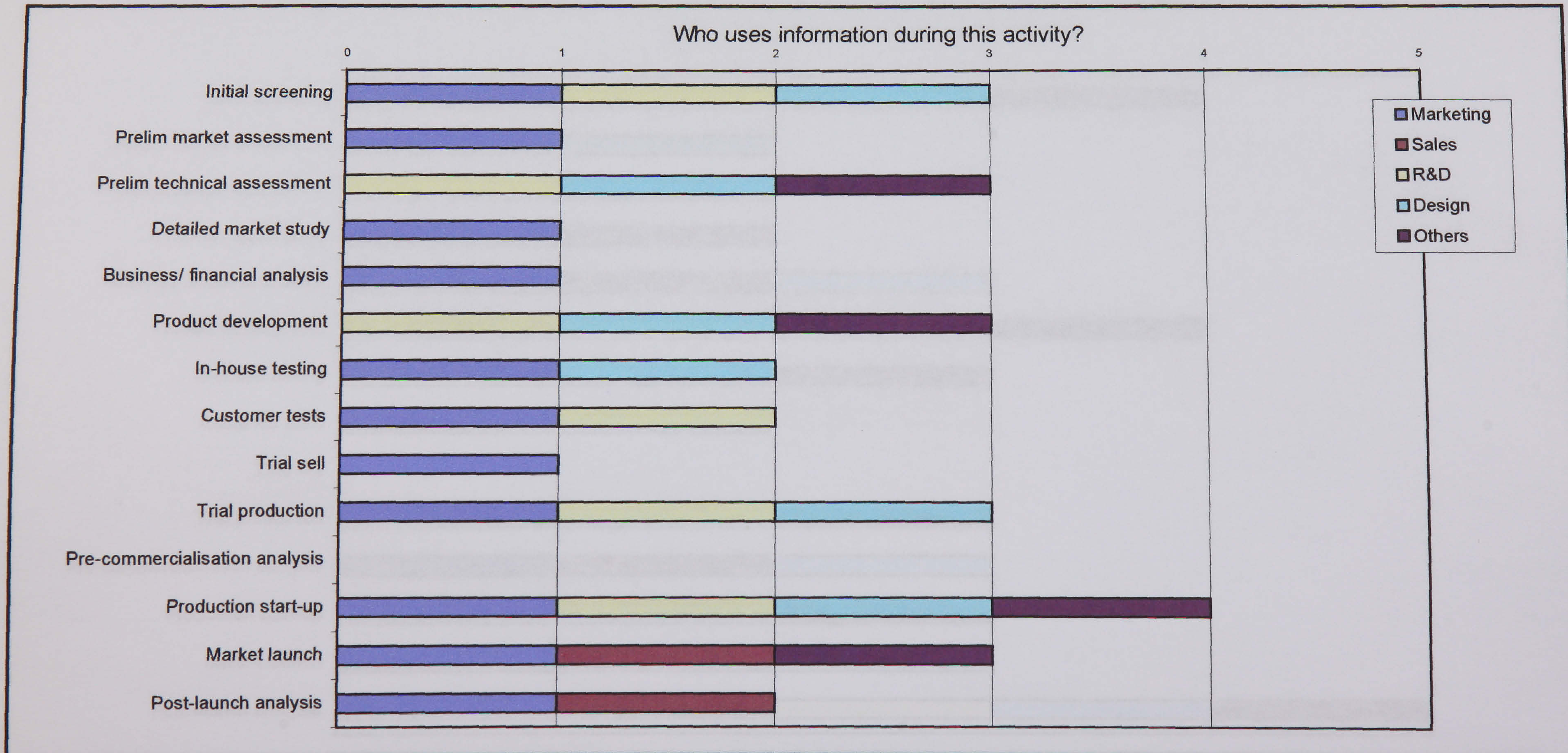

Figure R.1 <u>Company A:</u> Involvement of each functional group in the *use* of information during the different NPD process activities

(N.B. Only manufacturing was named as an "other" for Company A).

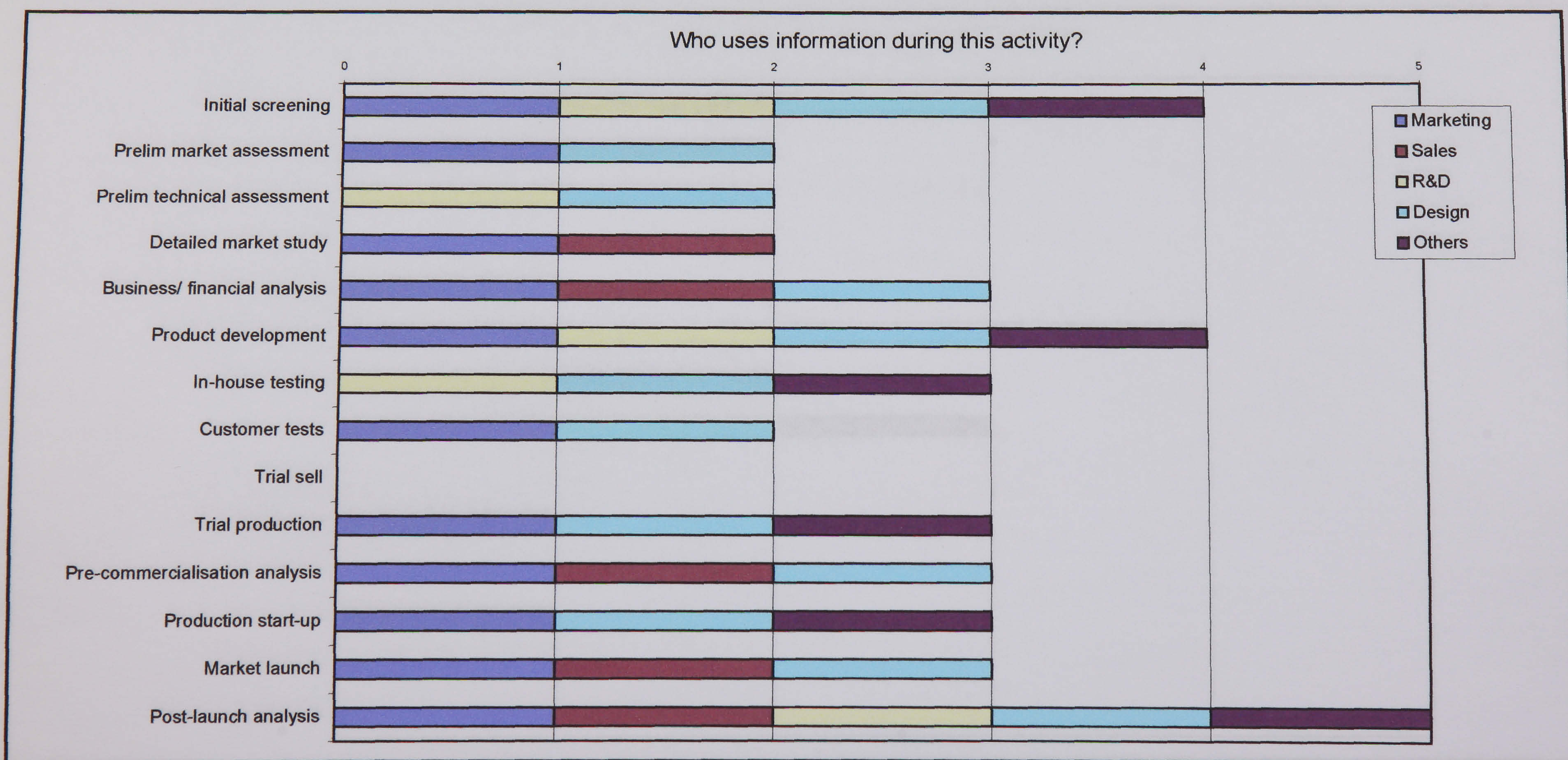

Figure R.2 **<u>Company B:</u>** **Involvement of each functional group in the *use* of information during the different NPD process activities**

(N.B. Manufacturing and service were named as "others" for Company B).

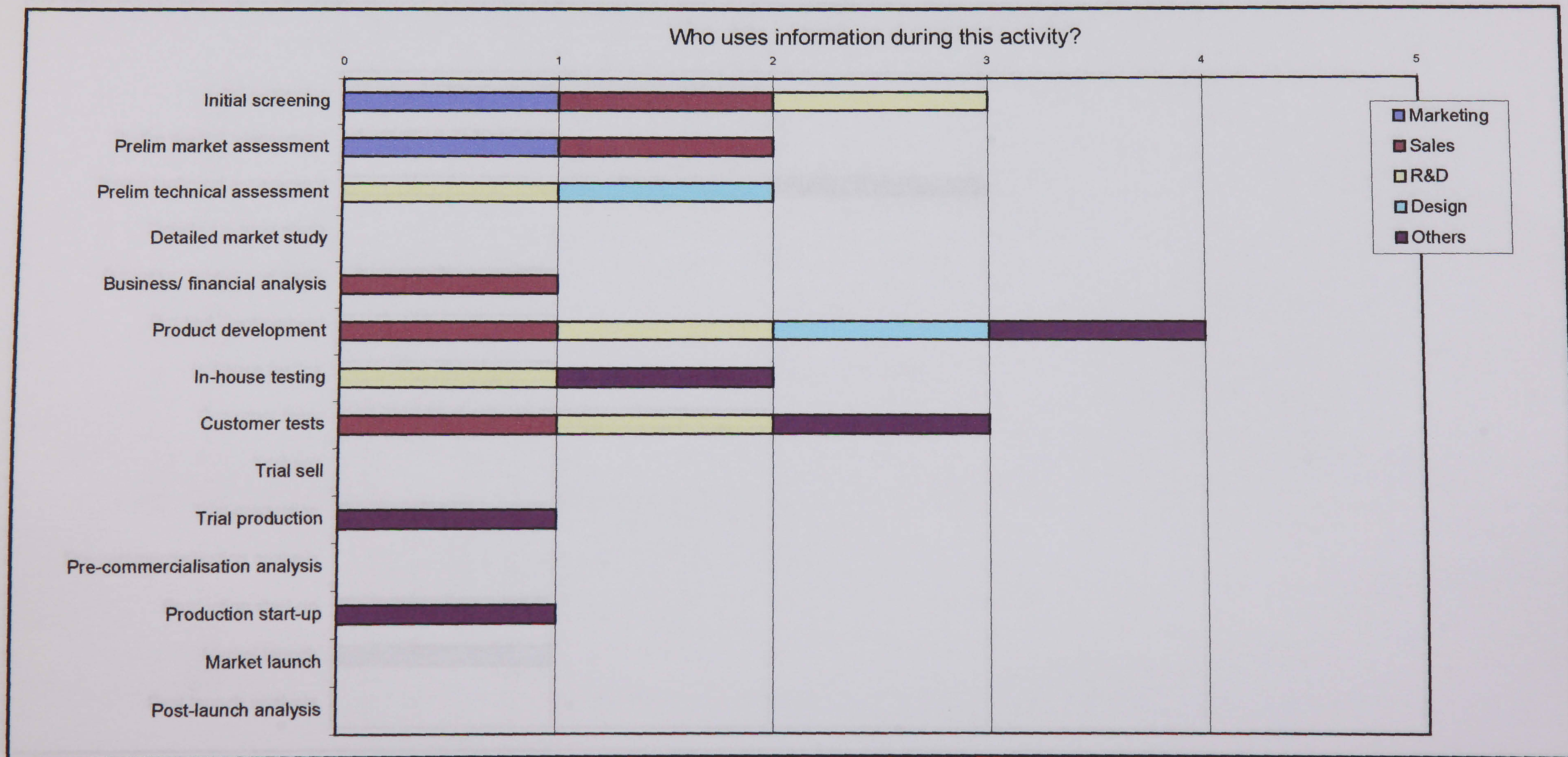

Figure R.3 **Company C:** **Involvement of each functional group in the *use* of information during the different NPD process activities**

(N.B. Manufacturing and quality were named as "others" for Company C).

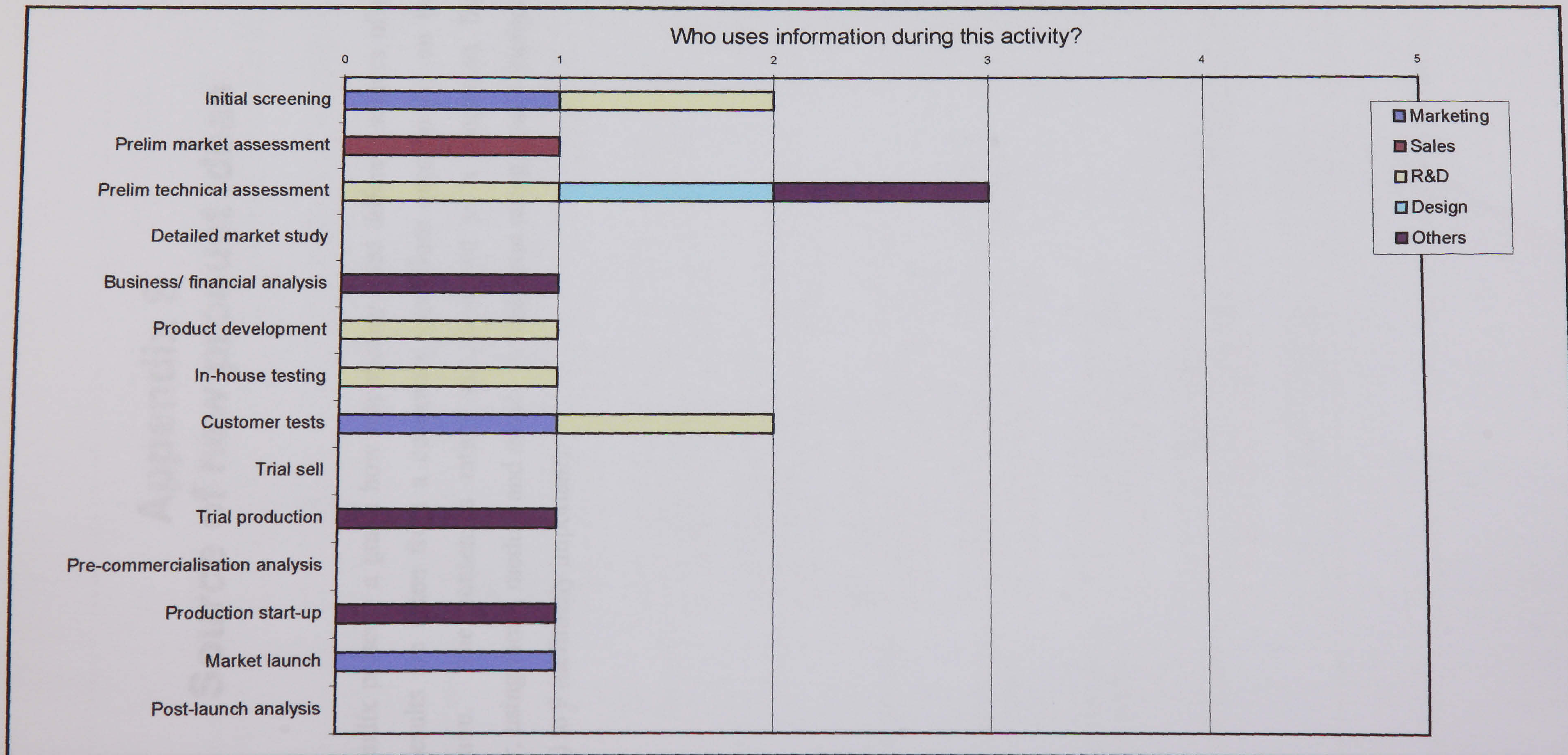

Figure R.4 <u>**Company D:**</u> **Involvement of each functional group in the *use* of information during the different NPD process activities**

(N.B. Manufacturing and finance were named as "others" for Company D).

Appendix S
Source of new product ideas

This appendix presents a graph how respondents rated different sources of product ideas. Results are taken from a consensus view from question A3 on the final questionnaire. The consensus rating was produced as a judgement from the researcher, using mean, median and mode. A nine point rating from 0 (definitely not important) to 9 (definitely important).

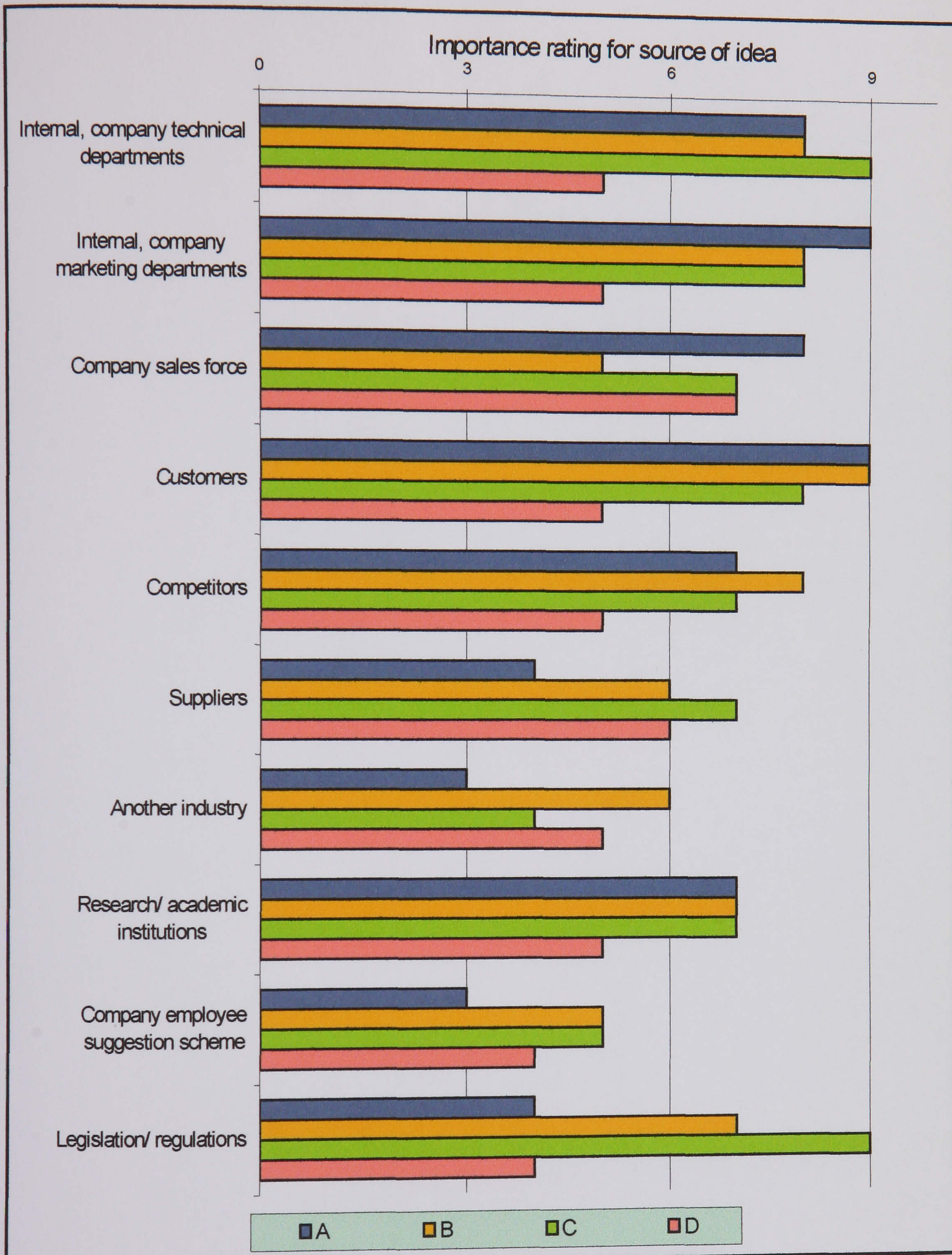

Figure S.1 The importance of different sources for new product ideas