Design and innovation in successful product competition

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Design and Innovation in Successful Product Competition

Robin Roy and Johann c.k.h. Riedel

Design Innovation Group, Faculty of Technology,
The Open University, Milton Keynes MK7 6AA, UK.

Tel: +44 (0)1908 653970 Fax: +44 (0)1908 654052
email: r.roy@open.ac.uk

Abstract

This paper presents results from a project entitled 'MArket Demands that Reward Investment in Design' (MADRID). Among other aims, MADRID seeks to identify the contribution of design and innovation to product competitiveness in different markets.

The paper provides a conceptual analysis of the role of design and innovation in product competition. The concepts are employed to conduct an analysis of a sample of new and redesigned products using data from a previous study on the 'Commercial Impacts of Design' (CID). CID was a study of over 220 design and product development projects in British SMEs which had received government financial support for design.

The key conclusions from this re-analysis of the CID data are:

• In commercially successful product development projects more attention had been paid than in the loss-making projects to genuine product improvements rather than just styling or costs.

• Commercially successful product development projects involved a multi-dimensional approach to design with a focus on product performance, features and build quality and, where relevant, technical or design innovation. Loss-making projects tended to involve a narrow, often styling-oriented, approach to design with more attention paid to cost reduction than to performance, quality and innovation.

1. Introduction

Numerous studies, reports and commentators have identified the crucial role that product design and technical innovation plays in improving the competitiveness of products, firms and national economies (see e.g. Rothwell et al. 1983; Berger et. al., 1989; House of Lords, 1991; Wray, 1991; Freeman, 1992; Utterback, 1994). To take some recent typical observations. The management guru, Tom Peters, commented, 'we are all in desperate pursuit of new advantages....the most significant fertile ground for those new advantages will come from design' (Peters, 1995a). The UK Department of Trade and Industry and Confederation of British Industry concluded from a survey of best practice firms that ' a sustained commitment to, and investment in, innovation is essential for competitive success.' (DTI/CBI, 1993). Michael Porter (1990) in his comprehensive study of The *Competitive Advantage of Nations* notes, 'firms gain competitive advantage in international competition through improvement, innovation and upgrading....The innovations that lead to competitive advantage involve an accumulation of small steps and protracted effort as much as dramatic breakthroughs.' (p. 70).

Despite a general agreement on their importance, the precise roles of design and innovation in improving the competitiveness of a company's products remains a complex issue. This complexity arises partly because product design and innovation can have many meanings. In this paper we understand *product design* as the choice and configuration of elements, materials and components that give the product particular attributes of performance, appearance, ease of use, method of manufacture, etc. And we define *product innovation* as the application of new concepts, inventions or technologies in the design of the whole product or key components. Complexity also arises because design and innovation can be used to improve product competitiveness in a number of ways – for example, to reduce costs, to increase performance, to improve quality, to differentiate from rival products, to offer a completely new product, and so on. A better understanding of the most effective role(s) of design and innovation in competition is therefore required.

This paper presents some of the results from a research project entitled 'MArket Demands that Reward Investment in Design' (MADRID) funded by the UK Design Council. The aims of the research are to identify:

1) which types of market(s) are most likely to produce the best commercial returns from investments in design and product development by UK firms;
2) the contribution of design and innovation to product competitiveness in different markets;
3) the long-term commercial benefits of investment in design and innovation.

An earlier paper by the authors (Riedel et al., 1996) addressed the first aim. This paper focuses on the second of the above aims. It analyses the role(s) of design and innovation in product competition and presents empirical results and conclusions from an analysis of a sample of new and redesigned products using information from a previous study on the 'Commercial Impacts of Design' (CID).

1.1 The Commercial Impacts of Design study

CID involved a major survey, using face-to-face interviews plus postal questionnaires, of design and product development projects in over 220 small and medium-sized firms. These firms ranged in size from one-person businesses to firms employing up to 500 people, plus a few firms with 1,000 or more employees. The firms had received government support under the Department of Trade and Industry/Design Council Support for Design (SFD) programme to engage a design consultant for a limited period at zero cost or at a subsidised rate to help with the development of new or improved products, components, product graphics or packaging, . The firms were sampled to be representative of UK manufacturing industry as a whole (rather than of the SFD programme) and the projects embraced a wide range of products and technologies, from electronic instruments, industrial lasers and railway equipment, to textiles, furniture and domestic ceramics. Nearly half of the projects involved inputs mainly of product design expertise (e.g. design of a range of hospital furniture); nearly 30% involved either inputs of engineering design (e.g. mechanical design of a packaging machine) or of both engineering and industrial design (e.g. electronic/mechanical design plus styling of a hi-fi amplifier). In addition nearly a quarter of projects involved mainly graphic design expertise (e.g. design of food packaging), but these projects have been omitted from the analysis in this paper.

Quantified financial data (on project costs, product sales and profit margins), sufficient to calculate the payback on the total project investment, was obtained for many of the successful projects, while qualitative and/or quantitative commercial data was gathered for most of the other projects, including failed projects. The CID study, for the first time, provided quantified information on the commercial returns upon investing in professional design expertise at the product level. For example, the study showed that 60% of all of the design and product development projects surveyed were commercially successful, while nearly 90% of the projects that were put into production succeeded commercially, with an average payback on investment of 15 months. CID also provided useful information on the indirect benefits of the projects, such as firms increasing their employment of professional research, design and development staff and learning skills in briefing and managing design consultants. (For details see e.g. Potter et al, 1991; Roy and Potter, 1993; Bruce, Potter and Roy, 1995.)

2. Design and Innovation in Competition

As noted above a better understanding of the most effective role(s) of design and innovation in competition at the product level is required. The approach adopted to gain this understanding arose from previous work which analysed the role of design and innovation in affecting price and non-price competition (e.g. Stout, 1977; Rothwell and Gardiner, 1984; Buzzell and Gale, 1987; Cox and Kriegbaum, 1989; Ughanwa and Baker, 1989; Roy, 1990; Walsh et al., 1992).

This work showed, for example, that the competitiveness of a manufactured product can be improved by (a) good product *design*; (b) product *innovation* and (c) production *process* improvements. It also showed that product design could affect both *price* competition, through design for economic manufacture and low life-cycle costs, and *non-price* competition, either through the technical design of the product itself to improve performance, appearance, quality, etc., or by taking into account associated service-related non-price factors such as product advertising, packaging and display and designing for ease of servicing and repair (see Table 1).

Table 1 here

2.1 Design and Innovation in Camera Competition

To gain a fuller understanding of how design and innovation might affect product competition in a real example, a case analysis of the camera market was carried out. Cameras were chosen because they are relatively complex products which embody a wide range of technical and design elements that are constantly being changed in response to a differentiated and competitive market. Competition in the camera market could therefore be expected to involve most of the different roles of design and innovation available to companies, which could then be used to analyse other products, including less sophisticated and slower-changing products.

An examination of the camera market and the different types of cameras was performed. This was done so that the technology, design configuration, features, materials, etc. which differentiated the cameras from each another could be determined. The sources used for the analysis were *Which?* consumer test reports on cameras (e.g. Consumers' Association, 1995a; 1995b), specialist magazines, advertisements and brochures.

The analysis revealed that product competition between camera manufacturers takes place at several levels within particular price bands/market segments, namely between:

- cameras of same product class (e.g. different models of 35mm compact camera priced below £150);
- cameras that perform similar functions, but which are in different product classes (e.g. zoom compact cameras v. single-lens reflex (SLR) cameras, both priced at £150-£250);
- cameras that perform similar functions but use incrementally different technologies (e.g. conventional compact cameras v. compact cameras featuring the 'Advanced Photo System', both priced at £100-£150);
- cameras that perform similar functions, but which use radically different technologies (e.g. conventional SLR cameras v. electronic digital cameras, both priced at £400-£600).

In addition there is some competition between cameras across adjacent price bands (e.g. autofocus compact cameras priced below £100 v. zoom compact cameras priced £100-£150).

Having identified the areas in which competition between different types and models of camera is likely to take place, the next step was to try to identify how design and innovation could be used to obtain a competitive advantage for a particular product through improvement or by differentiation from rival products.

This analysis also showed that product design can be used to enhance product competitiveness in several ways. The different roles of design that a manufacturer might employ to improve or differentiate a particular product are listed in Table 2, together with examples from camera design and technology.

Table 2 here

Table 2 shows that design of the whole product or key components may be used to improve its basic technical performance (e.g. lens quality); to provide new functions (e.g. film dating); to improve ease of use (e.g. autoloading of film); to provide the so-called 'X' factor, or what Peters (1995b) calls 'wow', that attracts a buyer to the look and feel of the product; to improve the build quality, reliability or durability of the product through choice of materials and components, and so on.

Such changes in the design of the product may of course involve the creation, adaptation or adoption of new technologies, inventions or innovations in materials or components. Or it may involve a novel design configuration. But even with such component innovations, improvements to the design of the product may be insufficient to give a manufacturer a competitive edge over its rivals. Design configurations and component innovations may be imitated or adapted, with the result that all manufacturers may end up offering variants on essentially similar products at similar prices within existing product classes. In this situation – when the product has evolved into one or more 'dominant designs' (Utterback, 1994) – competition turns to manufacturing process innovation to reduce prices; service-related non-price factors (sales promotion, delivery, after-sales service, etc.); and to *innovation* at the level of the whole product or its major sub-systems. Such product innovation can be incremental in terms of the basic technologies involved, or radical in terms of design and/or technology.

Applying the categories to the camera example produced Table 3, which gives some examples of incremental and radical innovations in camera design and technology. The Advanced Photo System (APS) cameras launched by various manufacturers in 1996 use a new type of film incorporating a magnetic strip to provide automatic titling and time marking of photographs, choice of print formats and several other new features (Consumers' Association, 1996). APS represents the first new film format since the disc camera, launched by Kodak in 1982 but now withdrawn. The radical innovation of Polaroid instant photography, patented in 1951, is still embodied in several camera designs, but may be displaced for many applications by the introduction of electronic digital cameras which can provide instant images when downloaded to a computer.

Table 3 here

2.2 The Design/Innovation Polar Profile Map

The analysis so far has shown that there are multiple ways in which design and innovation may be employed to enhance the competitiveness of a product. One technique for representing such multiple dimensions is in graphical form. A 'polar profile' map was therefore devised, based on the design/innovation 'dimensions' identified above. This polar map shows seven dimensions through which the competitiveness of a product may be enhanced – six concerned with Design and one with Innovation (labelled 'Technology') – see Figure 1. Each dimension on the polar map has two elements so as to include most of the categories listed in Tables 2 and 3. For example, the 'Style' dimension has two elements representing the styling of the product itself and styling of the product packaging.

Figure 1 about here

3. Design and Innovation in Commercial Performance

The tables of design/innovation roles, and the corresponding polar profile map, may be seen as general analytical tools with which to identify different ways of using design and/or innovation to improve product competitiveness. For the purposes of the MADRID study, however, they were employed to analyse the roles of design and innovation in commercially successful and loss-making product development projects from the existing Commercial Impacts of Design (CID) survey database (briefly described in Section 1). The analysis also aimed to discover if different polar profiles emerged according to the type of project.

The process of analysing and profiling the products from the CID database was carried out in stages.

First, a set of projects which involved inputs of product design, engineering design, or engineering plus industrial design for which detailed financial data was available were selected from the face to face interview section of the CID database. (Pure graphics and packaging design projects were excluded.) This provided 32 projects which were divided into quartiles according to their commercial performance as measured by the payback period on the total investment, with the fastest payback ranked as 1.

12 projects which made a financial loss (due to non-implementation or subsequent market failure) were also identified as suitable for profiling.

Thus a total sample of 44 products or projects was selected for analysis.

3.1 Design Roles

Having identified the sample, the role(s) of design in the development or improvement of each of the 44 selected products/ projects was analysed using categories similar to those shown in Table 2 for the camera example.

It is important to note that this analysis was based on a discussion by research team members of the information in the CID database and not on new information obtained from the firms concerned. To identify the design role(s) for a product/ project each was examined in turn, using the available CID data, including the original questionnaires relating to the project, product brochures, and additional information such as photographs, drawings and samples of the product. Questionnaire information taken into account included the description, specification and illustrations of the product, the business aims of the design project, and what the firm said gave the product a ‘competitive edge’.

For example, in a project to develop a new range of household ceramics, the product was designed for improved features (both function and ease of use), more modern styling (of the product itself) and to extend the existing range. This product would have thus scored two entries under Features and one each under Styling and Range.

Repeating this analysis for each product enabled frequency counts of the design roles for sub-groups of the whole sample to be produced. For example, Table 4 compares the design roles for the upper two with the lower two payback quartiles for the commercially successful products. A similar table comparing the design roles in the non-implemented and the implemented loss-making projects was also drawn up, but for reasons of space is not included here (for details see the full report on the design/innovation role analysis – Roy and Riedel, 1996).

Table 4 here

To highlight any differences in design role and commercial performance, a summary chart comparing the relative frequency of the main design roles or ‘dimensions’ in the profitable and the loss-making projects was compiled using the frequency data from the detailed tables (Figure 2).

Figure 2 here

3.2 Innovation Roles

The above method of analysis, used to identify the design roles in the 44 CID projects, was repeated for the innovation roles. For example, Table 5 shows the innovation roles for the commercially successful products and the loss-making projects.

This analysis indicated that only some 20% of the projects (7 of the 32 commercially successful and 2 of the 12 loss-making) were considered to have involved any kind of innovation. The innovations ranged from a supermarket cheque-writing machine and a multi-functional garden tool to an patented device for joining wire.

Table 5 here

3.3 Polar Profiles

The above analysis is based on aggregated information from a variety of products, ranging from electronic equipment to textiles. In order to see if there were differences for different types of product, the information in the design and innovation role tabulations was employed to plot a polar profile map, similar to that in Figure 1, for each of the 44 selected products.

In profiling a particular product, if one element of a given design or innovation dimension was considered to be present in the project it was plotted on the inner ring of the polar map (i.e. in position '1'). If both elements seemed to be involved it was plotted on the outer ring (i.e. as '2'). (The exception was the 'Technology' dimension, in which a radical innovation scored 2 while an incremental innovation scored 1.)

Thus, for example, in a project that involved the redesign of a music recording console, the CID data indicated that the firm concerned improved both the product's specification and its technical performance. It was therefore plotted in position '2' on the 'Performance' dimension. On the Features dimension it scored '1', because there was improved ease of use but no new features. For Style it scored 1, having improved product styling but no new packaging. For Quality the redesign aimed to convey an impression of improved quality, while retaining existing build quality, giving a 1 score. On Cost/Price, assembly costs were reduced while maintaining sales price, hence a score of 1. No change in Range or Technology was involved, which each scored 0. This gave the polar profile for rank (1) project number 8, here classified as an Electronics project (the top left profile in Figure 3).

The profiling process thus gave the roles of design and/or innovation for the 32 commercially successful products grouped into payback quartiles. Figure 3 shows the polar profile maps for the eight projects which paid back their total investment most rapidly.

Polar profiles were also produced for the 12 commercially failed projects grouped into non-implemented and implemented but loss-making, products. Figure 4 shows a selection of these.

Figures 3 and 4 here

3.4 Findings of the Design and Innovation Role Analysis

A number of observations from the above frequency counts and polar profile maps can be made:

• There appears to be little difference in the frequency and distribution of the roles of design between the commercially most successful products (those in the two upper payback quartiles) and the less successful (in the lower two payback quartiles) – see Table 4. That is, it could not be said that commercially successful products involved more attention to any one design role than the less successful products.

• However, if the role of design in the *commercially successful* projects is compared with that in the *loss-making* projects there do appear to be some differences. In particular, in the successful projects there was more frequent use of design to improve product performance, features and quality than in the loss-making projects. In the loss-making projects, design was more often used for product styling, cost reduction, range unification or customisation than in the profitable projects – see Figure 2.

• A slightly higher proportion of the successful projects involved product innovation – mainly incremental in nature – than the loss-making projects. However, there were insufficient numbers of innovative projects in the sample to come to firm conclusions regarding the benefits and the risks of radical and incremental innovation.

• The polar profile maps clearly show different patterns in the roles of design and innovation for different types of commercially successful project. For example, successful electronic design projects, such as those ranked (1), (2) and (8) in Figure 3, appear to involve consideration of *multiple* dimensions of design and innovation (Performance, Features, Style, Quality, Cost, etc.). In contrast, successful ceramics design projects, such as those ranked (3), (4) and (6) in Figure 3, seem to require consideration of only two, or perhaps three, design dimensions (typically Styling and Product Range).

• The polar profile maps indicate that design projects of all types and levels of complexity – from electronics and mechanical engineering to clothing – which made a commercial loss typically involve consideration of only one or two dimensions of design and innovation (most often Styling and/or Product Range). In other words the loss-making projects tended to involve a narrow, often styling-oriented, approach to design to the exclusion of other aspects which might be important – see Figure 4.

In general the conclusion from this analysis is that commercially successful product development projects, and certainly the more technically complex ones, require a broad, multi-dimensional approach to design of the whole product with a focus on product performance, features and build quality and, where relevant, technical or design innovation. Loss-making projects, even technically complex ones, tend to involve a narrow, often styling-oriented, approach to product design with more attention paid to the product range and cost reduction than to performance, quality and innovation.

3.5 The Role of Contextual factors

Of course the objection might be made that the results outlined above are not necessarily due to the influence of design or innovation, since many other contextual factors might have been involved. To check this firms were asked to rate the relative influence of design and other factors which might have affected the commercial outcome of the project. In only a small minority of projects (12% of the whole CID sample and fewer for this sub-sample) were factors other than design or innovation considered to be the main influence on commercial outcomes. These other factors were mainly marketing effort, pricing and market changes. So while one cannot attribute all the commercial and competitive effects to design and innovation alone, it is probable that they played the major part in the outcome of most of the projects studied.

4. Conclusions

The paper has shown that the roles of design and innovation in improving the competitiveness of a company's products is a complex issue.

A case analysis of the camera market was carried out which showed that design and innovation can be used to improve or differentiate a product from its competitors in many ways. Thus, the design of the whole product or key components may be used to improve its basic technical performance; to provide new functions; to improve ease of use; to provide the styling that immediately attracts customers; to improve build quality, reliability or durability; to reduce manufacturing, distribution or life cycle costs; and/or to unify or extend a product range. The camera example also showed that improvements to the design of the whole product or innovations in particular components may be insufficient to give a manufacturer a competitive edge over its rivals. In this situation manufacturers may attempt to innovate at the level of the whole product or its major sub-systems. Such product innovation can be incremental in terms of the basic technologies involved, or radical in terms of design and/or technology.

Using this framework, the design and innovation roles for a sample of 32 commercially successful products and 12 loss-making projects from the previous Commercial Impacts of Design (CID) study were analysed.

The key conclusions of this analysis include the following:

- For the sample as a whole, there appears to be little difference in the roles of design between the commercially most successful products and the less successful. Likewise there appears to be no significant difference in the frequency of innovation (radical or incremental) between the commercially successful and the less successful products.
- However, if the role of design in the *commercially successful* projects is compared with that in the *loss-making* projects there are differences. In commercially successful product development projects more attention had been paid to genuine improvements in product performance, features and quality than in the loss-making projects, which tended to focus on styling or costs.
- There were clearly different patterns in the design and innovation roles for different types of commercially successful project. For example, successful electronic design

projects appear to involve consideration of multiple dimensions of design and innovation, while a successful ceramics design project may require consideration of only two or three design dimensions.

- Commercially successful product development projects – and certainly the more technically complex ones – involved a broad, multi-dimensional approach to design with a focus on product performance, features and build quality and, where relevant, technical or design innovation. Loss-making projects tended to involve a narrow, often styling-oriented, approach to design, with more attention paid to the product range and cost reduction than to performance, quality and innovation.

5. Future Work

The analysis of the roles of design and innovation in competition has been used for the development of a questionnaire to be used in a second phase of the MADRID research project. This phase involves revisiting approximately forty firms from the original CID study and will test the validity of the conclusions drawn in this paper. It will also investigate the long term benefits of design and the role of design and innovation in company strategy.

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TABLES

Table 1 Price and Non-Price Factors in Competition

FACTOR	EXAMPLE
Price factors	Sales price, discount, financial arrangements for purchase, trade-in allowances, depreciation, running costs, servicing costs, parts costs.
Non-price 'Technical' factors (embodied in the product)	Specification and performance, build quality, appearance and image, innovativeness, technological sophistication, ease of use and maintenance, reliability and durability, compatibility with other products, flexibility and adaptability, ergonomics, portability, safety, comfort.
Non-price 'Service' factors (dependent on organisational arrangements of servicing, production and distribution)	Delivery time, after sales service, user training, packaging, distribution networks, availability of spare parts, technical back up, upgrades, user-friendly manuals, advertising.

After: Walsh et al. (1992, p. 66)

Table 2 The Role of Design in Product Competition

DESIGN ROLE	EXAMPLE (**Camera design and technology**)
Improve specification/ basic technical performance	Lens quality, maximum aperture Shutter speeds Zoom lens range Size and weight, etc.
Provide new/improved features	
- improved function	Auto exposure override Flash 'red-eye' reduction, fill-in flash Film dating, self-timer Weather-proof case, etc.
- improved ease of use/ergonomics/safety	Autofocus/'point and shoot' Autoloading/advance/rewind LCD display of functions
- 'bells and whistles'	Panorama mode Remote control, etc.
Improve style/ image/Provide the 'X' factor/'Wow'/pizzazz	
- the product itself	Shape, configuration, colour, materials, finish (e.g. original Canon Sureshot, Canon Epoca, Olympus XA-2, Olympus LT1)
- product packaging and display	Packaging and graphics
Improve build quality/ reliability/durability Convey impression of quality	Quality of manufacture, workmanship, materials (e.g. Nikon, Leica cameras)
Reduce manufacturing, distribution, etc. costs - reduce sales price and/or - Increase profit margin	Design for ease of manufacture (e.g. Kodak Instamatic cameras), Change materials, components (e.g. Disposable cameras)
Reduce running costs	
- energy, consumables, etc.	Solar powered (e.g. Sureshot Del Sol)
- servicing, repair, replacement	Design for ease of maintenance, reliability, durability
Unify/extend product range/ product family	e.g. Canon Sureshot range
Compliance with standards/regulations (including environmental)	Standard 35 mm film Standard 35 mm lens mounts
Customisation/special purpose	Architectural plate cameras Underwater cameras Panoramic cameras

Table 3 The Role of Innovation in Product Competition

INNOVATION ROLE	EXAMPLE (Camera design and technology)
Incremental innovation	Kodak disc camera Advanced Photo System (APS)
Radical innovation	Polaroid instant photography Nikon digital camera back Casio QV-10 digital camera

Table 4 Design Roles in Commercially Successful Product Development Projects

	COMMERCIAL	PERFORMANCE
DESIGN ROLE	**Upper two quartiles (payback period)** (16 projects) *Frequency*	**Lower two quartiles (payback period)** (16 projects) *Frequency*
Performance	**5**	**5**
Improve specification/ technical performance		
Features	**17**	**13**
Provide new/ improved features		
- improved **function**	9	6
- improved **ergonomics**/ease of use/safety	8	7
Style	**16**	**14**
Improve style/ image/provide the ‘X’ factor/‘Wow’/pizzazz		
- the **product** itself	14	10
- product **packaging** and display	2	4
Quality	**9**	**9**
Improve **build** quality/reliability/durability	3	4
Convey **impression** of quality	6	5
Cost/Price	**7**	**8**
Reduce manufacturing, distribution, etc. costs	2	1
- Reduce sales **price**	3	4
- Increase **profit** margin	2	3
Range	**13**	**11**
Unify product range	2	2
Extend range/product family	11	9
Reduce running costs	**0**	**0**
- energy, consumables, etc. - servicing, repair, replacement		
Compliance with standards/ regulations (including environmental)	**1**	**1**
Customisation/ special purpose	**0**	**4**
Other	**5**	**2**

Total sample: 32 projects

The numbers in **bold** are total occurrences for each design role, for the 16 successful projects present in each of the upper two and lower two payback quartiles.

Table 5 Innovation Roles in Commercially Successful and Loss-making Product Development Projects

	COMMERCIAL	PERFORMANCE
INNOVATION ROLE	**Successful** (32 projects) *Frequency*	**Loss-making** (12 projects) *Frequency*
Incremental	**5**	**1**
Radical	**2**	**1**

Total sample: 44 projects

FIGURE CAPTIONS

Figure 1 The Design/Innovation Polar Profile Map.
Each 'dimension' on the map (Performance, Features, etc.) represents a broad approach to improving the competitiveness of a designed product , and each dimension is broken down into two elements (given in brackets) representing more specific ways of enhancing product competitiveness

Figure 2 Comparison of Design Roles for Commercially Successful and Loss-making Projects

Figure 3 Polar profile maps for the eight most commercially successful products – top quartile for payback on total investment.

Each profile is labelled with the project's rank position on payback (in brackets); the project identification number and the type of product. (E.g. The top left profile is payback rank (1) project number 8 for an electronics product.)

Figure 4 Polar profile maps for selected loss-making projects. The upper 6 maps are for non-implemented projects; the lower 2 are for implemented projects.

Each profile is labelled with the project identification number and the type of product involved.

Authors' Biographies

Robin Roy is a Senior Lecturer in Design at the Open University with a B.Sc. in mechanical engineering and M.Sc. and Ph.D. degrees in design and planning from the University of Manchester Institute of Science and Technology. Since joining the OU he has chaired and contributed to many courses, including *Man-made Futures*; *Design: Processes and Products*; *Design: Principles and Practice*; *Design and Innovation*; *Managing Design* and *Innovation: Design, Environment and Strategy*.

He is head of the OU/UMIST Design Innovation Group, which he founded in 1979. His research interests include ecodesign and sustainable technologies, the management of design and innovation, and the design evolution of bicycles and railways. He has written or edited eight books and published over sixty research papers on these and other topics.

[Photo of Robin Roy]

Johann Riedel is the Design Council Co-Partnership Research Fellow in the Department of Design and Innovation in the Faculty of Technology at the Open University. He has a B.Sc. in electrical and electronic engineering, M.Sc. in social and economic aspects of science and technology and a Ph.D. in design management. He has over ten years experience teaching and researching innovation, design, and management. He is currently working on the MADRID - 'Market Demands that Reward Investment in Design' project.

He has several other research interests including corporate strategy, the Internet and the 'information revolution', computers and organisational behaviour. He has written chapters for books and published over twenty research papers.

[Photo of Johann Riedel - if available]