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Design and innovation in Norwegian industry

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Abstract

Design and Innovation in Norwegian Industry

It is often suggested that design is a central component of innovation. Good-quality design affects not only the aesthetic appearance of a product, but also its overall technological character and performance. So we would expect design capabilities to be a key aspect of how companies develop and modify products, and therefore of their competitiveness.

In recent years Statistics Norway (Statistisk Sentralbyrå) has developed new data on design expenditure and new product development in Norwegian firms, and the STEP group analysed this data for the Norwegian Design Council, looking at the effects of design activities on innovation output and profitability in Norwegian industry. Is it really the case that design-intensive firms perform better than firms which do not use design inputs?

The report asks three basic questions:

- Do design-performing firms have more innovative activity (that is, higher expenditures on innovation in general) than ‘Non Design’ firms?
- Do design-performing firms have higher levels of innovation (that is, higher proportions of their sales coming from new products) than ‘Non Design’ firms?
- Are design-performing firms more profitable?

The data analysis shows that the answer to each of these questions is ‘yes’. Firms that spend money on design perform better than those that do not. Firstly, they spend more on innovation as a whole and they place a higher value on innovation objectives than Non Design firms. Secondly, they generate a significantly higher proportion of their sales from new and technically changed products. Thirdly, when we look at accounting data for the firms concerned, they appear to be more profitable. The study strongly suggests that design capabilities are of great importance for both the innovation performance and the competitiveness of Norwegian firms.

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Chapter 1: Design and innovation

1.1 Introduction

How important is industrial design in the innovative activities of Norwegian firms? To answer this question it is useful to discuss how we understand the innovation process as a whole, and how design activities fit into innovation processes. In this chapter we offer an overview of how design relates to modern theories of innovation, and a view of how ‘innovation-oriented’ design can be conceptualised.

1.2 Design and competitiveness

Industrial design can be a strategic resource within companies. The right design can be a decisive factor when a new product enters the market, since it will make customers feel the product is more attuned to their needs. There is a range of literature which provides examples of such stories through detailed case studies. Industrial design focuses on functionality or characteristics of products. Often, the desired characteristics involve a trade-off; making a product more elegant can make it harder to use, making it cheaper can lessen the quality and making it technologically optimal may reduce user-friendliness. Within this process, design may play an important role in identifying a balance between complex and conflicting aspirations. Consequently one would expect to find a higher rate of successful product development within firms that engage in product design. This report will assess, on the basis of quantitative data, whether or not there is a correlation between investment in product design and company performance.

1.3 Modern theories of innovation

In understanding the process of innovation, modern analysis usually begins from Schumpeter's view that competition is primarily a technological phenomenon. The basis of competition is the quality, design characteristics and performance attributes of products. Firms seek competitive advantage on the one hand by continuous development of technologically differentiated products, and on the other by changing processes so as to generate these products with competitive cost structures. Usually, innovation takes the form of incremental change within fields in which firms have specialised skills and experience; that is to say, firms seek to establish a technically differentiated product range within an established technological framework.

What is involved in the innovation process itself? Most modern research sees innovation

- first, as an interactive social process which integrates market opportunities with the design, development, financial and engineering capabilities of firms,
- second, as a process characterised by continuous feedback between the above activities
- third, as a process characterised by complex interactions between firms and their external environments
- fourth, as a process which is continuous rather than intermittent

The primary problem for the firm is to build technological competence and capabilities which will enable it to create distinct areas of competitive advantage. Through marketing exploration and general relationships with customers or product users, firms attempt to identify opportunities for innovation. However, this is usually done within the context of an existing set of technical skills, and an existing knowledge base. Firms use their engineering and design skills to create new products within the general knowledge base which they possess. Research - in the sense of a search for novel technological solutions - is usually undertaken only when firms face problems which they cannot solve within their existing knowledge bases. In other words, *research is not necessarily the primary process generating innovative ideas: it is better seen as problem-solving activity within the context of on-going innovation activity.*

A key point is that firms can combine these various components of the innovation process in many ways. Firms not only produce differentiated products, they generate innovations in different ways.

1.4 What do firms do when they innovate?

Unfortunately we are still some way from being able to provide an adequate model of the innovation process. Within economics, technological change has largely been understood either as something outside the economic system, or as something which is determined by the environmental situation of the firm (such as the market structure of the industry). However, there has been a wide range of recent work which offers a good foundation for conceptualising innovation. What follows here is a sketch of the general structure of this concept and of the specific firm-level activities which it involves.

As a point of departure, innovation should be seen in the context of the competitive behaviour of the firm; it is one component of a set of activities which make up competitive strategies. Competition in industrial market economies is technological in two senses. Firstly, in the face of consumer demand for products, firms compete in terms of the design, quality and performance characteristics of products; that is, in terms of a set of technically determined product attributes. Secondly, firms compete with process technologies which shape both the technical forms of the product, and the cost structure of the firm. In general, this is a dynamic, evolving phenomenon: patterns of demand evolve and change, and this together with the innovative activities of competitors means that firms must innovate on a continuing basis. The technical outcomes of most innovation processes are uncertain, as are the economic outcomes; the latter follows from the fact that the firm makes its choices in an environment of interdependent decision-making, where success or failure depends not only on what the firm does but on the actions and choices of competitors. Firms must, because of these considerations, develop strategies: that is plans and objectives for process and product technology, which are based on conjectures about the nature of demand, the likely actions of competitors, and their own technological capabilities.

Possible technological strategies are bounded or constrained by two factors. Firstly, there are the *technological opportunities* facing the firm: these opportunities occur within an existing set of historically and technically determined design and production parameters.

How firms respond to technological opportunities depends in large part on the second factor shaping technological strategy. This is the *technological capability* of the firm: the skills of its employees, its areas of technical competence, and the nature of its organisation and management. These capabilities are themselves dynamic: they depend on past performance (so the firm's capabilities are often shaped by its history of past success or failure), and they can be changed by conscious processes of change and learning.

Firms and industries differ in terms of the technological opportunities they face. At any particular time, there is usually also variation in the capabilities of firms, since their capabilities are the result of historically shaped learning paths. At the same time, success in technological competition is usually based on difference or diversity: it implies a conscious attempt by firms to differentiate their products or their production processes from those of their competitors. For all these reasons, there is considerable variation and diversity within and between industries, in terms of technological strategies, assets and behaviour.

Against this background, what activities can the firm undertake if it wishes to innovate, that is to change its technological assets, capabilities and performance in the area of production? The main options are:

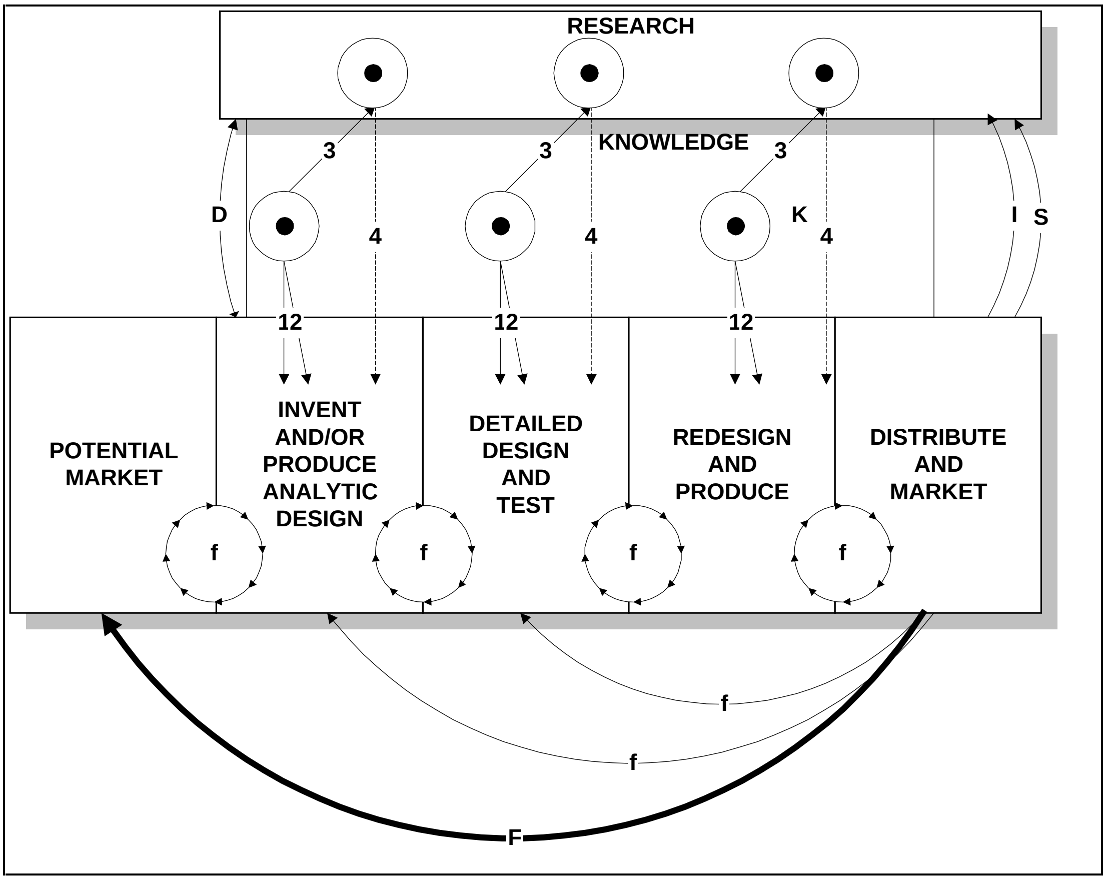
> (1) The firm can undertake basic research to extend its knowledge of fundamental processes related to production.
>
> (2) It can engage in strategic research (in the sense of research with industrial relevance but no specific applications) to extend the array of applied projects which are open to it, and also in applied research to produce specific inventions or modifications of existing techniques.
>
> (3) It can develop new products on the basis of learning around its existing knowledge base. Bringing new products to commercial feasibility can involve (i) prototype design, (ii) development and testing, (iii) further research to modify designs or technical functions, (iv) market exploration, and (v) the development of pilot and then full-scale production facilities.
>
> (4) It can, by paying fees or royalties, purchase technical information in the form of patented inventions (which usually require research to adapt and modify), or it can purchase information and skills through engineering and design consultancy of various types.
>
> (5) It can develop (through internal training) or purchase (by hiring) human skills relevant to production.
>
> (6) It can invest in process equipment or other inputs which embody the innovative activities of others; this can range from components, to machines, to entire plants.
>
> (7) It can reorganise management systems and the overall production system and its methods.

All of these functions can be carried out independently by the firm, but some can involve collaboration, joint ventures, or inter-firm agreements of various kinds; they can also involve collaboration between the firm and the public sector. Furthermore, all of these activities can take the form either of small-scale incremental change, or radical disruptions of existing methods, or of some combination of these. Moreover, innovation processes can be extended into the marketing and distribution activities of the firm.

1.5 Design in a model of innovation

Perhaps the best available model consistent with the innovation activities described above is the so-called "chain-link" model proposed by Kline and Rosenberg. This is described in Figure 1.1.

Figure 1.1. The Chain-Link Model of Innovation



Source: L. Kline and N. Rosenberg, "An Overview of Innovation", in R. Landau and N. Rosenberg (eds.) **The Positive Sum Strategy. Harnessing Technology for Economic Growth** (Washington DC: National Academy Press), 1986, p.289

The chain-link model sees innovation as a set of six interconnected development activities, often highly uncertain in their outcomes. By far the most important components of innovation in this model are design activities and marketing: the key problem for the firm is to link its design competence with market demand. Because of this uncertainty there is no simple progression between the phases of the process: it is often necessary to go back to earlier phases in order to solve developmental problems, so feedback loops exist between all the phases of the process. A key element determining the success or failure of innovation is the extent to which firms are able to maintain the links between the phases of the innovation process: the model emphasises, for instance, the central importance of the connection between marketing and the invention/design phases.[1] In the chain-link model R&D is not viewed as a source of inventive ideas: it is seen as a form of problem solving, which may be called upon at any point in the innovation process. At any particular time a firm has an existing knowledge base within which it seeks solutions to the problems which inevitably occur in producing innovations. The research system, on a different level, takes up problems which cannot be resolved within the existing knowledge base, and thereby extends the knowledge base of the firm. But this approach has important implications for how we understand "research". Because research can relate to any phase of the innovation process, it is a complex and internally differentiated activity which potentially forms a wide variety of functions. It is an adjunct to the innovation process, not a precondition for it; indeed many of its activities will be shaped by the innovation process, and many of its problem areas will derive from innovative ideas generated elsewhere. Above all, it should not be seen simply as a process of discovery which precedes innovation.

1.6 The concept of ‘analytic design’

A key point about the interactive model of innovation presented above is the role of ‘analytic design’ within it. What exactly is meant by this term?

One way of approaching the role of design is through an important conceptual distinction in the study of innovation. This is a distinction between the concept of a ‘technological regime’ or ‘technological paradigm’, on the one hand, and a ‘design configuration’ on the other.

The concept of the "technological regime" is one of the key elements in the modern economic theory of technological change. A "technological regime" refers to the whole complex of scientific knowledge, engineering practices, process technologies, infrastructure, product characteristics, skills and procedures which make up the totality of a technology. In a study by Georghiou *et al* on post-innovation improvements and competition the concept of a technological regime is also used. A technology regime is defined as:

> a set of design parameters which embody the principles which will generate both the physical configuration of the product and the process and materials from which it is to be constructed. The basic design parameters are the heart of the technological regime, and they constitute a framework of knowledge which is shared by the firms in the industry[2]

A closely related concept, of ‘technological paradigm’ has been developed by Giovanni Dosi, who defines a paradigm as follows:

> A technological paradigm defines contextually the needs that are meant to be fulfilled, the scientific principles utilised for the task, and the material technology to be used. (...)

---

[1] This accords with a very solidly established result in innovation analysis, which is that innovative success depends heavily on the degree to which marketing is integrated with the technical aspects of the innovation process. For a general discussion, see C. Freeman, **The Economics of Industrial Innovation**, , (London: Pinter) 1990, Ch.5: "Success and Failure in Industrial Innovation."

[2] L. Georghiou, J.S. Metcalfe, M. Gibbons, T. Ray, J. Evans, 1986, **Post-Innovation Performance: Technological Development and Competition**, MacMillan, London, p. 32.

> A technological paradigm is both an exemplar - an artefact that is to be developed and improved (such as a car, an integrated circuit, a lathe, each with its particular techno-economic characteristics) - and a set of heuristics (e.g. Where do we go from here? Where should we search? What sort of knowledge should we draw on?).[3]

Information and Communication Technology (ICT) is an example of such a paradigm which came to replace the paradigm of energy- and material-intensive mass production. The term "paradigm" is used to describe the radical transformation of the prevailing engineering and managerial common sense for best productivity and most profitable practice, which is applicable in almost any industry (i.e. it is a *meta* paradigm). Further, each new techno-economic paradigm involves a particular input or set of inputs (the "key-factor" of the paradigm) which fulfils the following functions: clearly perceived low and rapidly falling relative cost, an almost unlimited supply over long periods, and a clear potential for the use or incorporation of the new key factor or factors in many products and processes throughout the economic system.

The concept of paradigm or regime defines the broad structure of a technology. Within the technological regime, however, many variants are possible. These are usually the outcomes of a design process:

> one could say that the technological regime, that is, the shared knowledge base of an industry, remains constant from year to year but within that framework technical change is identified in the set of design configurations and manifested in the changing composition of product and process characteristics. ... a given technological regime may evolve in two ways, the development of a new design configuration and/or development within existing design configurations[4]

This idea of design, as an activity within a well-understood set of technological principles, suggests that design may be an extremely creative process without necessarily involving new technological principles. That is, it is something quite separate from invention in the innovation process. It is this which Rosenberg and Kline refer to when they use the term ‘analytic design’:

> What is the nature of the designs that initiate innovations? Historically these have been of two types, ‘invention’ and ‘analytic design’. The notion of invention is generally familiar: it is a new means for achieving some function not obvious beforehand to someone skilled in the prior art. It therefore marks a significant departure from past practice. Analytic design, on the other hand, is a routine practice on the part of engineers. It consists of analysis of various arrangements of existing components or of modifications of designs already within the state of the art to accomplish new tasks or to accomplish old tasks more effectively or at lower cost.[5]

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[3] Giovanni Dosi, 1988, Sources, Procedures and Microeconomic Effects of Innovation, **Journal of Economic Literature**, p. 1127.

[4] Giorghiou et al, p.34

[5] Kline and Rosenberg, p.292

The point here is that design may be a crucial input to innovation without necessarily involving either research or invention. This function of design has certainly been neglected in the past study of innovation. But which industries rely on design in innovation, and how do design inputs relate to innovation performance? We turn now to an empirical study of these questions, looking at the Norwegian industrial sector.

Chapter 2: Design activities in Norwegian industry - an overview

2.1 Innovation and design : a quantitative overview

The basic concern of this chapter is to outline differences between design-using and Non Design-using firms in relation to innovation.

This chapter - like those which follow - is based on quantitative data from the 1993 Norwegian Innovation Survey, which collected data relating to many different aspects of innovation inputs and outputs in Norwegian industry. We begin with an overview of this unique data source, and then provide an overview of design activities in Norwegian industry based on this source.

The survey collected general information on each firm, including figures for total turnover, exports, investments and employees, and information on firms' connections with larger concerns. In addition, the survey collected innovation specific data covering the following areas:

- Costs associated with development of new products (R&D, training, design, market research, procurement of new equipment and tools).
- The firm's motivation and objectives in connection with the innovation(s), and the obstacles they have met in their innovation activities.
- Turnover, and the proportion of this accounted for by new or significantly modified products, distribution of turnover in relation to which phase a product is in (introductory, growth, maturing and decline).
- Sources of new technology and information in connection with innovation activities.
- Technological co-operation.
- Connections with public sector support activities.

2.2 Definition and measuring of innovation

Innovation is a complex phenomenon. It is therefore important to note that this study does not describe the innovation process in its entirety, but rather focuses on some of the central aspects of innovation activities and results. The following gives a brief description of how this study defines and measures "innovation".

"Innovation" is a concept which can be defined very broadly. In technical literature innovation is defined as doing something new, usually on the basis of new knowledge. This can, however, be further defined as new products or processes, new structures of organisation, or new knowledge of physical processes.[6] Beyond a certain point, many aspects of the innovation process do not allow themselves to be measured, or are extremely difficult to measure. Innovation can in a broad sense be compared with economic concepts such as "use" or "welfare" - concepts which are subjective, not open to comparison or direct measurement. This does not mean, however, that all aspects of innovation are impossible to measure, nor that we cannot find relative quantitative *indicators*. This is particularly true in the case of new products; they have a real existence, they can be identified by firms in their collected product-range and their sales can be estimated, often with a high degree of accuracy. As one of the most important objectives of this investigation was to obtain economic information about innovations, the survey concentrated primarily on this aspect of innovation; new products.

The data from the investigation is based on three basic concepts: A definition of *technology*, a definition of *innovation* and a definition of two types of *new products*. Technology is defined as "knowledge, skills, competence and equipment" necessary for the development and/or manufacturing of a product. We say that an innovation has been carried out when "a new or modified product is introduced on to the market, or when a new or modified process is employed in commercial production". There are two types of product innovation; "basic" and "lesser":

- a basic innovation is a product which is introduced to the market and is new or significantly altered as regards use, technical construction, design or use of materials. Such innovations can be based on entirely new technologies or on combinations of existing technologies used towards new ends.

- a lesser innovation is where the technical characteristics of an existing product have been improved. This can take place in the following ways:

  - a simple product has been improved in terms of performance or lower manufacturing costs, as a consequence of new components or materials being used,

  - a product composed of a series of integrated sub-systems has been improved as a consequence of alterations to one or more of its sub-systems.

In addition, the definition excludes purely aesthetic changes, such as a new colour or small changes to design and packaging.

In this context it is necessary to define what is required for a product to be called "new". A product innovation can be new in several ways: new to the firm, new to the industry, or new on a global scale. This investigation is first and foremost concerned with those product innovations which are new to *the firm*. The study is not, therefore, concerned with identifying the most advanced innovations, but rather with looking at the technological changes taking place within individual firms. However, the questionnaire does also ask about innovations that are new to the industry as a whole, and we are therefore in a position to distinguish between innovations that are wholly new, and those which simply represent the diffusion of technology between firms.

[6] Everett Rogers gives an example of a broad definition: ‘An *innovation* is an idea, practice or object that is perceived as new by an individual or other unit of adoption’; E. Rogers, **Diffusion of Innovations** (3rd edition), (New York: Free Press), 1983, p.11

In order to measure the results of their innovation activity, firms are asked to account for changes in their product-range in accordance with the above definitions. The most important aspect of innovations is of course that they actually reach the market-place; that they are not simply new in a technological sense, but that they are also commercialised. The questionnaire asks firms to estimate the proportion of sales turnover accounted for by the various types of innovation. The most important indicator of innovation ability in this study, therefore, is the proportion of sales and export profits accounted for by altered products.

The branch coverage and response rates are shown in Table 2.1:

Table 2.1 Gross and net sample; selection-percent, response rate and no. of firms according to industry.

	Gross sample		Net sample		Population
Industry	Selection percent	No. of firms	No. of firms	Response rate	Coverage rate
INDUSTRY	34	1848	954	52	18
Food, beverage and tobacco	34	372	183	49	17
Textiles, clothing	33	91	49	53	17
Wood products	29	224	103	46	13
Pulp and paper	61	38	21	55	34
Graphical industry	30	247	127	51	15
Chemistry	38	108	44	41	16
Mineral products	34	73	42	58	20
Metals	68	45	27	60	41
Metal products	30	214	121	56	17
Machinery	38	156	85	54	21
Electrical machinery, etc.	39	87	48	55	21
Transport equipment	37	142	76	54	20
Scientific instruments, optics	35	17	9	53	19
Other manufacturing	33	34	19	56	18
MINING	32	40	22	55	18
OIL AND GAS	88	14	10	71	62
TOTAL	**34**	**1902**	**986**	**52**	**18**

2.3 Design costs across industries

We will now turn to the distribution of innovation expenditures across industries. Which innovation activities are most important? Questions regarding different aspects of innovation activities were, naturally, only posed to those firms that reported having innovation costs. Consequently we compare firms with design expenditure to firms reporting innovation costs other than product design. The topics in this part of the survey covered motivation for innovation activity, sources of information, technology transfer and R&D co-operation. When considering more general topics such as industries, size and turnover we also included firms with no innovation activities. As mentioned above, the compilation of data has until recently focused on R&D. The statistical manual that is the base for the collection of R&D data specifically names six areas of activity that are **not to be included** in these data-sets**.** These are tooling up, pre-production development, market analysis, investment in equipment, purchasing of technological information and design[7]. This list

[7] OECD, **Measurement of Scientific and Technological Activities ('Frascati Manual')** (OECD: Paris), 1981, pp.17-19.

represents many of the activities besides R&D that modern theories of innovation incorporate in their analyses[8]. The main reason for this is that R&D is of marginal significance for developing new products and processes in a range of industries. The Norwegian Innovation Survey asks about many of the above mentioned activities, including:

- R&D
- Product design
- Pilot production and product start-up
- Purchase of patents and licences
- Market analyses
- Other innovation costs

Since this paper concentrates on design, it should be noted that the contents of the term design varies across countries and across industries. In Norway people identify the term mostly with aesthetic aspects. In a survey, 47% of Norwegian firms associate the term with "appearance, form and colour" while 34% answered "composition" and 10% "user characteristics and functionality"[9]. However, in the current survey the term "Product Design" is tied to the improvement or development of products. For instance, graphical design is excluded, as is alteration of products that is not connected to changing construction or performance. Still, the term is not precisely defined in the survey. It is not unlikely that a number of activities which in English are included within the terms “engineering design” and “industrial design”, will in Norway be included within the categories “product development” or “pilot production”. Thus the survey results may be slightly skewed (in a way which underestimates use of design activities). However, the answers are based on the respondents’ own perceptions of the nature of their activities, and we consequently believe that they give a realistic picture of the effort put into different types of innovation activities.

Figure 2.1. below presents the distribution of innovation expenditure across industries. As is evident from the figure there are large variations in input factors across the different industries, but we will, naturally, be concentrating on the product design component[10].

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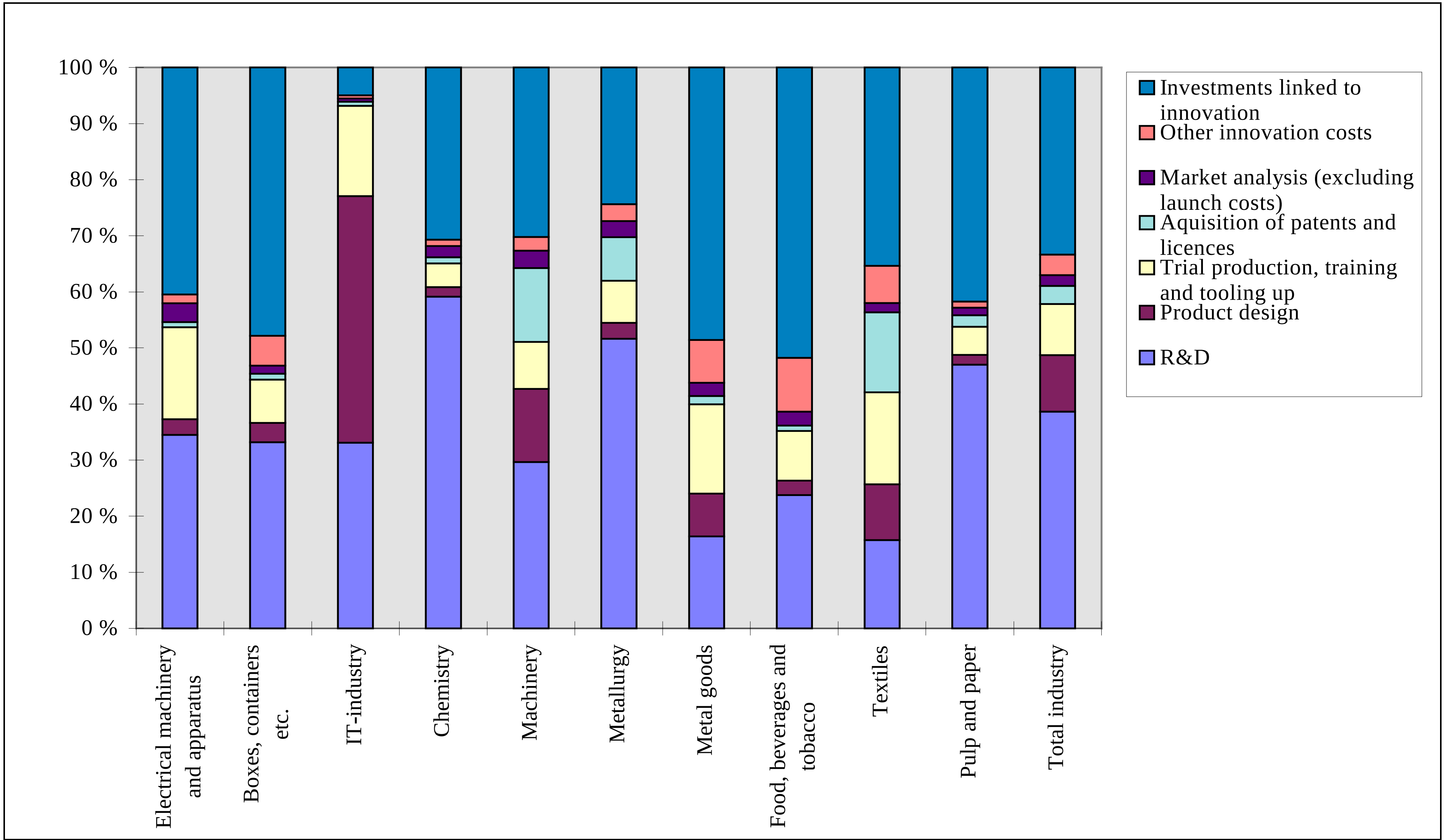
[8] See Rosenberg and Kline, op. cit.

[9] ScanFact (1996) Design i norske bedrifter (’Design in Norwegian Companies’)

[10] Nås, S.O., Sandven, T. and Smith, K. “Innovasjon og ny teknologi i norsk industri: En oversikt”, STEP-report nr. 4/94, as well as STEP Arbeidsnotat nr. 6-15/95

Figure 2.1 Innovation activities across industries



Product design is not dominant in most industries, except for IT (44%). The average is around 10%, but most industries estimate their product design expenditures at between 1.7% and 3.5% of their total innovation costs.

However, if we distinguish between those firms that include product design as one of their innovation activities and those with only other innovation activities, we find a different picture. In all 352 firms in the survey reported expenditure associated with one or more innovation activities. Of these firms 194 engaged in product design as one of their activities. 158 firms engaged in some innovation activity **other than** product design (R&D, market analyses etc.). If we look at the distribution of these two groups across industries the proportion of firms in each industry that engage in product design varies greatly. (Note: There are thus three groups of firms in the survey: Firms engaged in Product Design will henceforth be called Design Firms, firms engaged in other innovation activities, but not in Product Design, will be called Non-Design Firms, while the third group, firms without any innovation expenditure, will be called Non-Innovative firms.)

Table 2.2 Number of firms with product design expenditures across industries

ISIC	**Industry**	**Design Firms**	**Non Design Firms**
22	Oil and gas	2	8
23+29	Mining	1	3
31	Food, beverage and tobacco	28	27
32	Textiles, clothing	9	3
33	Wood products	12	14
341	Pulp and paper	4	7
342	Graphical industry	10	22
35	Chemistry	9	18
36	Mineral products	11	5
37	Metals	5	11
381	Metal products	32	7
382	Machinery	27	13
383	Electrical machinery, etc.	16	11
384	Transport equipment	22	4
385	Scientific instruments, optics	2	3
39	Other manufacturing	4	2
	Total	194	158

Figures 2.2 and 2.3 below show the distribution of innovation expenditures within both groups. The first figure shows that where a firm does report Product Design expenditure, this accounts for a rather large share of its innovation costs. In addition the share for Market Analyses is nearly twice as great for the Design Group as for the Non-Design Group.

The two groups also differ in terms of how much they spend on innovation. Figure 2.3 shows that innovation expenditure per employee is almost 55.000 NOK in the Design Group and near 40.000 NOK in the other group. However, in terms of using external services, the latter group is more active.

Figure 2.2. Innovation expenditures (running costs) by innovation activity.

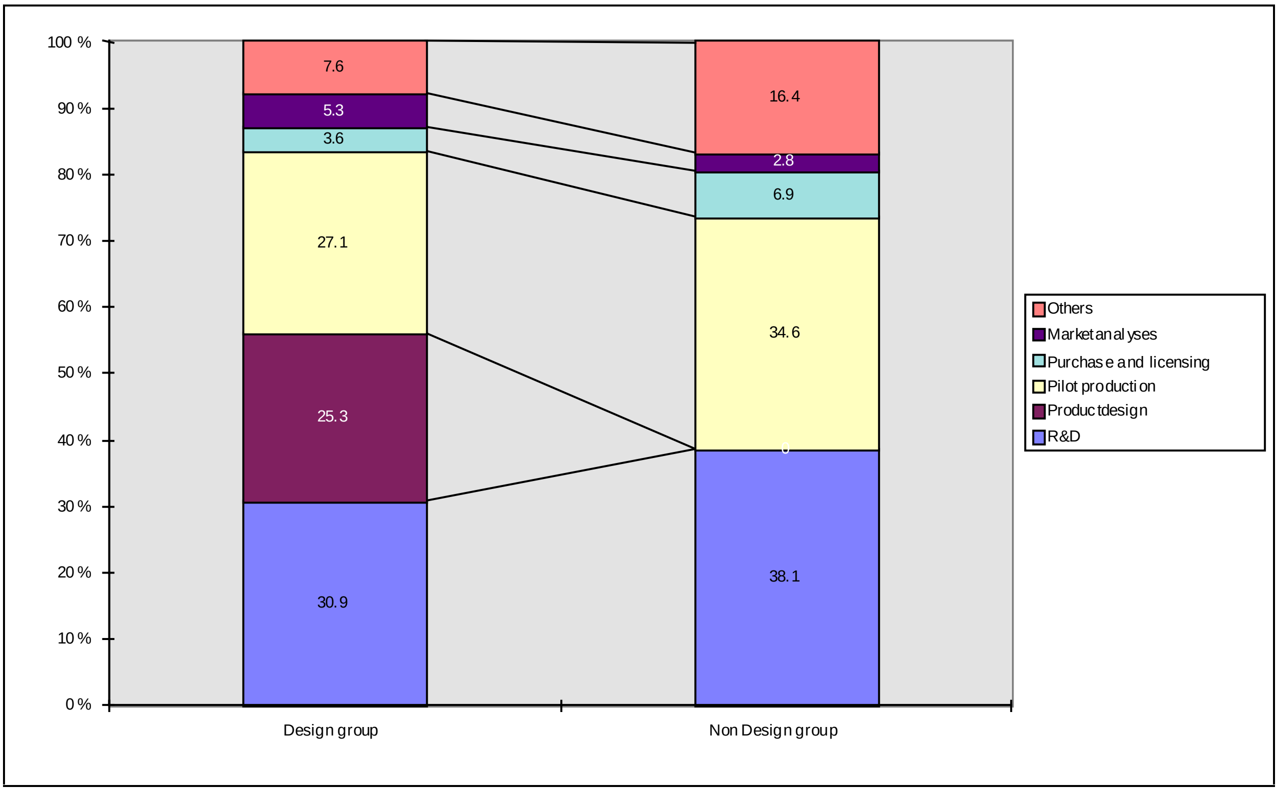
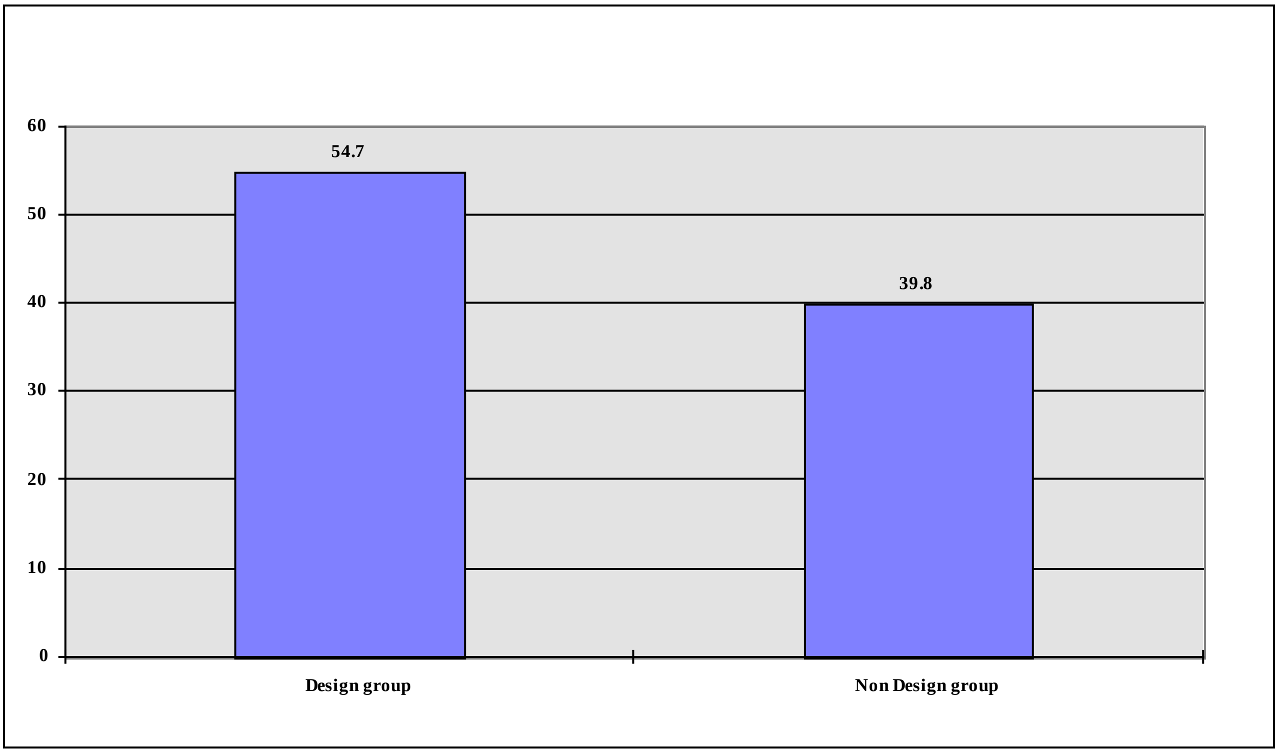


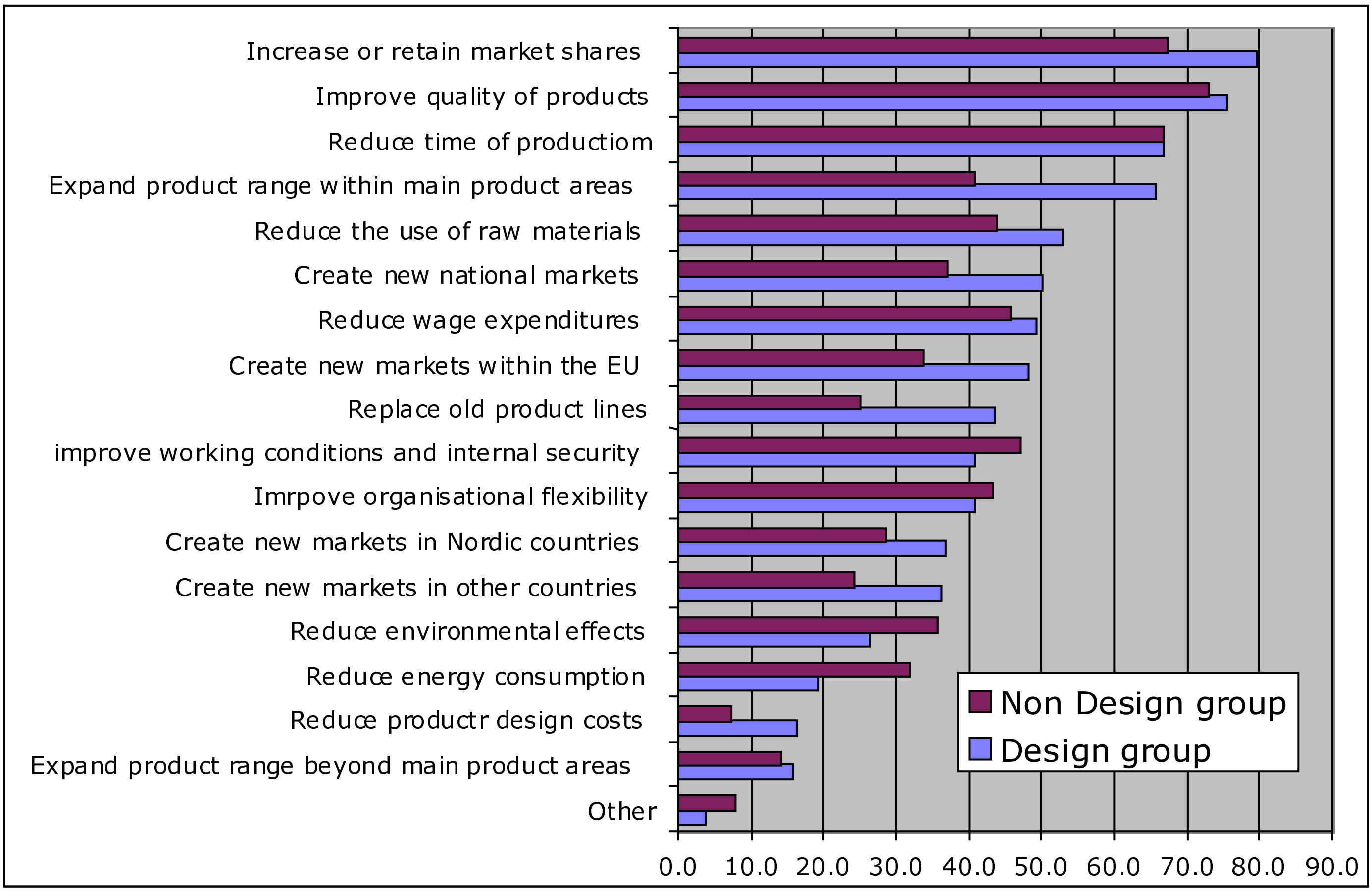
Figure 2.3. Innovation expenditure per employee. **(1000 NOK)**



2.4 Objectives of innovation activity

Apart from the above mentioned variances, the survey can also give us some idea of whether firms' objectives differ between the two groups. The companies were asked to provide information on the relevance of a range of objectives to their particular case. Whilst answers did not differ radically between the two groups, it may be noteworthy that the design firms did emphasise objectives related to product range more than the other firms.

Figure 2.4 Objectives of innovation activities



The objectives rated most important to the design firms were to

- Create new national markets
- Reduce material consumption
- Expand product range within main areas
- Reduce time of production
- Increase product quality
- Increase or retain market shares

These objectives were mostly shared with Non-Design firms as well. Apart from differences in relation to "product range", the largest variance can be seen in the aim of "reducing product design costs".

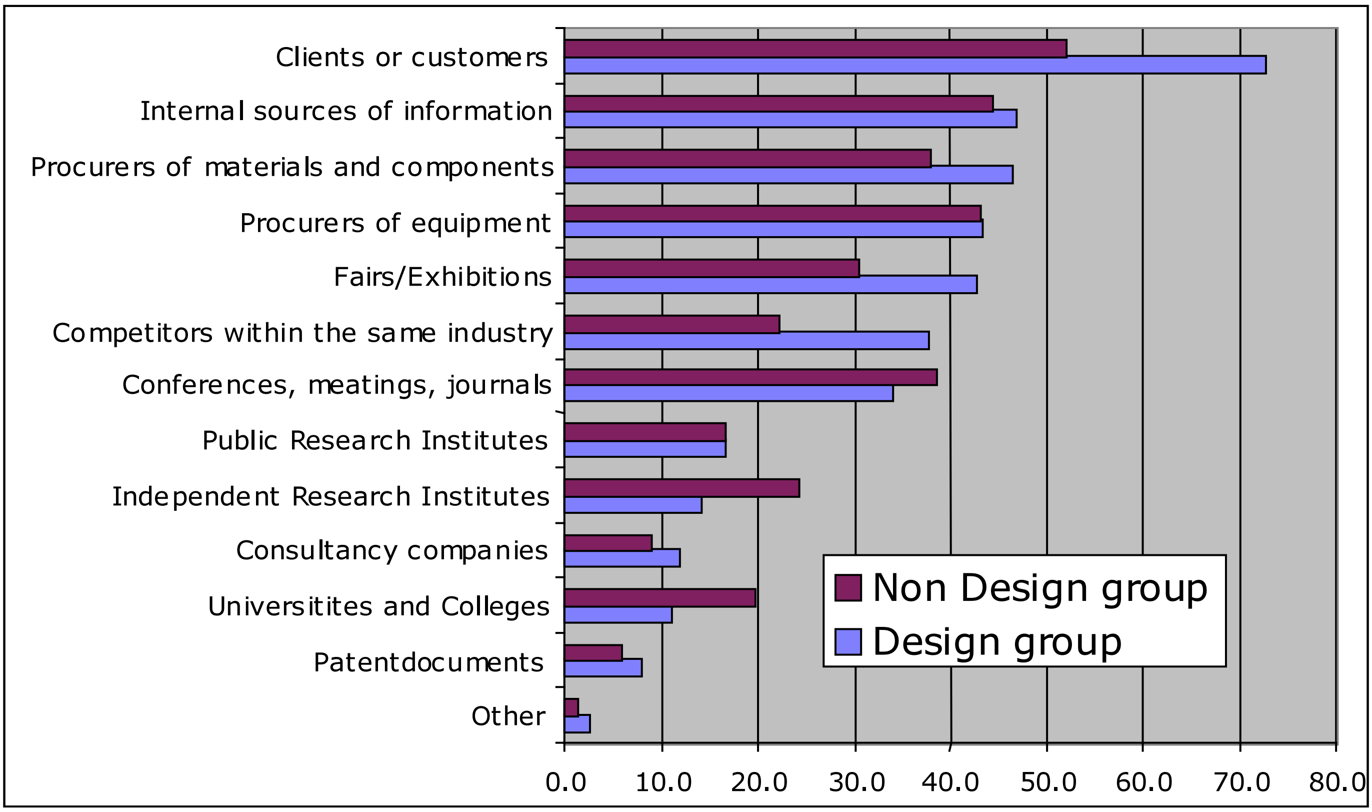
2.5 Sources of information within innovation activity

There are a number of sources of information that companies use in their innovation activities. The most important for both groups were

- Procurers of equipment
- Procurers of materials and components
- Internal sources of information
- Clients or customers

In addition, the Non Design group reported that conferences and meetings were of high importance. The variance between the two groups is even less pronounced in this regard, except for "clients or customers", which three-quarters of the design firms rated as decisive and "competitors within the same industry".

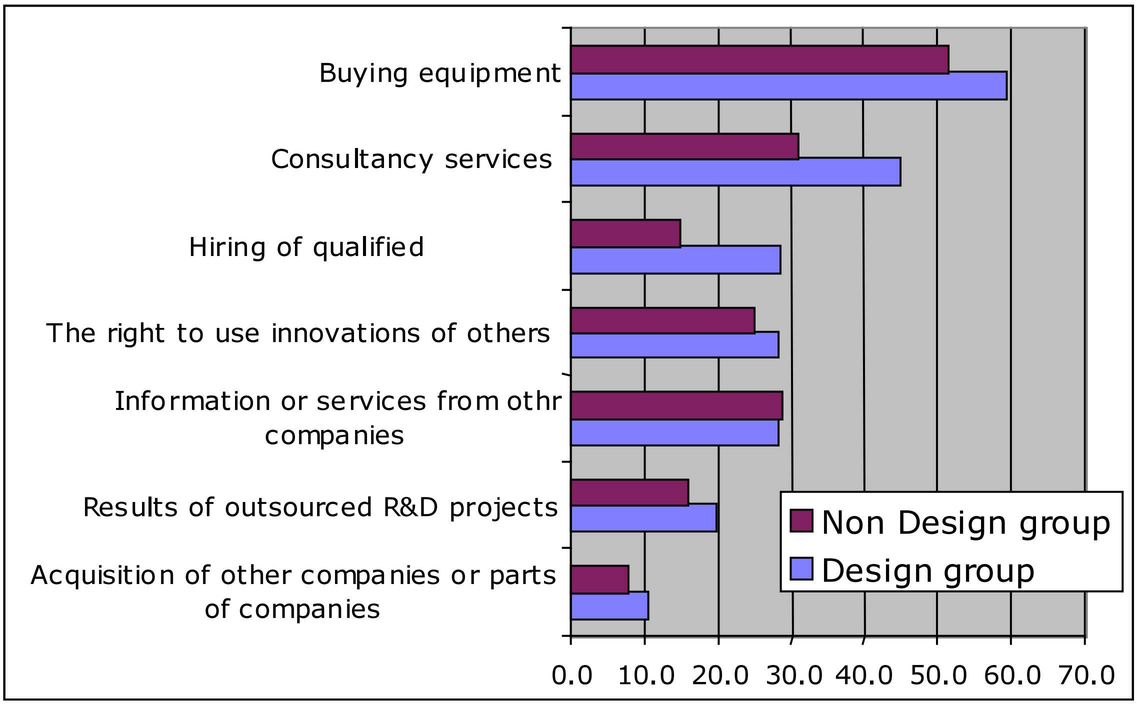
Figure 2.5 Sources of information for innovation activities



2.6 Technology transfer - acquisition of technology

A key aspect of innovation activity is the acquisition of technology. Figure 2.6 below shows the proportion of companies in both groups that reported acquiring technology through different channels. Differences are notable for one category, namely "Hiring of qualified personnel"; almost twice as many design firms rated this as an important channel than Non Design firms. If we consider this together with the high share accounted for by consultancy services, it seems likely that design firms depend to a greater extent on acquiring intangible technological knowledge, related more to personnel than to hardware. Nevertheless, purchase of equipment was considered the most important category of all.

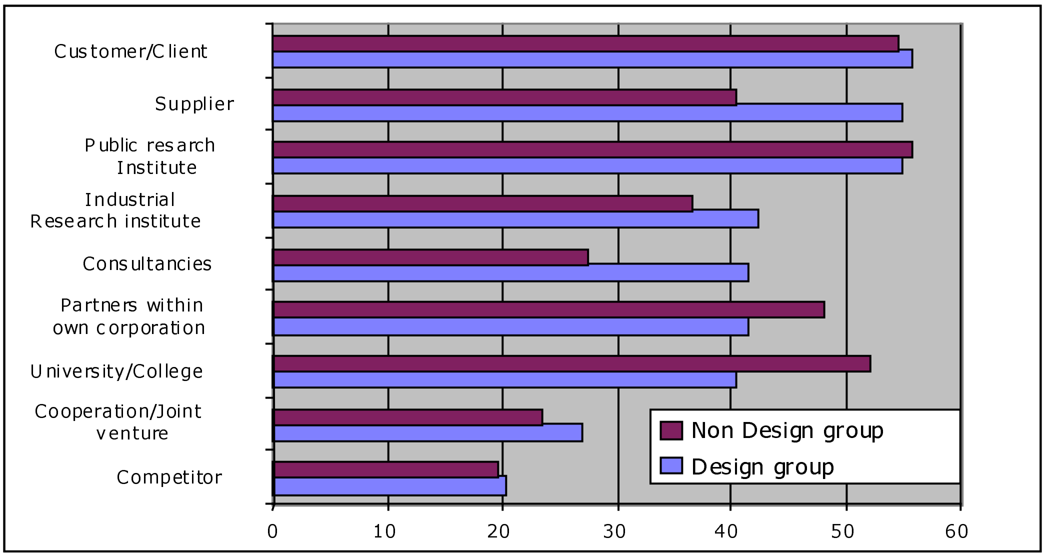
Figure 2.6. Ways of acquiring technology



2.7 R&D-Co-operation

Although this study focuses on product design, R&D is a component that deserves a closer look. In particular, it would be interesting to look at differences between the groups in relation to R&D co-operation.

Figure 2.8. Share of firms with R&D co-operation and type of partner



Approximately 50% of the firms in both groups reported having participated in a joint R&D project (54% of Design firms and 49% of Non-Design firms). 90% of these firms have co-operated with a partner within Norway, while 45% had at least one Nordic partner, 43% reported one or more EU partners and 27% had partners in other countries.

The figure below shows the different types of R&D partner companies worked with. The most frequent partner was a public research institution, something that is not uncommon in Norway. Again, differences only show in a minority of the answers, but consultancies and to some degree suppliers are more frequent R&D partners for Design firms. The most important co-operation partners for both groups were customers and clients. Both these results confirm the impression of this category being an important source of information.

2.8 Conclusions

We began this chapter by introducing the data material. We then wanted to establish whether there were any significant differences between two groups of firms in the survey, namely Design firms and Non-Design firms. We wanted to see what the scope, aims and methods of innovation activities could tell us about these two groups of firms. We established that in general there are large similarities, but also some important differences. Notably the Design firms tend to invest more in innovation activities. Almost 4 out of 5 firms in this group stated a clear objective for their innovation efforts, and their objectives were more often targeted towards modifying or substituting their product range.

Regarding sources of information, the Design firms clearly see the market as a vital component. Contact with customers, suppliers and competitors are examples of this. Both groups considered the purchase of equipment to be an important source of information, but the design firms also included the hiring of personnel in this process. Considered as a whole these results indicate that the diffusion of both tangible and intangible knowledge is a highly relevant and distinctive feature of this group.

Chapter 3: Characteristics of design firms

3.1 Introduction

In the preceding chapter, the focus was on innovation-related activities and characteristics. In this chapter we will also look at more general features, specifically industry sector, size, turnover and export shares. Naturally we will include the group of firms that reported no innovation expenditures as a third group, since this information was collected whether the firms made any innovation efforts or not.

Table 3.1. Distribution of firms

Firms with innovation activities:	Design firms	194
	Non Design firms	158
Non Innovative firms		634
Total		986

Of the 986 firms making up the survey, 352 reported innovation expenditures in 1993. (See Table 3.1) As mentioned above, 194 firms reported product design as one of their activities. In the following sections we will compare the three groups to see how, if at all, the three groups differ.

3.2 Industry sectors

In this section we want see the distribution of firms within each group across different industry sectors. The sectors are based, mostly, on a two level ISIC classification, but we have included a more detailed overview for some sectors.

Table 3.2 Industry distribution

Industry	All firms		Design firms		Non Design firms		No Innovation firms	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Oil and gas	10	1.0	2	1.0	8	5.1	0	0.0
Mining and extrusion	22	2.2	1	0.5	3	1.9	18	2.8
Food, beverage and tobacco	183	18.6	28	14.4	27	17.1	128	20.2
Textiles, clothing	49	5.0	9	4.6	3	1.9	37	5.8
Wood products	103	10.4	12	6.2	14	8.9	77	12.1
Pulp and paper	21	2.1	4	2.1	7	4.4	10	1.6
Graphical industry	127	12.9	10	5.2	22	13.9	95	15.0
Chemistry	44	4.5	9	4.6	18	11.4	17	2.7
Mineral products	42	4.3	11	5.7	5	3.2	26	4.1
Metals	27	2.7	5	2.6	11	7.0	11	1.7
Metal products	121	12.3	32	16.5	7	4.4	82	12.9
Machinery	85	8.6	27	13.9	13	8.2	45	7.1
Electrical machinery, etc.	48	4.9	16	8.2	11	7.0	21	3.3
Transport equipment	76	7.7	22	11.3	4	2.5	50	7.9
Scientific instruments, optics	9	0.9	2	1.0	3	1.9	4	0.6
Other manufacturing	19	1.9	4	2.1	2	1.3	13	2.1
Grand Total	986	100.0	194	100.0	158	100.0	634	100.0

Not surprisingly, Food beverages and tobacco, Metal products, machinery, transport equipment and electrical machinery are the largest sectors in absolute terms within the design group. Other reports have indicated that these sectors are design intensive, in the sense that a large share of (larger) companies in these industries do engage in product design[11]. In relative terms the picture is slightly different. Compared to the overall distribution, machinery, transport equipment and electrical machinery are especially over-represented within the design group, while mining, wood products and graphical industry are under-represented. The figures compare the shares of different sectors within the groups to the share of the same sectors within the total of all firms (i.e. Mining: Share within Design group = 0.52% - share of all firms = 2.23% → 0.52/2.23 = 0.23 - the figures are rounded off in the tables).The three first mentioned industry sectors are of medium or high R&D-intensity, i.e. the firms in the sector spend on average more than 1% of their turnover on R&D. It is therefore not surprising that these firms also engage in product design. Compared to the Non Design firms, some sectors seem to concentrate more on other aspects of their innovation activities, in most cases on R&D. Oil&Gas, Pulp and paper and the Metal industry are examples of this. Another point to note is that 157 of 194 firms in the Design group reported both R&D and Product Design activities.

Table 3.3 Industry distribution - relative shares

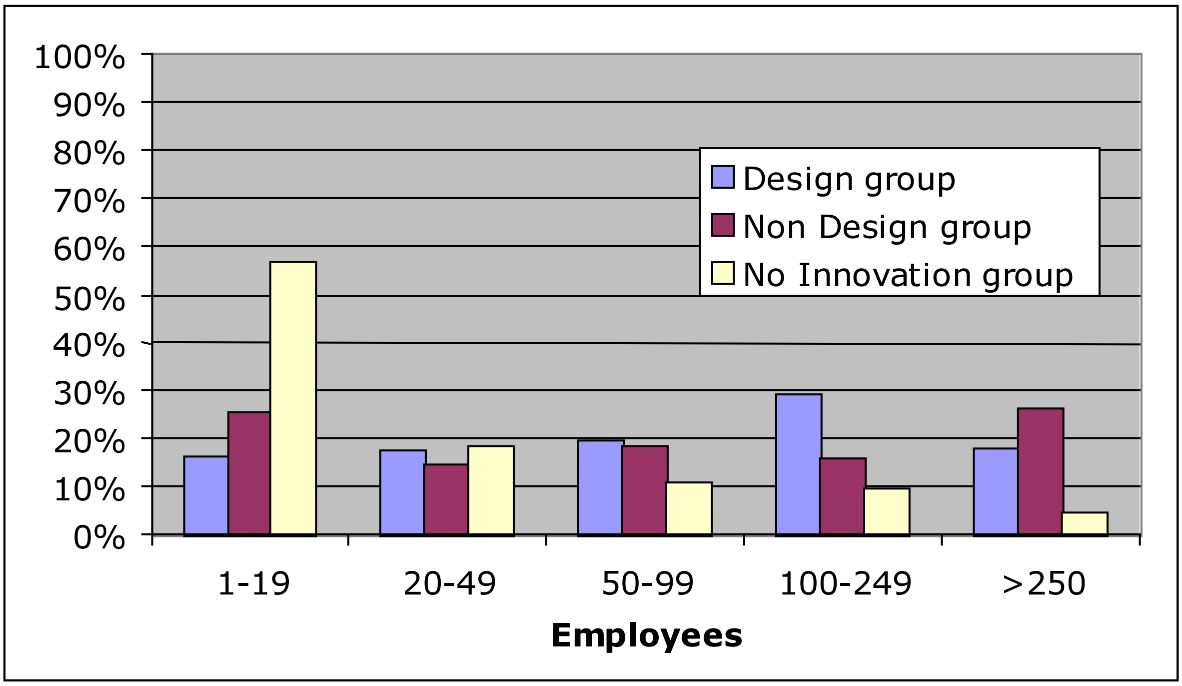
Industry	Design firms	Non Design firms	No Innovation firms
Oil and gas	1.0	5.0	0.0
Mining	0.2	0.9	1.3
Food, beverage and tobacco	0.8	0.9	1.1
Textiles, clothing	0.9	0.4	1.2
Wood products	0.6	0.8	1.2
Pulp and paper	1.0	2.1	0.7
Graphical industry	0.4	1.1	1.2
Chemistry	1.0	2.6	0.6
Mineral products	1.3	0.7	1.0
Metals	0.9	2.5	0.6
Metal products	1.3	0.4	1.1
Machinery	1.6	1.0	0.8
Electrical machinery, etc.	1.7	1.4	0.7
Transport equipment	1.5	0.3	1.0
Scientific instruments, optics	1.1	2.1	0.7
Other manufacturing	1.1	0.7	1.1
Grand Total	1.0	1.0	1.0

3.3 Firm size

Generally firms with innovation expenditures are larger than non-innovative firms. In the largest group Non Design firms dominate, but almost 47% of the Design firms employ 100 people or more, while the share of Non Design firms with more than 100 employees is 42% and for No Innovation firms the share is only 13%.

[11] Nærings- og energidepartementet - Arbeidsgruppe for Industridesign (Ministry of industry and energi - committee on Industrial design), "Industridesign som konkurransefaktor for norsk næringsliv" (Industrial design as competitive factor in Norwegian industry), Nærings- og energidepartementet, Oslo, 1995, p. 10

Figure 3.1. Distribution of firms by size



3.4 Financial characteristics

We also wanted to look at economic features within the three groups. Since size is a factor we have used indicators based on average numbers per employee. This way we avoid any skewness that size would imply, and get figures that make comparisons across the groups relevant.

The differences are quite pronounced. Regarding turnover per employee, the largest variations lie between Innovation firms and No Innovation firms, being one third as high in the two first groups as in the latter. When it comes to gross investments, the most dominant group is Non Design firms.

Table 3.4 Financial characteristics

	Design firms	Non Design firms	Non Innovation firms
Turnover per employee (Mill Nok)	1.5	1.5	1
Gross investments per employee (1000 Nok)	72	202	30
Share of sales			
-on domestic market (%)	67.5	68.7	87
-to exports (%)	32.5	31.3	12.7

3.5 Conclusions

It is not surprising that firms that engage in product design are found within the sectors that traditionally engage in R&D, especially in view of the number of firms engaged in both activities. This picture complies with the ideas expressed within the "Chain-Link" model. Innovative firms have diverse resources and choose their problem-solving methods according to the nature of the problem to be solved.

Whether one uses in-house or external expertise, both R&D and Product Design often require resources and capabilities of some size. This agrees with those results that indicate a higher level of investment and turnover. The size distribution of these firms also confirms this impression, as does their export orientation. However, these characteristics are equally true for firms that engage in other kinds of innovation activities only. The differences are mainly between innovating and non innovating firms. We will now turn to see if there are any differences in company performance.

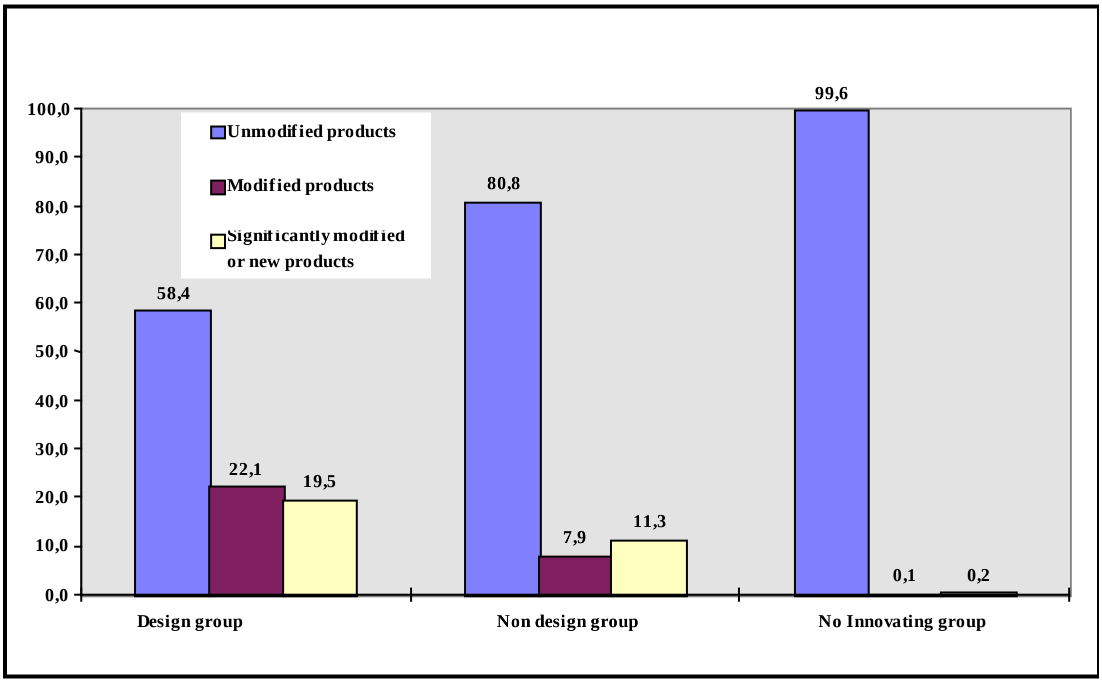
Chapter 4: Firm performance

Is it possible to distinguish between the three groups in terms of performance? The main idea behind this study was to look at two decisive factors when measuring firms' performance, innovation and economics. We used the survey results combined with financial data to make a data set. The first part of this chapter will present the findings regarding innovation data, while the second will look at financial characteristics. In both parts we have compared outputs to different input factors and tested for any statistical significance of our results.

4.1 Design intensity and innovation output

Design intensity is defined in this context as design expenditure as a share of firm's total turnover. Innovation output is measured as the share of total sales accounted for by New or significantly modified products. Output is divided into three categories, "Unmodified products", "(slightly) modified products" and "New or significantly modified products". The figure below shows distribution across the three groups of firms. Firms that engage in design, report that on average 41.6% of their sales come from modified or new products, of which 19.5% are new or significantly modified. Of the firms engaged in other innovation activities, 80.8% of their sales are made up of unmodified or "old" products. In the last group, firms that do not report any innovation expenditure, the introduction of New or significantly modified products is almost non existent.

Figure 4.1. Share of sales from New or significantly modified products



In other words there seems to be a not so surprising connection between innovation efforts and the output of New or significantly modified goods. However it is interesting to see the even higher level of innovation among firms engaging in product design than other innovation activities. The figure above only presents the average results for all three groups. We wanted to see if the data implied an even stronger correlation between the different activities and innovation output. Consequently we examined whether there were any statistically significant correlations in the data.

Correlation between product design and innovation output.
It is difficult to determine how particular factors contribute to a company's performance. However, statistical analysis can aid in the interpretation of our results. We tested for correlation between design intensity as defined above - design expenditure as a share of total turnover - and the share of new or modified products in total sales. In other words we tested to see whether it is reasonable to say that greater design intensity results in greater output of new or modified products. We also tested for the significance of design with regard to other innovation activities. In other words we tested for the importance of product design in relation to overall innovation expenditures.

Table 4.1. Correlation coefficient and significance of product design intensity and share of new and modified products of total sales.

Category	Correlation coefficient
Modified products	0,143*
New or significantly modified products	0,167*

* Significance of level 0.01 (p<0.01)
** Significance of level 0.05 (p<0.05)
*** No significance

Table 4.2. Correlation coefficient and significance of product design's share of total innovation costs and share of new and modified products of total sales.

Category	Correlation coefficient
Modified products	0.448*
New or significantly modified products	0.321*

* Significance of level 0.01 (p<0.01)
** Significance of level 0.05 (p<0.05)
*** No significance

The above tables show that there is a statistically significant correlation between the input in product design and output in terms of new or modified products. Table 4.1 shows that there is a statistical correlation between the effort put into product design and the ability to output new or modified products. The figures in Table 4.2 indicate that of the six innovation activities measured in this survey, the contribution of product design to successful innovation is quite high. However, earlier in this report we did point out the differences between industries when it comes to engaging in product design. We therefore give a breakdown of the correlation figures on industry levels in the tables below.

Table 4.3. Correlation coefficient and significance of product design intensity and share of modified products of total sales.(N=954)

Industry	ISIC	Correlation	Significance	No
Scientific instruments, optics	385	0.98	0.01	8
Mineral products	36	0.85	0.01	40
Textiles, clothing	32	0.70	0.01	48
Mining	230+290	0.60	0.01	22
Pulp and paper	341	0.52	0.05	19
Metal products	381	0.46	0.01	118
Wood products	33	0.43	0.01	103
Metals	37	0.42	0.05	27
Machinery	382	0.40	0.01	79
Transport equipment	384	0.29	0.01	74
Graphical industry	342	0.27	0.01	125
Chemistry	35	NS		41
Electrical machinery, etc.	383	NS		46
Food, beverage and tobacco	31	NS		180
Oil and gas	220	NS		3
Other manufacturing	39	NS		19

What is clear is that the effect of product design varies across industries. In some of the industries it must be noted that the number of firms is too small to be of any viability. (Not only regarding the total number of firms in the survey. In the case of Mining only three companies reported any innovation expenditures, which skews the results in the table). It is interesting, however, to note that the industries that have a high correlation rate are mainly those that were over-represented or normal within the Design group (See Chapter 3). The corresponding figures for output of new or significantly modified products are given in the table below. In general, the level of correlation is slightly lower than in the previous table. It also shows that there are some variations, such as for transport equipment, chemistry and food (product design seem more important) and pulp and paper (less important).

Table 4.4. Correlation coefficient and significance of product design intensity and share of new or significantly modified products of total sales. (N=954)

Industry	ISIC	Correlation	Significance	No
Mining	230+290	0.84	0.01	22
Textiles, clothing	32	0.69	0.01	48
Transport equipment	384	0.68	0.01	74
Metal products	381	0.52	0.01	118
Machinery	382	0.49	0.01	79
Chemistry	35	0.45	0.01	41
Food, beverage and tobacco	31	0.45	0.01	180
Metals	37	0.42	0.03	27
Wood products	33	0.39	0.01	103
Mineral products	36	0.36	0.05	40
Electrical machinery, etc.	383	NS		46
Graphical industry	342	NS		125
Oil and gas	220	NS		3
Other manufacturing	39	NS		19
Pulp and paper	341	NS		19
Scientific instruments, optics	385	NS		8

The differences between the two tables can also be caused by the fact that product design plays different roles. In some industries continual modification of products is based on product design, while in others product design is a dominant factor in developing new products. However, it is not possible to say anything more exact on the basis of the survey results, other than that there is a strong correlation between companies' engagement in product design and the success rate of their innovation efforts.

Regression analysis - Modified products

We also used regression analysis in order to examine more closely the relative importance of different innovation factors. To do so we compared the output variable - share of modified products - with the different input factors, or input variables. The higher the coefficient the greater the contribution of this particular factor in explaining the result - in this case the output of modified products. The results, given in the table below, are interesting since they indicate that product design is the most important factor of all. They are also all statistically significant, except for the factor "purchasing of patents and licences".

Table 4.5. Regression analysis of the impact of different innovation activities on the rate of modified products

Innovation factors	coefficient	t Stat
R&D	0,16	10,9*
Product design	0,36	12,2*
Pilot production and product start-up	0,05	3,3*
Purchase of patents and licences	0,07	1,9***
Market analyses	0,29	4,6*
Other innovation costs	0,09	3,4*

* Significance of level 0.01 ($p<0.01$)
** Significance of level 0.05 ($p<0.05$)
*** No significance

Regression analysis - New or significantly modified products

When it comes to new or significantly modified products the coefficients are lower, but still significant. Again product design seems to be the most important factor.

Table 4.6. Regression analysis of the impact of different innovation activities on the rate of new or significantly modified products

Innovation factors	Coefficient	t Stat
R&D	0,15	9,4*
Product design	0,24	7,3*
Pilot production and product start-up	0,13	6,8*
Purchase of patents and licences	0,15	3,6*
Market analyses	0,06	0,9***
Other innovation costs	0,08	2,9*

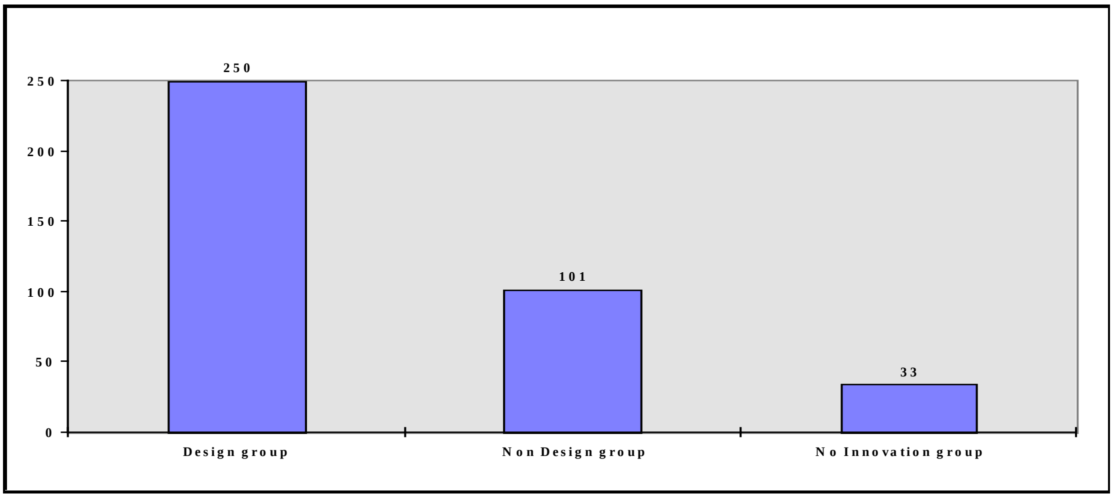
* Significance of level 0.01 ($p<0.01$)
** Significance of level 0.05 ($p<0.05$)
*** No significance

All in all there seems to be a clear correlation between the level of innovation activities and the rate of new or modified products that are introduced to the market. Product design does seem to be a crucial factor in this process.

4.2 Design and economic performance

Now we turn to another measure of performance. We wanted to see how the firms in the three groups compared to each other on a range of economic indicators. These figures are based on accountant data for all these firms in one year. Thus it must be noted that the results provide us with more of a snapshot rather than a thorough and detailed investigation. The first indicator is "Operating profits per employee".

Figure 4.2. Operating profits pr employee. **(1000 NOK)**



Firms in the Design group did have a higher rate of profits per employee, more than twice as much as the Non Design group and nearly seven times as high as the No Innovation group. However, the divergence within each group is very large and it is difficult to say anything certain about any of these groups with regard to profits. In order to expand the picture we also present some other indicators in the table below.

Table 4.7. Overview of economic performance

Category	**Results***
Operating profits pr employee	*1000 NOK*
No Innovation group	33
Non Design group	101
Design group	250
Return on Equity	*I %*
No Innovation group	11,2
Non Design group	8,4
Design group	11,6
Return on total assets	*I %*
No Innovation group	9,4
Non Design group	11,2
Design group	10,8
Share of firms with positive net results	*I %*
No Innovation group	69,1
Non Design group	72,0
Design group	73,3

* The figures are average results within each group. The differences are not statistically significant.

While the first indicators suggest a better performance for the Design group, the results differ only slightly with regard to the last three indicators. The return on equity figures suggest that the Non Design group to a slightly lesser degree finance their activities through borrowing, while the return on total assets show that the innovating firms are more profitable than the No Innovation group. However these are average figures and do not imply any statistically significant difference between the groups. In other words the ties between innovation factors and profits are not confirmed by the survey material in a strong sense. It is also difficult to base one's strategic decisions on the specifications of "average firms". An alternative interpretation of the data in this chapter could also be that large firms with a solid base and thorough strategies engage themselves in product design.

Chapter 5: Conclusions

We wanted in this paper to see whether a specific data source could tell us something about the importance of product design for companies' performance. In Chapter 1 we presented the theoretic foundations for the investigation of this question. Chapter 2 presented the data material, as well as a number of characteristics related to the scope, aim and methods of innovation activity within the two groups of firms that engaged in innovation activities. The decisive factor differing between these two groups was whether firms engaged in product design or not. In general we found strong similarities, but also some important differences. Notably the Design firms tended to invest more in innovation activities. Almost 4 out of 5 firms in this group stated a clear objective for their innovation efforts, and their objectives were more often targeted towards modifying or substituting their product range. Regarding sources of information, the Design firms clearly see the market as a vital component. Contact with customers, suppliers and competitors are examples of this. Both groups saw the purchase of equipment as an important source of information, but the Design firms also included the hiring of personnel in this process. These factors indicate that the diffusion of both tangible and intangible knowledge is a highly relevant and distinctive feature of this group.

In Chapter 3 we found that firms that engage in product design are found within the sectors that traditionally engage in R&D. The results also indicated a higher level of investment and turnover. The size distribution of firms showed that firms in both groups that engaged in innovation activities were on average larger than non innovating firms. They also were more export oriented.

The results of Chapter 4 indicate that product design is an important part of successful innovation activity. In the introduction to this report it is emphasised that competitiveness is built on a set of strategies, and the data suggest that product design is one of the strategies that can lead to the successful introduction of new or modified products on the market. What is not possible to tell from the survey results is *how* product design influences this process. However, it seems certain that the role of product design varies across industries. The results in this paper are not surprising, bearing in mind the model described before. We know that successful innovation follows a conscious effort on the part of firms to increase innovation capabilities. These firms operate under different conditions, depending on industry sector, localisation, size, market strength and history. Engaging in product design will consequently be an important way to increase competitiveness through adjusting, modifying and creating products in a way that adapt to the needs of the market.

However, our interpretation of the economic indicators is more ambiguous. The results presented in Chapter 4 may be accounted for by specific and atypical events which are reflected in the accountancy figures for that specific year. Interpretation of such figures is also difficult within this context; a high profit rate may indicate the opposite of innovative behaviour, i.e. spending (as in dividends) instead of reinvesting through innovation efforts. Nevertheless, if we look at all the results as a whole we find that firms which engage in product design are large, have higher turnovers, invest more and have a high share of their sales coming from new or modified products.

In order to say anything more precise about the role of product design for innovation and profitability we would need a more specialised set of questionnaires, detailing development over time. Valuable information would include, for instance, data on the survival rates of companies, co-operation patterns, the deployment of product design strategies and the consequences thereof, and economic performance before and after product design tasks were initiated. This would give us a better foundation for understanding the significance of product design. However, the preliminary results of this report still suggest a number of conclusions. Firms that spend money on design perform better than those that do not. Firstly, they spend more on innovation as a whole and they place a higher value on innovation objectives than Non Design firms. Secondly, they generate a significantly higher proportion of their sales from new and technically changed products. Thirdly, when we look at accounting data for the firms concerned, they appear to be more profitable. The study strongly suggests that design capabilities are of great importance both for the innovation performance and the competitiveness of Norwegian firms.

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STEP-gruppen ble etablert i 1991 for å forsyne beslutningstakere med forskning knyttet til alle sider ved innovasjon og teknologisk endring, med særlig vekt på forholdet mellom innovasjon, økonomisk vekst og de samfunnsmessige omgivelser. Basis for gruppens arbeid er erkjennelsen av at utviklingen innen vitenskap og teknologi er fundamental for økonomisk vekst. Det gjenstår likevel mange uløste problemer omkring hvordan prosessen med vitenskapelig og teknologisk endring forløper, og hvordan denne prosessen får samfunnsmessige og økonomiske konsekvenser. Forståelse av denne prosessen er av stor betydning for utformingen og iverksettelsen av forsknings-, teknologi- og innovasjonspolitikken. Forskningen i STEP-gruppen er derfor sentrert omkring historiske, økonomiske, sosiologiske og organisatoriske spørsmål som er relevante for de brede feltene innovasjonspolitikk og økonomisk vekst.

The STEP-group was established in 1991 to support policy-makers with research on all aspects of innovation and technological change, with particular emphasis on the relationships between innovation, economic growth and the social context. The basis of the group's work is the recognition that science, technology and innovation are fundamental to economic growth; yet there remain many unresolved problems about how the processes of scientific and technological change actually occur, and about how they have social and economic impacts. Resolving such problems is central to the formation and implementation of science, technology and innovation policy. The research of the STEP group centres on historical, economic, social and organisational issues relevant for broad fields of innovation policy and economic growth.