DANISH **R**ESEARCH **U**NIT FOR **I**NDUSTRIAL **D**YNAMICS

DRUID Working Paper No. 98-4

The Dynamics of the Diversified Corporation and the Role of Central Management of Technology

by
Jens Frøslev Christensen
February 1998

THE DYNAMICS OF THE DIVERSIFIED CORPORATION AND THE ROLE OF CENTRAL MANAGEMENT OF TECHNOLOGY

Jens Frøslev Christensen
Department of Industrial Economics and Strategy,
Copenhagen Business School, Nansensgade 19, 6., DK-1366
Copenhagen K Denmark. Tel +4538152535, fax +4538152540, e-mail
jfc@cbs.dk.

Abstract

This paper discusses 1) the generic forces that drive the evolution of diversified industrial corporations and their implications for the corporate technology base, 2) the changing role of the central R&D lab in the context of these forces, and 3) the role of management of technology in promoting dynamic coherence in diversified - and highly decentralized - corporations. The line of argument in the paper is illustrated by an in-depth case-study of Danfoss, a Danish multi-divisional corporation operating within mechatronical markets.

Key words
Corporate strategy, diversified corporations, management of technology

JEL
L22, O32, L64

ISBN (87-7873-040-6)

Contents

1. INTRODUCTION

Management of technology may operate at different levels: It may be concerned with the management of specific innovation projects, the management of R&D in a central lab or in a one-business firm, a division or business unit, or it may be concerned with the management of the overall corporate technology base in a diversified corporation. This paper deals with the latter case. The notion of corporate technology base refers to the corporation's total portfolio of technical capabilities and managerial competences in developing new technologies, products and processes[1]. In the diversified and transnational corporation the corporate technology base is not a unified base with a central organizational and geographical locus. On the contrary, it has increasingly become dispersed in different parts of the corporation (i.e. the central R&D labs, divisional R&D centres, engineering and manufacturing departments or design centres or teams in business units and even in network relations with firms and institutions outside the corporation).

In recent years there has been widespread "downsizing" efforts within headquarters of large multi-divisional corporations. This tendency has also involved downsizing of central R&D (i.e. in the form of corporate labs), decentralization of R&D to divisional or business unit levels, and increasing use of external suppliers of technology. To the extent that downsizing of central R&D has not led to overall downsizing of internal R&D, these dynamics have arguably contributed to stimulate motivation and entrepreneuship at decentral levels and a stronger market-orientation in technological innovation.

However, a likely negative implication of downsizing central R&D may be increasing corporate fragmentation which may contribute to undermine core competences, reduce inter-divisional synergy and increase duplication of innovative efforts. Moreover, technological innovation may become biased towards incrementalism and short-termism at the expense of long-term exploration of new oportunities.

[1] The notion of “technology base” is discussed more in-depth in Christensen (1996a).

This paper discusses 1) the generic forces that drive the evolution of diversified corporations and their implications for the corporate technology base, 2) the changing role of the central R&D lab in the context of these forces, and 3) the (potential) role of management of technology in promoting dynamic coherence in diversified - and highly decentralized - corporations. Dynamic corporate coherence is here defined as the corporate capacity to exploit and explore synergies from a diversity of capabilities, competences and other resources (Christensen and Foss, 1996).

In section 2 “The Dynamic Forces of the Diversified Corporation and Implications for the Technology Base” the Chandler/Williamson strategy-structure issue is revisited and four generic forces characterizing the growth of the multi-divisional corporation are identified: 1) Diversification, 2) increasing division of labour, 3) decentralization, and 4) internationalization. The implications of these forces for the structure and profile of the corporate technology base is discussed. It is argued that combined these forces have promoted a creeping fragmentation of the corporate technology base and short-termism and risk-aversion in R&D-investments. However, these forces have also given rise to a stronger market-orientation in innovative efforts, and better possibilities to promote inter-functional integration in innovative efforts.

These implications primarily hold for the "traditional" Williamsonian M-form, while different M-form variants provide a more differentiated picture as discussed in section 3 “Variants of the M-form and the management of the corporate technology base”. Especially I make a distinction between the “pure” M-form structures to realize financial economies, an “synergistic” M-form structures to realize vertical or synergistic economies, or in short, corporate coherence.

In section 4 “The Changing Organization of the Central R&D Lab” and section 5 “The Role of Corporate Management of Technology in Pursuing Dynamic Coherence” the focus is narrowed from the overall corporate level to the specific level of central R&D and corporate management of technology within technology-intensive “synergistic” corporations. Section 4 attempts to give a broad outline of important changes in the role

and organization of the central R&D lab, and section 5 focuses on the options for managing the corporate technology base. Four objectives for the management of the corporate technology base that may contribute to strengthen the dynamic corporate coherence are briefly discussed:

- Providing overall strategic guidance of the corporate technology base and innovative efforts.
- Providing "parenting value"[2] to divisions and business units in their innovative efforts.
- Assuring a proper balance and alignment between short-term, incrementally innovative efforts (exploitation) and long-term explorative efforts.
- Increasing horizontal technology transfer and sharing, as well as synergy and coordination in research and technological innovation between divisions and business units.

The line of argument in the paper is illustrated by different case material, especially material from an in-depth case-study of Danfoss, a Danish multi-divisional corporation operating primarily in mechatronical, industrial product markets (Iversen & Christensen, 1996)[3]. Although Danfoss for decades has been a consistently successfull company, the idea of using Danfoss as a case of reference is not to provide an ideal case of how to manage technology in a diversified corporation, nor to provide empirical evidence for the arguments in the paper. Rather, the Danfoss-case provides an opportunity to illustrate most of the issues discussed in this paper by the same company: To provide an example of a “synergistic” corporation (section 3), how it has handled the dynamic forces of diversified corporations (section 2), the organization of its technology base (section 4), and its overall management of technology (section 5).

[2] This term is borrowed from Goold, Campbell and Alexander (1994),

[3] The case study is based on both a comprehensive written material on Danfoss and interviews especially with vice-president Hans J.Pedersen and technology manager Vibeke Gustafsson (both Corporate Technology and Research).

2. DYNAMIC FORCES OF THE DIVERSIFIED CORPORATION AND IMPLICATIONS FOR THE TECHNOLOGY BASE

Since the work of Chandler (1962) the relationship between the strategy and the organizational structure of diversified large corporations has been subject of intensive research and debate. Research by among others Hill and Hoskisson (1987) and Goold and Campbell (1987) have focused attention on the significance of different variants of the M-form corporation. Others have argued that the increasing complexity in the wake of globalization stimulates the emergence of new organizational network structures that transcend the M-form (Prahalad and Doz, 1987, Bartlett & Ghoshal, 1989, 1993, Hedlund, 1994). From a competence-based perspective Prahalad and Hamel (1990) have argued that the "strategic business unit" paradigm of the conventional M-form has contributed to fragment the diversified corporation and undermine its core competences. Recent discussions on the diversified corporation have focused on the coherence of the corporation (Teece et al., 1994, Christensen and Foss, 1996, Foss and Christensen, 1997) and the "parenting" roles of the corporate headquarters (Chandler, 1994, Ferlie and Pettigrew, 1996, Goold, Campbell and Alexander, 1994).

Below, I shall discuss the implications for the corporate technology base of some generic tendencies in the strategy-structure dynamics of diversified corporations.

Generic forces of M-form corporations and their implications for the corporate technology base

Since the transformation of such large American corporations as General Motors into multidivisionals in the first half of this century it has gradually become conventional wisdom that the decentralized multi-divisional (M-form) structure - as compared to the functional (or unitary) structure (U-form) - provides a more adequate way of dealing with administrative and operational problems of managing the multi-product corporation.

Chandler (1962) and Williamson (1975) provided the economic rationale for this conventional wisdom. They argued that headquarters in M-form firms should: 1) take

responsibility for the overall strategic boundaries and direction of the corporation (notably for acquisitions, divestures, and long-term investments), 2) monitor and audit the affairs and performances of the divisions (which may require specialized corporate staff), 3) reallocate resources generated by divisions on the basis of relative yields rather than returning them to their source division, 4) use corporate incentives to promote profit seeking behavior in the divisions (i.e. compensation schemes, promotion incentives). On the other hand, divisional management should have full autonomy in operational matters. According to Williamson such M-form structures are more likely to favour goal pursuit and least-cost behavior in line with neoclassical maximization behavior than are functionally organized corporations.

At least four overall forces have characterized the evolution of the large multi-business corporation:

1. Diversification into a) new business areas or product markets, and b) new technologies.
2. Increasing division of labour (for example with respect to organizing the corporate technology base, or with respect to the focus of individual business units or functional departments).
3. Increasing organizational decentralization implying increasing scope for autonomy at lower levels (i.e. the divisions, business units or profit centers), not only in operational matters but also in strategic matters.
4. Internationalization into still new geographical areas and globalization of management and production structures.

While these forces have been underlying fundamental corporate growth dynamics throughout this century and only subject to temporary set-back, other forces show more limited historical validity. The last decades' increasing tendency for outsourcing or joint knowledge accumulation with external parties seems to have reversed earlier tendencies for vertical integration (Kaufman et al, 1996). However, the scope of this paper does not allow a specific treatment of this issue.

The four generic forces driving the evolution of the modern multi-business corporation all contribute to increasing differentiation, diversity and complexity, and - to the extent interdependencies exist between divisions and businesses in the corporation - they call for measures to assure integration or coherence. This section focuses on the implications of these tendencies - individually and as a whole - for the overall corporate approach to R&D and technological innovation (the organization of the corporate technology base, the profile of innovative assets and the focus of innovative efforts). However, while this section does not take account of potential coordination mechanisms, the subsequent section discusses M-form variants with coordinative planning mechanisms that seek to exploit synergies and scope economies and counter the inherent fragmentation tendencies of the "classical" M-form.

Ad. The dynamics of diversification.

Diversification has been the subject of systematic research by economists and strategy researchers for many years. This research has mostly focused on product or business diversification and the relationship between types of diversification (i.e. related versus unrelated) and economic performance. There have only been few studies which adress the dynamics of technology diversification, that is, the firm's expansion of its technological asset base (particularly Pavitt et al., 1989, Granstrand and Sjölander, 1990 and 1993, Oskarsson, 1993). Technology diversification seems to have been even more pronounced - at least within technology-intensive firms - than product diversification (Pavitt et al., 1989), and at the product level technological upgrading is likely to lead to increasing levels of R&D and an increasing number of required technologies for each new product generation (Granstrand and Sjölander, 1990). This tendency for increasing diversity of the technology base has been a central factor stimulating the rising managerial (as well as academic) attention to technology management and strategy in recent years.

If technological diversification is exclusively linked to product-market strategies at divisional or business unit levels, and no corporate or inter-divisional coordination is taking place, the corporate technology base will tend to become not only increasingly

complex, but also increasingly fragmented. This implies that the corporate technology base becomes a collection of divional technology bases, and this collection does not necessarily reflect the most adequate technology base for the corporation as a whole. This may not pose any problems, if technological innovation either is not important for the competition of the business units, or does not require large R&D investments. However, in R&D-intensive corporations with inter-divisional complementarities, fragmentation may pose serious problems in terms of economic inefficiencies such as overlapping or underutilization of divisional competences (Coombs and Richards, 1993), and poor coordination of interdependent technologies across divisions (Argyres, 1995).

Full divisional responsibility for technological development in a corporation may also cause problems when discontinuities in terms of technological trajectories are required. The path-dependent pattern of evolution and branching of technological development underlie the notion of "technological trajectories" (Dosi, 1982; Nelson and Winter, 1977). Some technological trajectories evolve over time into many derived technologies and provide a platform for many product applications and market opportunities, while others are linked to specific applications in specific products and processes, and thus, are dead-ends with respect to both technical and product market opportunities (Kim and Kogut, 1996). If the individual divisions/business units do not have the financial resources and competences to make the transition from increasingly obsolete or dead-end trajectories to new prospective platform trajectories, substantial growth prospects may be lost. This may call for a coordinated, corporate-level R&D and management of technology effort.

Ad. Increasing division of labour

As technology-intensive firms grow larger and diversify into new product markets and new technologies, the functional and managerial organization of the technology base tend to become increasingly specialized. Product development tends to become separated from manufacturing, long-term R&D tends to become seperated from short-term development activities, R&D activities in one technical field tend to become

separated from R&D in another field, etc. This increasing specialization is caused by the dynamics of increasing returns to differentiation, but the process is also stimulated by the "diversity dynamics" of diversification (as mentioned above) and internationalization (see below).

In large corporations operating in high-technology markets there is no longer one R&D department that comprises the total corporate portfolio of innovative and technological assets. Parallel to the broadening scope of the technology base (due to technology diversification) the different assets and associated activities become specialized in increasingly narrow sub-categories of technical fields and functions, and these different parts of the technology base are spread all over the corporation, from science laboratories to product development, product customization, engineering, design and manufacturing support departments (or individuals/groups) in product divisions, subsidiaries, or joint ventures. This process of increasing division of labour increases compartmentalization, cultural segregation and, eventually, political rivalry over resources between various parts of the corporate technology base and imposes increasing requirements on coordination.

Hitatchi Ltd provides a case of illustration. As one of the world's leading electronic companies Hitatchi is spending around 5 billion dollars on R&D, more than any other company in the world. The corporation has 33 R&D laboratories, nine of which are directly under the corporate headquarters, two are located in Europe, and two others in the U.S. These laboratories can be classified in six categories (Bowonder & Miyake, 1994, p.66):

- Laboratories with short-term research focus for quick commercialization of innovations originating from various product groups (Central Research Labs).
- Specific divisional R&D laboratories dealing with short-time horizon innovation projects (Semiconductor Design and Development Centre).
- Highly specialized laboratories with core competence as the focus (i.e.VLSI Lab).

- Laboratories with multi-disciplinary expertise with focus on generic competence in one application segment (for example, Space Systems Labs).
- Laboratories that specifically focus on long-term projects in emerging technologies (for example, Advanced Research Lab).
- Laboratories which act as interfaces for new projects, user-supplier interaction, and technology scanning (for example, System Development Lab).

In Hitatchi different sorts of coordination and integration measures is in work to assure overall coherence in R&D activities. However, if there were no such countervailing coordination mechanisms this division of labour dynamic would tend to promote a fragmented competence building at the level of the specialized competence categories and the individual business units and departments. Paradoxically, while this specialization process reflects the accumulation of knowledge and capabilities, the same process may contribute to the undermining of core competences (and corporate coherence) and make it difficult to build synergies between different assets (Prahalad and Hamel, 1990).

Ad. Decentralization

The processes of diversification and increasing division of labour (and internationalization, see below) has made large multibusiness corporations so complex that centralized planning has given way to delegation and decentralization to lower organizational levels. But decentralization is also a consequence of the principles of economic organization (as formulated by Williamson, 1975) for controlling the efficiency of divisions, and achieving efficient allocation of capital resources: First, the separation of strategic and operating functions, secondly, the implementation of functional autonomy of divisions, and thirdly, the establishing of a top-down financial control of divisional profit performance.

Decentralization in the form of divisionalization[4] has also involved decentralization of R&D and management of technology in large diversified corporations (Coombs and Richards, 1993, Coombs, 1996, Rubenstein, 1989, Whittington, 1990, National Science Board, 1992). Loescher (1984) argues that the tendency for tight, top-down financial control may lead to risk-avoidance by divisional managers. Hill (1985) hypothizes that M-form efficiency focus is linked to short-termism and low R&D commitment, that is, "static efficiency" (or operational efficiency and exploitation of existing competences and resources) at the expense of "dynamic efficiency" (or innovative and explorative efforts that provide opportunities for value creation at the longer term). In an authoritative study of industrial R&D in the U.S. it is concluded that "In large corporations, efforts is shifting away from central laboratories toward division-level effort with greater emphasis on risk minimization to meet the needs of today's customers; emphasis is also shifting away from new markets toward existing markets" (National Science Board, 1992, iii). The advantages of divisionalization are that it stimulates stronger market orientation, better inter-functional integration between R&D, marketing, manufacturing, etc. (Coombs, 1996) and a focus on incremental innovation. In short, the decentralization dynamics tend to promote both short-termism in innovative efforts and a strong, but risk-averse, market-orientation.

Ad. internationalization and globalization

The dynamics of internationalization have implied a need for the corporation to be present and build relationships in an increasing number of countries or regions. This presence can take very different forms, among others: The establishment of foreign sales agencies to stimulate export-based market positions; the establishment of foreign manufacturing subsidiaries that can benefit from low labour and transport costs, tariff advantages, or national manufacturing competences; intergration of national manufacturing subsidiaries into national and transnational regional production systems and networks (Ernst, 1996); or the building of R&D centres outside the mother-country of the corporation.

[4] The term divisionalization here refers to decentralization of some previously centrally managed activities to either product divisions or more decentral levels (business units or profit centres within the business

Like business diversification, internationalization contributes to increase complexity in managing the corporation: Balancing the difficult and ever-changing trade-off between global coordination and concern for local/national requirements[5].

While the international dispersion of corporate manufacturing facilities to a large extent reflects different national factor market endowments of relevance for manufacturing (including logistics) costs and quality, the international distribution of facilities for the corporation's technical research and innovation cannot be reduced to "factor market" and cost concerns. Internationalization of industrial R&D is a more recent phenomenon and has not progressed as far as the internationalization of corporate manufacturing (Granstrand, Håkanson and Sjölander, 1993). Granstrand and his colleagues find that the forces working for geographical decentralization to some extent is retarded due to countervaling forces in favour of centralization (such as scale economies in R&D, need to protect technical know how from leaking, wish to minimize costs of coordination, historical path-dependency). The forces favouring geographical decentralization may either be associated with the objective of better serving foreign national markets or enhancing the efficiency of R&D. With respect to the former objective, national R&D laboratories may be established to provide product differentiation for specific national requirements. Sometimes national facilities originally set-up to provide technical support services for national manufacturing subsidiaries, gradually evolve into proper product and process development departments focusing on adaptation of products and processes to local circumstances or assuring "design for manufacturability". With respect to the objective of enhancing R&D efficiency, foreign national R&D may also be involved in the more profound development of new technological capabilities. This objective is reflected in two categories of foreign R&D units. First, the R&D of foreign acquisitions, in which the R&D competences may constitute the primary reason for the acquisition. Secondly, the "monitoring R&D unit" that is set up with the primary objective of "tapping into" a foreign scientific infrastructure (Granstrand et al, 1993, p.

---

units).

[5] The so-called multi-domestic matrix organization of for example ABB is a reflection of the need to balance this trade-off (Taylor, 1991, Bartlett and Ghoshal, 1993).

416f.). Moreover, one or more foreign subsidiaries may evolve into a strategic centre for the corporation or for a group within the corporation within a certain product area or function (Forsgren et al, 1991). If such foreign centres arise, the overall power-structure of the corporation may change from a hierarchic centre-periphery structure into a multi-centre structure. Forsgren et al (1991) make a distinction between four categories of such centres:

- production centre (developing products of its own, and manufacturing and selling this product to several countries).
- marketing or purchasing centre (having full responsibility for marketing or purchasing of the products within a business area encompassing several countries).
- Research centre (independently carrying out R&D aiming at fulfilling the requirements of several other units in the corporation.
- Management centre (division with management stationed abroad).

The emergence of production centres (with own product development), research centres and management centres may undermine the traditional authority of the corporate lab and give rise not only to downsizing of central R&D but also to a strategic proliferation of R&D-efforts that is not the result of corporate strategic intent nor subject of control from the level of the headquarters.

Implications for the corporate technology base

Taken together, the four tendencies provide incentives for changes in innovative efforts and innovative competence profiles. Hoskisson and Hitt (1988) provide moderate (although not statistically significant) support for the hypothesis that M-form firms invest relatively less in R&D than functionally organized (U-form) firms. However, rather than an overall downgrading of R&D, the decentralized M-form may induce incentives for changes in the innovative asset profile that will tend to 1) fragment or weaken the internal coherence of the corporate technology base (implying a potential failure to explore and exploit cross-divisional synergies, as well as risk of duplication of innovative efforts), 2) favour short-termism and incrementalism in innovative efforts

such as line extensions, and suppress more radical innovation, thus moving the balance between incremental and explorative efforts in favour of the former. Moreover, this move towards incrementalism may favour process, product and design innovative competences relative to science-based competences (Christensen, 1995, 1996b). Such changing balance of the innovative competence profile may underlie the tendencies to reduce the role and autonomy of central science laboratories and to induce a stronger "internal market mechanism", that is, guiding and funding from divisional levels (see section 4).

In sum, when the dominant dynamics of the corporation are based on strategies and trajectories at divisional and national levels rather than strategies and visions at corporate level, the outcome is likely to be increasing inter-divisional and corporate-wide fragmentation of the corporate technology base despite possibly increasing intra-divisional coherence. So far, this discussion has taken the conventional M-form as given. In this form divisional autonomy in operational and functional matters is considered decisive, since top management intervention in these matters will reduce efficiency by weakening incentives. However, this focus on incentives has lead to a theoretical neglect of coordination issues in the multibusiness firm. M-form theory has overlooked, as Argyres (1995) maintains, "...the condition of complementarity, under which intervention may produce coordination gains which offset these incentive losses".

Today most diversified firms are multidivisionals (Hill and Pickering, 1986). However, as Hill and Hoskisson (1987) and Goold and Campbell (1987) have pointed out, M-form structures are not homogeneous, and many M-form firms vary in substantial ways from the ideal form suggested by Williamson.

3. VARIANTS OF THE M-FORM AND THE MANAGEMENT OF THE CORPORATE TECHNOLOGY BASE

Firms may become multi-product companies through three main strategies: vertical integration, related diversification, and unrelated diversification. Each of these strategies is associated with a specific type of economic objective (Hill and Hoskisson, 1987):

Vertical integration strategies seek to exploit "vertical economies" that arise from scale or integration economies, from increase in control over resources or outlets, or from elimination of the transaction costs of using the market. Related diversification strategies seek to benefit from "synergistic economies" (synergies or scope economies between resources and competences). Finally, unrelated diversification strategies seek to exploit financial economies (by reducing risk, applying portfolio management, and overcoming external capital market failures).

To each of these three strategies corresponds a set of planning and control arrangements within the basic M-form framework (Hill and Hoskisson, 1987, p.333): The "pure" M-form is consistent with a strategy of unrelated diversification in order to realize financial economies, but not consistent with either vertical integration or related diversification strategies. Both of these latter strategies require a degree of central coordination and interdivisional cooperation. Moreover, Hill and Hoskisson maintain that it is difficult for a firm to go for both financial economies on the one hand, and synergistic or vertical economies on the other, while they find similarities between the systems necessary to realize vertical and synergistic economies and, thus, suggest that these are more compatible (Hill and Hoskisson, 1987, p. 335).

If we now introduce the corporate technology base perspective, it seems obvious that the "pure" M-form (to realize a strategy of financial economies) will tend to "balkanize" the corporate technology base along the lines discussed in section 2. This may not cause any problems as long as the technology base consists of generic technologies that are not proprietary to the firm and do not contain strong systemic features. In contrast, the "synergistic" M-form structures (to realize vertical or synergistic economies) are more likely to promote coherence both in terms of relatedness of the business fields of the corporation (as suggested by Teece et al., 1994) and in terms of the couplings and synergies between different parts of the corporate technology base (Christensen, 1997) - to the extent that technology base synergies come to the attention of the corporate strategy agenda.

Based on case-studies of 16 British diversified corporations, Goold and Campbell (1987) find three major types of management styles used by senior management at corporate headquarters: Strategic planning, strategic control, and financial control. These management styles are defined in terms of two dimensions of the centre's influence, planning influence and control influence. Planning influence concerns the centre's contribution to the strategy process in the business units. Control influence concerns the centre's way of reacting to results achieved. Strategic planning corporations have a high level of central planning influence, while the centre's control influence is flexible and focused more on strategic targets than on annual budgets. Strategic control corporations exert a more moderate level of planning influence, while control measures are stricter and cover both financial and strategic targets. Financial control companies have a low level of central planning influence, while the centre focuses on tight financial control.

In a recent paper Chandler (1994) reviews both his own and Goold and Campbell's work on the functions of headquarters in multibusiness companies. Like Goold and Campbell he finds that strategic planning and strategic control companies are generally smaller and less diversified than financial control companies. While strategic planning and strategic control companies tend to operate in relatively high-technology industries, have relatively large R&D departments, and exploit interbusiness and interdivisional opportunities, financial control companies tend to operate in service industries and in industries involving relatively inexpensive production facilities and small R&D expenditures. Moreover, financial control companies show a low level of interbusiness and interdivisional interdependencies.

Combining the classifications of Hill and Hoskisson (1987) and Goold and Campbell (1987) some tentative implications concerning the management of the corporate technology base may be drawn. The "pure" M-form structure may favour unrelated diversification and the exploitation of financial economies. This corresponds to the financial control type of corporations which are mostly prevalent in relatively low-technology areas, and subsequently no efforts, whatsoever, are mobilized to manage the

overall corporate technology base. On the other hand corporations which pursue strategies of related diversification or vertical integration in order to exploit synergistic or vertical economies will tend to use some kind of either strategic planning or strategic control style which may very well include some level of centralized R&D as well as efforts to promote dynamic coherence of the corporate technology base. It is, however, likely that the problems of short-termism in innovative efforts and fragmentation of the corporate technology base, are not exclusively associated with the "pure" M-form, but are also present or inherently creeping into the more "synergistic" M-form corporations as they diversify into still new business areas and the technology base grows more complex[6]

Danfoss - a "synergistic" M-form corporation[7]

Since its establishment in 1933 Danfoss has been one of the most successful Danish manufacturing companies. Every single year since 1933 Danfoss has shown a positive profit. In 1995 Danfoss reached a turnover of around $2 billion and had about 17.000 employees. The company manufactures thousands of different products and product models within 13 broader product lines (particularly mechatronical products for industrial markets), among others thermostats for cooling and freezing equipment, comfort automatics (products for temperature control, radiator thermostats, etc.), cooling and airconditioning automatics, hydraulic components and industrial instrumentation (i.e. electronic flow meters).

Most of the Danfoss products have one thing in common: They are located in technical equipment and systems to control dynamic processes. Danfoss has global market leadership within several of its product areas (e.g. some types of hydraulic equipment, intelligent cooling systems, radiator thermostats, non-CFC compressors and thermostats for refrigerators and freezers).

---

[6] Coombs and Richards (1991 a+b) provide some illustrative evidence on the complexity of promoting coherence of the technology base in large diversified companies.

[7] The content of this section and subsequent parts on Danfoss is based on Iversen and Christensen (1996), an subsequent interview with vice-president Hans Jørgen Pedersen (Corporate Technology and Research).

In the early 1970's Danfoss transformed its organization from a higly centralized U-form company to a more decentralized M-form company. The number of product divisions has grown from four in 1971 to ten today. Moreover, two sales divisions are responsible for sales in different geographical regions. In april 1996 the product divisions became part of one of three new divisional groups (product families): Refrigeration Controls, Heating Controls and Motion Controls. This organizational restructuring also implied that the four general managers were not any longer also divisional managers - a double task that tended to overload the managers in question. Thus, one purpose was to release managerial capacity in the organization; another purpose was to focus synergy attention to inter-divisional relations within the product family groups.

The growth of Danfoss has been based on the continuously launching of new or improved products and expansion into still new geographic markets and customer segments. The nearly persistent success of Danfoss can to a large extent be explained by its ability to identify and exploit new market opportunities through innovative application and combination of different assets in the corporate technology base and through the ability (and luck) to build new technological competences that mesh well with the existing ones and provide new commercial opportunities. Scale economies, effective and high-quality manufacturing and "design for manufacturability" are critical competitive advantages of Danfoss' most important products - certainly of the most successfull of them all: the radiator thermostat. Growth has from the end of the 1930s and up until the mid 1970s been focused on internally generated growth based on mass production. Not until the 1980s did Danfoss begin to expand through acquisitions, and in the 1990s acquisitions have become a vital part of Danfoss' strategy for growth and globalization. In Europe acquisition options are sought among firms with products that are complementary to Danfoss products. In the rest of the world Danfoss is seeking to acquire firms not only for the sake of their products but also their distribution system. Generally acquisitions have primarily been made to strengthen market positions and not acquire critical R&D capabilities.

Danfoss has been marked by all the generic forces discussed in section 2.

The dynamics of diversification has involved both product market diversification and technology diversification. Danfoss started out in 1933 with two types of valves for refrigerating plants. Up until 1940 the product portfolio was added 38 new product, all related to refrigerating or cold storage plants. During World War II another 37 products were added. From the beginning of the 1950s the rate of new product introductions was further increased, and by the end of the 1960s the product portfolio consisted of about 300 products (Boje & johansen, 1994). There are no comparable

figures accessible concerning the development during the last decades, but it seems fair to suggest that there has not been a slow-down in the rate of new product launching. From the initial focus on valves for refrigerating plants, new products came to include automatics equipment for stoking, heating, compressed-air, and water supply plants. In the 1950s Danfoss started manufacturing compressors and radiatorthermostats; in the 1960s and 1970s Danfoss introduced different types of hydraulic components, electronic frequency controls and flow meters. During the 1980s and 1990s Danfoss has focused on developing improved versions of existing products, offering new products for existing customers, introducing products with reduced environmental effects, and delivering complete systems (for instance for complex heating regulation) that integrates electronics and precision mechanics.

Technology diversification has been just as significant as product market diversification. Thus, for example the primarily mechanical engineering base of the early Danfoss era has been supplemented by electronics and software capabilities since the 1950s[8]. Capabilities in hydraulics have become a decisive asset in the technology base from the

[8] The founder of Danfoss, Mads Clausen, hired an electronics engineer in 1953 and in the beginning of the 60s the newly established Danfoss Electronics manufactured customized electrical rectifiers. When this production stopped in 1965 due to poor commercial results the department was turned into a Technical Research Center with 20 employees. This center was given the task to identify a promising area for Danfoss within electronics. Out of this searching and R&D effort grew the frequency control - the first successfull electronics product in Danfoss. The frequency control provides continuous regulation of alternating-current motors, and today Danfoss is among the international leaders within the field. Electronics is, however, not only linked to this specific field within Danfoss but has gradually diffused into most of the product lines and been aligned with mechanical engineering, hydraulics and other technical fields of expertise in Danfoss.

1960's and onwards[9]. Other more specific technical capabilities (i.e. stainless steel technology, computational fluid dynamics) have been developed in the context of the expanding product portfolio.

Also the dynamics of increasing division of labour and decentralization have been very profound in Danfoss with respect to the organization and specialization of the technology base. While all the company's R&D assets were centralized in the central R&D lab, Corporate Technology and Research (CTR) until the beginning of the 1970s, divisionalization implied a gradual build-up of product and process development activities within the increasing number of divisions. In other words, divisionalization led to a dispersion of R&D, and a division of labour between the longer term R&D-activities to build fundamental technological competences in CTR and the shorter term development activities in the divisions. CTR also expanded its capacity to provide technical and procedural assistance to the divisions with respect to for instance problems in product development. Thus, like most other corporate R&D functions, CTR gradually came to comprise the two broad strategic purposes that Graham (1985) has identified as follows: "[O]ne motivated by relatively short-term technical needs that are in some sense generic to multiple parts of the corporation, the other motivated by the desire to insulate some R&D activity from day-to-day operating concerns and to focus it on long-term corporate needs ouside the current scope of any operating divisions" (p. 181). Moreover, in the 1980s and 90s CTR also developed competence in overall management of technology (see section 5). Decentralization of R&D-efforts were further stimulated when CTR was formally shut down in 1996 (for further elaboration on the activities in and the closure of CTR, see section 4).

With respect to internationalization Danfoss has a sales presence in more than 100 countries, sales agencies in 35 countries and manufacturing facilities in 11 countries. As

[9] This asset was also initiated by the founder of Danfoss as he in 1959 decided to go into partnership production of harvester threshers (combines) - a quite unrelated product market diversification. The production was stopped in 1962 after significant loss. However, Danfoss continued to produce hydraulic components for combines and gradually hydraulic equipment became one of the most important product areas and hydraulics a high-level capability area in Danfoss.

mentioned earlier acquisitions have primarily been made to strengthen market positions, not to acquire critical technologies. While increasing product development activities take place in some of the foreign subsidiaries (for example development of compressors for refrigerators and freezers in Mexico and large frequency transformers in U.S.A.), so far no fundamental technology development takes place in the foreign subsidiaries.

Danfoss has primarily become a multi-product company by pursuing a strategy of related diversification rather than unrelated diversification or vertical integration, even if the two latter also to some extent have been been followed, especially in the early history of Danfoss. The attempts to exploit "synergistic economies" through some degree of central coordination and inter-divisional cooperation have been significant even if decentralization has also implied tendencies for divisional autonomy and corporate fragmentation. In the terminology of Goold and Campbel (1987) Danfoss' planning and control systems seem more in accordance with the strategic control type than with both the financial control type and the strategic planning type, although there are some elements that bring Danfoss closer to the latter. This is also reflected in the organization of the corporate technology base to which I shall return in section 4 and 5.

The following sections will only deal with the more "synergistic", technology-intensive M-form corporations and penetrate somewhat deeper into the role of the central R&D lab and the potential role for management of the corporate technology base in a context of predomiantly decentral R&D.

4. THE CHANGING ORGANIZATION OF THE CENTRAL R&D LAB

The conventional role of the central R&D laboratory is to provide long-term research and development of new technological capabilities and trajectories that may feed into new ventures, product or process development either within the central lab itself or in engineering, manufacturing or product development departments of divisions and business units.

From World War II and the following decades the large central laboratory emerged as the leading institution for industrial R&D (Whittington, 1990). Some of the main advantages of centralized R&D (organizationally as well as geographically) can be summarized as follows:

- Concentration of R&D within a single organization on the same location facilitates coordination of projects and reduces the risk of redundancies (Twiss, 1992).
- Integration of multidisciplinary and tacit knowledge is a decisive part of most technological innovation, and this integration tends to be facilitated by physical proximity (Patel and Pavitt, 1991)
- R&D is subject to economies of scale: One single laboratory is more likely than a diversity of small R&D departments to achieve "critical mass", attract talented engineers, and mobilize resources for complex R&D problems.
- By locating R&D personel in laboratories distant from operational activities they can concentrate on long-term R&D and avoid getting distracted from daily operational problems (Twiss, 1992).

Some of these advantages, however, have not materialized in practice or have become less obvious as some typical weaknesses associated with centralized R&D have become visible in the context of the growing complexity of the diversified corporation. To the extent that product divisions become involved in innovative activities themselves, coordination and communication problems may evolve between central R&D and divisional R&D[10]. To the extent that the central R&D lab has authority to interfere in divisional R&D affairs, incentive problems may easily occur at divisional levels. As divisions grow larger, divisional R&D may surmount the "critical mass" treshold for effective R&D and make one of the basic rationales for central R&D, economies of

[10] As divisions grow larger the same kind of coordination problems may be reproduced between divisional R&D centres and innovative activities in business units and subsidiaries which refer to the division in question.

scale, less adequate[11]. Thus, as divisions grow larger (and more autonomous) and as the corporation grows more diversified (and increasingly difficult to assist from central R&D) the central R&D lab tends to become decoupled - not only from the divisions' operational affairs, but also from their innovative activities. This may result in 1) a bad fit between the supply of "high brow" knowledge from the lab and the practical requirements of the business units, 2) poor technology transfer mechanisms due to the distance in skills and priorities between the two parties, and 3) undermining of the legitimacy and authority of the central lab from the perspective of the increasingly powerful divisions. Thus, while isolation from the operating divisions originally was an advantage, it has tended to become a disadvantage.

A typical way of handling this problem in the 1970s and 1980s was to increase divisional power over the central R&D implying that divisional managers became directly involved in the steering committees of central labs, and that a larger share of central R&D should be ordered and financed by the divisions. This has generally provided a better link between the central and divisional R&D efforts. However, in many cases the transmission of funding and power from corporate to divisional level has lead directly to downsizing of central R&D and/or creeping short-termism in the form of smaller ad hoc projects at the cost of visionary long-term projects. These changes in the economic organization of the central R&D have been accompanied by a change in the terms of cooperation: Increasingly the "transfer logic" implying that new discoveries were "thrown over the wall" to the design and engineering departments has been replaced by a "teamworking logic" in which the corporate lab is part of teams operating on conditions that are very much specified at the level of the business unit (Edelheit, 1995).

Few companies seem to have gone so far as Siemens - the German electrical engineering group - in putting the idea of an internal market for R&D into practice (Wagstyl, 1996).

[11] Eventually one division's or subsidiary's R&D may evolve into a strategic research centre for the whole or larger parts of the corporation (Forsgren et al, 1991), and this upcoming research centre may be viewed as a new central lab (outside the domaine of the headquarters) that can either substitute the "old" central lab or threathen its traditionel position.

Siemens has - next to Hitatchi - the world's largest corporate R&D budget (around $4,8 billion)[12]. Until 1994 Siemens' central laboratories secured two-thirds of their finance from the group headquarters, which charged the money as a "tax" on the divisions. The rest was funded directly from the divisions or from government research programmes. The divisions resented paying this "tax", and central funding was reduced to one-third, and the amount contributed directly by divisions was increased to one-half. Moreover, the divisions were given the freedom to contract their R&D to outside organizations. Thus, the divisions are not obliged to use the services of the central laboratories. The laboratories not only had to orient their work more directly to the needs of their customers in the divisions. They also had to advertise their services using lectures and demonstrations. "The "buyers" from the operating divisions choose the programmes they want to fund and then negotiate the details, including price, with the laboratory managers (Wagstyl, 1996).

The organization of R&D in Danfoss

The changing organization of R&D in Danfoss seems quite typical of the described tendencies in the evolution of R&D in the multi-divisional corporation (Iversen & Christensen, 1996). In the 1960s Danfoss was a quickly growing functionally organized company with a conventional R&D lab, Corporate Technology and Research (CTR). However, up through the 1970s the newly established and rapidly expanding product divisions gained growing control over resource allocation decisions in CTR. This resulted in increasing numbers of small projects without much coherence and overall guidance. In the 1980s, under the direction of Jørgen M. Clausen, son of the founder of Danfoss, CTR regained significant autonomy and began to focus on a more limited number of strategic R&D and venturing projects. Gradually the product divisions grew so large that they increasingly became capable of managing their own R&D within their respective business domains, including - to some extent - venture projects which involve prospects for product market diversification. This resulted in a substantial transformation of CTR from a R&D lab to a centre for corporate technology

[12] Some 44,800 people work in R&D in Siemens. Far the most of these work in the operating divisions, and about 1,700 are assigned to the central laboratories where the mainpart of the longer-range research

management that transcended the traditional role of the corporate R&D lab, even if R&D still played an important role. While most of R&D in Danfoss was carried out in CTR in 1960's and early 70's the CTR-based R&D in the early and mid 1990s only covered about 20% of total R&D in Danfoss. By then around one fourth of total costs in CTR was financed by the divisions.

Other activities than R&D-projects successively came to play a relatively increasing role within CTR: Technical service (consultants providing specific technical assistance for the divisions), the management of patents, standardization and certification activities, quality control, and management of technology across the corporation (the latter of which will be discussed in section 5).

In 1996 the radical decision was taken to close down CTR that by then had 150 employees. This was done to spur divisional management to take full responsibility for R&D and to more thoroughly integrate technology and business strategies.The top management felt that the existence of CTR tended to become an excuse for not building sufficient technological competences at divisional levels. Technical service or consulting and standardization/certification activities were moved to a new Central Service department that is owned by the divisions. Some R&D-projects and the quality control activities have been moved from CTR to the divisions. The patent unit, some R&D and venture projects, and the management of technology activities are carried on at corporate level under the direction of the former CTR manager, Hans Jørgen Pedersen.

These restructurations have not been implemented with the intention to downsize overall R&D investments. The objective is to create a stronger bottom-up commitment to R&D in which the location of ownership and responsibility is considered af key issue. Corporate management is willing to co-sponsor venture and R&D activities if the proposals a) are backed up by at least two divisions, b) have a long-term explorative perspective, and c) do not have a natural home base within one of the divisions.

---

takes place (Wagstyl, 1996).

In the subsequent section I shall explore the potential roles of corporate technology management and provide further illustration from the Danfoss case.

5. THE ROLE OF CORPORATE MANAGEMENT OF TECHNOLOGY IN PURSING DYNAMIC COHERENCE

While the conventional central R&D lab has come under severe strain as the corporation has diversified and divisional R&D has been strengthened, there seems to be a growing demand for corporate-level management of technology. However, this does not necessarily imply a reversal of the general tendency to decentralize innovative efforts. A "back to centralism" in the management of the corporate technology base could easily impose significant bureaucratic costs and incentive problems that could induce opportunistic behavior in a context of assymetric information. This could undermine the advantages that the decentralized M-form has demonstrated with respect to the organization and functions of the technology base:

- A stronger market-orientation (including responsiveness to national or local requirements) in technological development and innovative efforts.
- Less bureaucracy and fewer vertical levels involved in decisions concerning the allocation of R&D resources between alternative projects.
- Greater motivation and entrepreneurial spirit as a consequence of a situation in which local operations and initiatives are not constantly disturbed or overruled from higher levels.
- Better potential for intimate inter-functional arrangements between R&D, marketing and other functional areas in the pursuit of product or process development (Coombs, 1996).

What is called for, is a balanced perspective on corporate management of technology, in which there is still a role to play at the corporate level, even if the larger part of R&D and the managagement of technology take place at the more decentral levels and even in collaboration with external parties. This implies that the "pure" M-form has to be

counterbalanced by some elements of central coordination and inter-divisional cooperation, and generally by loosening the rigidity of organizational structures and creating elements of flexibility and variety in exploring opportunities. Pavitt (1991) argues that an essential dimension of successful large firms' managerial competence is the ability to combine the differentiated technological competencies into effective units for identifying and developing innovations.

This section discusses the options for managing the corporate technology base in technology-intensive corporations with the purpose of increasing dynamic corporate coherence.

Pursuing dynamic coherence of the corporate technology base

Dynamic corporate coherence is defined as the corporate capacity to exploit and explore synergies from a diversity of capabilities, competences and other resources (Christensen and Foss, 1996). In high technology corporations coherence of the corporate technology base is a critical aspect of the overall corporate coherence[13].

The coherence of the technology base signifies the degree of coordination and interrelatedness within the technology base between the different technological and innovative capabilities. A high level of coherence reflects a technology base comprising a diverse portfolio of innovative competences, and characterized by the exploitation and exploration of a high level of communication, knowledge exchange, synergy and coordination in innovative efforts - not only in horizontal relations (between divisions and business units) but also in vertical relations (between the corporate centre of R&D and technology management and divisional innovative efforts), as well as in external relations.

[13] The notion of coherence of the technology base may apply to three dimensions as discussed in Christensen (1997): 1. The external coherence (or "fit") reflects the degree to which the competences constituting the technology base match the requirements of the competition. 2. The contextual coherence reflects correspondence between the technology base and the broader firm or corporate context (the complementary assets, the operational and infrastructural firm context, the company's

Below I shall briefly discuss the following objectives of a corporate centre of technology management:

1. Providing overall strategic guidance of the corporate technology base and innovative efforts.
2. Providing “parenting value” to the divisions and business units in their innovative efforts.
3. Assuring a proper balance and alignment between short-term, incremental innovative efforts (exploitation) and long-term explorative efforts.
4. Increasing horizontal technology transfer and sharing, as well as synergy and coordination in research and technological innovation between divisions, business units, and subsidiaries.

These objectives reflect different (although overlapping) dimensions of pursuing dynamic coherence of the corporate technology base. Strengthening the corporate coherence of the technology base should not, of course, be the only strategic concern for corporate management in diversified corporations. But it should certainly be of central concern to the corporation that seeks synergistic and vertical economies.

Ad. 1. Providing overall strategic guidance

One overall objective for the corporate management of technology would be the provision of long-term perspectives and guidelines for the rate and direction of the corporate technology base as well as for the overall strategic direction of the corporation.

In their study of 24 diversified companies with significant R&D performance, Coombs and Richards (1993) found..."that some companies are creating small units at the centre of the corporate structure (which may or may not be within the R&D function), the

---

strategy and culture). 3. The local coherence signifies the degree to which there are interdependencies and synergies between different parts of the technology base. This section exclusively deals with this latter dimension of coherence of the technology base.

purposes of which include the following:

- “analyzing the structure of the overall technology portfolio;
- ensuring that a technological competence in one business is known to and available to other potential user businesses in the group;
- identifying technical competencies which straddle businesses, in order to take steps to strengthen them through 'horizontal' organizational links and through small special budgets;
- considering the overall technology portfolio and injecting an appreciation of this portfolio into the broader strategic management processes of the company" (p.390).

Thus, such a corporate centre of strategic technology management could be a vital vehicle in promoting a coherent technology base "from above": A forum for reflection, coordination and strategic guidance on the one hand, and a window for making the different facets of the corporate technology base visible and accessible for divisons and business units on the other hand. These roles can only be performed effectively if a close and ongoing dialogue exists between the centre and the divisions and business units.

Ad. 2. Providing direct "parenting value" to the business units

While the overall strategic guidance role - if successful - provides "parenting value" of an indirect kind, direct "parenting value" implies the provision of specific inputs to the value generating processes in the divisions and business units. The role of the conventional R&D lab was in fact to supply R&D-inputs into the product and process development projects of the business units. As outlined in section 4 this role has been increasingly difficult to realize in the context of the isolated lab in the ivory tower and the growing complexity of the divional setting. The objective to improve the direct parenting value of the central lab underlies the increasing efforts in diversified corporations to tie the central lab in to the direct interests of the divisions by a) increasing divisional funding of the lab, b) increasing divisional political influence on resource allocation in the lab, and c) by replacing the "transfer logic" by a "teamwork logic" (cf. section 4),

It should be added, however, that central R&D and technology management may not only produce technical knowledge but also - and perhaps increasingly so - inputs to the development of organizational or managerial competences (such as procedures and standards for project management, quality management or user-producer relations in product development).

Ad. 3. Assuring a balance and alignment between exploitation and exploration

Balancing the trade-off between the reproductive and explorative dimensions of the technology base is a highly complex task in the large diversified corporation. Within the conventional conception of the large corporation with a central lab this balance was handled by a simple division of labour: The lab was responsible for the explorative efforts, while the operating divisions were responsible for the efficient exploitation and commercialization of inventions and discoveries generated in the lab.

Centralized R&D may play a role in countervailing the tendency in the wake of decentralization and internationalization towards compromising exploration and risky R&D investments in favour of exploitation (and short-termism). Thus, some degree of centralized control over and impetus in the strategic development of the technology base may be required to assure a coherence of the corporate technology base that balance the trade-off between short-term incremental and longer-term explorative efforts.

This objective may be difficult to reach if the R&D lab is exclusively locked-in to serve the immidiate requirements of the divisions. The answer is not, however, to go back to the "ivory tower" model of the lab; this model may very well assure a remarkable exploratory capacity, but it does not assure a fit between the exploratory outputs and the operational competences of the divisions. A very critical aspect of the balance between exploration and exploitation is that the new technologies developed can be aligned with the "old" operating technologies, and that requires a cooperative relation between the lab

and the divisions and a recognition that sometimes explorative efforts that go beyond the scope of the individual divisions is necessary[14].

Ad. 4. Strengthening horizontal linkages and coordination

Strengthening horizontal linkages and coordination seems an increasingly important, although higly difficult task for diversified corporations in which fragmentation of the corporate technology base is creeping in.

Two types of horizontal issues should be adressed: First, providing channels and incentives for inter-divisional communication, asset sharing and transfer; secondly, providing means to assure inter-divisional coordination when technological interdependencies exist.

Promoting inter-divisional communication and exchange would involve both some channels (an infrastructure) and some incentives. Examples of channels could be a) coordination groups and committees that cut across the interest of individual businesses and divisions; b) rotation programs among divisions for the younger personnel; c) cross-divisional project teams for diffusing core competencies and for loosing the bonds that might tie an individual to one business (Prahalad and Hamel, 1990, p. 91), d) implementing the "merchandiser" concept (Collinson, 1993) as developed by Sony[15]. Moreover, an efficient and sophisticated corporate-wide IT infrastructure is a basic precondition for any effort to expand inter-divisional communication.

Incentives are probably more difficult to assure than channels. Moreover, if incentives for inter-divisional exchange are weak, channels however sophisticated and formalized) will not be used effectively. While the economic incentives for divisional management in the conventional M-form is focused exclusively on the economic performance of the individual division, incentives in the synergy-oriented corporation should (also)

[14] Barpal (1990) illustrates how Westinghouse has organized its central R&D in order not only to assure direct parenting value to the divisions, but also to assure proper concern for explorative efforts.

[15] “Merchandisers” are individuals with a cross-divisional perspective. They are freed from routine tasks and given the authority to act as internal entrepreneurs.

emphasize inter-divisional cooperation (for example, profit bonus for divisional managers may be linked to inter-divisional or corporate rather than exclusively divisional profitability) (Hill, 1994)[16]. The complexity and stability of such integrating mechanisms can vary, depending on the degree of interdependence, and the uncertainty and durability of the relations (Hill, 1994).

When strong technological interdependencies exist between divisions in a corporation coordination on a set of standards for technology adoption decisions may yield significant benefits. And that may be difficult, if there is no hirarchical authority to assure that this will happen: "If potential adopters make decisions independently, however, only weak incentives may exist for them to invest in technologies which meet a common standard, since net gains from such investment to the individual adopter may be small or even negative, even if net gains to the group are large. The externalities are positive" (Argyres, 1995, p. 338-39). IBM had until recently a series of formal procedures for coordinating the strategies of the divisions. "Foremost among these was the so-called 'right of review'. If any division 'nonconcurred' with a strategic decision made by another division, it could demand that the decision be 'escalated' to the next level in the hierarchy" (Argyres, 1995, p. 349). Mostly, however, the threat of intervention from corporate management implied that most of these disagreements were resolved bilaterally (Goold and Campbell, 1987, p. 264).

[16] IBM was in the 1970's and 1980's a "benchmarking" case of strategic planning style corporation pursuing corporate coherence (Goold and Campbell, 1987). As one IBM executive commented: "IBM is a very big organisation, distinctive in how tightly we link everything together. We want to integrate as much as possible and maintain control through centralised planning and tracking, but we also want to decentralise implementation and operating decisions. There are no major strategic decisions that are delegated" (Goold and Campbell, 1987, p. 261). The incentive and bonus system for division managers in IBM reflected this corporate style. Following Argyres (1995) "Division managers' bonuses were said to depend heavily on corporate performance...Promotions of these managers were widely believed to depend on both the performance of their divisions and on subjective evaluations of their decision-making abilities. Those earning promotion were often seen as, in the words of one manager 'good team players, good IBMers' (p.349).

Corporate management of technology in Danfoss

During the first half of the 1990s Corporate Technology and Research (CTR) in Danfoss focused strongly on the creation of synergy across product lines and technologies in the corporation. One organizational tool designed and used by CTR is termed the “technology pyramid” which is a strategic posture of the corporate technology base. It contains a selection of technologies in which Danfoss can (or want to) claim world-class expertise. These technologies have significant value for more than one division[17]. Two sub-categories of technologies in the pyramid are distinguished: 1) Technologies that are considered "key competences" implying that Danfoss is or strives to be at the global forefront in R&D, and 2) technologies considered "key disciplines" implying a position among the leading competitors. Comitees consisting of members from different divisions and CTR provide strategic analyses and guidelines for different clusters of these technologies. Each comitee appoints a gatekeeper who is responsible for the development and monitoring of the relevant technologies, and a sponsor who has responsibility for budgets and for assuring proper linkages and coordination between the commitees and gatekeepers. At the practical level inter-divisional experience groups promote the improvement and development activities associated with each of the high-priority technologies. The technology pyramid is not static but regularly subject to consideration and changes.

Danfoss has moreover an elaborate network of inter-divisional commitees and groups for among other things standardization, quality management and information technology. The "technology pyramid" and the other networking efforts have been established to strengthen corporate coherence and synergy.

Until the closure of CTR in 1996 (see section 4) both corporate technology management, long-term R&D and short-term technical assistance was localized in CTR. In a dynamic context in which the product divisions have grown larger, increasingly autonomous, and have build their own R&D functions, there are no doubt that the

[17] For technologies that are only important to one division the division in question is expected to take full responsibility

technology management efforts, especially as linked to the technology pyramid and other inter-divisional networking activities, have exerted some overall “guiding” influence on the increasingly dispersed technology base. Not a top-down guidance, but a guidance based on interaction and consensus-building. Moreover, these measures have stimulated horizontal technology exchange, although specific incentive mechanisms have not been implemented to assure this. Altogether technology management has exerted a coherence-promoting influence countervailing the centrifugal forces from the relatively autonomous divisions.

While the divisions' R&D for the most part has a time horizon of 1-3 years and nearly exclusive focus on D, most of the central R&D has a horizon of 4-5 years, a stronger R-element, and a higher level of uncertainty. Not only does central R&D contribute to assuring long-term explorative efforts, it also plays some role in guiding
the direction of - at least some parts of - the divisional technology base. However, the immidiate “parenting value” of central R&D for the divisions primarily stems from the technical support service functions and patent services and not the long-term R&D.
It is too early to make any certain judgement of the implications of the CTR-closure in 1996 (see section 4). A likely scenario is that the overall central guidance of the corporate technology base will be somewhat reduced. Likewise, long-term explorative R&D may be reduced, at least at the shorter term. At the longer term, however, this will depend on the extent to which a) individual divisions build their own explorative R&D-capacities, and/or b) corporate and divisional co-sponsorship will be organized based on project proposals from at least two divisions. Whether horizontal synergy will be reduced, depends on the commitment to and effectiveness of technology management tools (such as the “technology pyramid”) and incentives to promote coherence across divisions.

6. CONCLUSION

This paper has discussed 1) generic forces of diversified corporations and their implications for the corporate technology base, 2) the changing role of the central R&D lab in the context of these forces, and 3) the (potential) role of management of

technology in promoting dynamic coherence in diversified - and highly decentralized - corporations.

Four overall tendencies in the growth of the multi-divisional corporation have been identified: 1) Diversification, 2) increasing division of labour, 3) decentralization, and 4) internationalization. It is argued that combined these dynamics have promoted an inherent movement towards fragmentation of the corporate technology base and more short-termism and risk-aversion in R&D-investments. However these dynamics have also given rise to a stronger market-orientation in innovative efforts, and better possibilities to promote inter-functional integration in innovative efforts. These implications primarily hold for the "traditional" Williamsonian M-form corporation and not to the same extent for the corporation that actively pursue inter-divisional synergy and corporate coherence which is mostly the case with technology intensive corporations.

In the context of these corporate forces for increasing diversity and complexity the role of the central R&D lab has undergone significant changes. As divisions grow larger and more autonomous with respect to R&D, and as the corporation grows more diversified the central R&D lab has tended to become decoupled from the divisions' operational as well as innovative affairs. The response to this problem has been either to close or downsize central R&D or to make the central R&D activities dependent of divisional funding and strategic influence, and to replace the traditional "transfer logic" by a "teamworking logic".

While the heyday of the conventional central R&D lab is over - at least in the large diversified corporation - the paper argues that management of the corporate technology base has an important and growing role to play in technology-intensive diversified corporations. Exactly the same forces that have contributed to increasing corporate diversity and undermined the central lab's corporate monopoly on R&D, have created the need for an overall corporate management of technology to pursue synergy and corporate coherence.

Four objectives for the management of the corporate technology base that may contribute to strengthen the dynamic corporate coherence were identified and shortly discussed: 1) Providing overall strategic guidance of the corporate technology base and innovative efforts, 2) providing parenting value to divisions and business units in their innovative efforts, 3) assuring a proper balance and alignment between exploitation and exploration in innovative efforts, and 4) increasing horizontal technology exchange coordination between divisions and business units.

If dynamic coherence of the technology base becomes a corporate strategic objective, then corporate centre must take (at least part of the) responsibility for promoting synergy, balancing exploitation and exploration, and assuring that the logic of technology diversification is subject to strategic analysis in terms of technology base coherence, and not exclusively the reflection of the business strategies of the divisions.

Acknowledgements

The research reported in this paper benefited from the support from DRUID (Danish Research Unit for Industrial Dynamics) and CISTEMA (Center for Inter-disciplinary Studies in Technology Management). An earlier version of this paper was presented at the Sixth International Conference on Management of Technology in Goteborg Sweden 25-28 June 1997. Helpful comments on an earlier draft from Poul R. Christensen, Massimo Colombo, Dieter Ernst, Nicolaj J. Foss, Mikael Iversen, Morten Overgaard Nielsen and Vibeke Gustafsson are gratefully acknowledged.

REFERENCES

Argyres, N.S. (1995), Technology strategy, governance structure and interdivisional coordination, *Journal of Economic Behavior and Organization*, Vol. 28: 337-358.

Barpal, I.R. (1990), Business-Driven Technology for a Technology-Based Firm, *Research Technology Management*, No. 4 July-August, 27-30.

Bartlett, C.A. & S. Ghoshal (1989), *Managing across Borders: The Transnational Solution*, Boston: Harvard Business School Press.

Bartlett, C.A. and S. Ghoshal (1993), Beyond the M-Form: Toward a Managerial Theory of the Firm, *Strategic Management Journal*, Vol. 14: 23-46.

Boje, P. & C. johansen (1994), *En iværksætter - Historien om Mads Clausen og Danfoss*, Odense: Odense Universitetsforlag.

Bowonder, B. & T. Miyake (1994), Innovations and Strategic Management: A Case Study of Hitach Ltd, *Technology Analysis & Strategic Management*, Vol. 6, No. 1: 55-81.

Chandler, A. D. (1962), *Strategy and Structure*, Cambridge, Mass.: The M.I.T. Press.

Chandler, A. D. (1994), The Functions of the HQ Unit in the Multibusiness Firm, in R. P. Rumelt, D. E. Schendel, and D. J. Teece (eds.), *Fundamental Issues in Strategy. A Research Agenda*, Boston, Mass.: Harvard Business School Press.

Christensen, J.F. (1995), Asset profiles for technological innovation, *Research Policy*, Vol. 24: 727-745.

Christensen, J.F. (1996a), Analysing the Technology Base of the Firm. A Multi-dimensional resource and competence perspective. In N. Foss and C. Knudsen (eds.), *Towards a Competence Theory of the Firm*, London: Routledge.

Christensen, J.F (1996b), Innovative Assets and Inter-Asset Linkages - A Resource-Based Approach to Innovation, *Economics of Innovation and New Technology* Vol 4: 193-209.

Christensen, J.F. (1997), Strategy and Structure - and the Management of Technology Base in Multi-Product Companies, forthcoming in Rod Coombs et al. (eds.): *The Organizational Dimensions of Technical Change*, Edgar Elgar.

Christensen, J.F. and N.J. Foss (1996), Dynamic Corporate Coherence and Competence-Based Competition, in A. Heene and R. Sanchez (eds.), *Competence-Based Strategic Management*, Oxford: Elsevier.

Collinson, S. (1993), Managing Product Innovation at Sony: The Development of the Data Discman, *Technology Analysis & Strategic Management*, Vol. 5: 285-306.

Coombs, R. (1996), Core Competencies and the Strategic Management of R&D, forthcoming in *R&D Management*.

Coombs, R. and Richards, A. (1991a), Technologies, Products and Firms' Strategies. Part 1 - a Framework for Analysis, *Technology Analysis & Strategic Management*, 3, 1: 77-86.

Coombs, R. and Richards, A. (1991b), Technologies, Products and Firms' Strategies. Part 2 - Analysis of Three Cases, *Technology Analysis & Strategic Management*, 3, 2: 157-175.

Coombs, R. & A. Richards (1993), Strategic Control of Technology in Diversified Companies with Decentralized R&D, *Technology Analysis & Strategic Management*, 5, 4: 385-396.

Dosi, G. (1982), Technological paradigms and technological trajectories. A suggested interpretation of the determinants and direction of technical change, *Research Policy*, Vol. 11: 147-162.

Edelheit, Lewis S. (1995), Renewing the Corporate R&D Laboratory, *Research Technology Management*, November-December: 14-18.

Ernst, D. (1997), From Partial to Systemic Globalization. International Production Networks in the Electronics Industry, Report prepared for the Sloan Foundation project on the Globalization in the Data Storage Industry. Globalization Project Report 97-02, Graduate School of International Relations and Pacific Studies, University of California at San Diego, and BRIE Working Paper # 98, the Berkeley Roundtable on the International Economie (BRIE), University of California at Berkeley.

Ferlie, E. and A. Pettigrew (1996), The Nature and Transformation of Corporate Headquarters: A Review of Recent Literature and a Research Agenda, *Journal of Management Studies*, Vol. 33 No. 4: 495-523.

Forsgren, M., U. Holm and J. Johanson (1991), Internationalization of the Second Degree: The Emergence of European-Based Centres in Swedish Firms. In S. Young and J. Hamill (eds.): Europe and the Multinationals. Worcester: Edward Elgar Publishing Ltd.

Foss, N.J and J. F. Christensen (1997), A Market-Process Approach to Corporate Coherence, forthcoming in *Managerial and Decision Economics*.

Goold, M. and A. Campbell (1987), *Strategies and Styles. The Role of the Centre in Managing Diversified Corporations*, Oxford: Basil Blackwell.

Goold, M., A. Campbell and M. Alexander (1994), *Corporate Level Strategy: Creating Value in the Multi Business Company*, New York: John Wiley.

Graham, M.B.W. (1985), Corporate Research and Development. The Latest Transformation, *Technology In Society*, Vol. 7: 179-195.

Granstrand, O., L. Håkanson and S. Sjölander (1993), Internationalization of R&D - a survey of some recent research, *Research Policy*, Vol. 22: 413-430.

Granstrand, O., C. Oskarsson, N. Sjöberg and S. Sjölander (1990), Business strategies for new technologies, in E. Deiaco, E. Hörnell and G. Vickery (eds), *Technology and Investment. Critical issues for the 1990s*, London: Pinter Publishers.

Granstrand, O. and S. Sjölander (1993), Internationalization and Diversification of Multi-technology Corporations, in: O. Granstrand, L. Håkanson and S. Sjölander, *Technology Management and International Business. Internationalization of R&D and Technology*. Chichester: John Wiley.

Hedlund, G. (1994), A Model of Knowledge Management and the N Form Corporation, *Strategic Management Journal*, Vol. 15: 73-90.

Hill, C.W.L. (1985), Internal Organization and Enterprise Performance: Some U.K. Evidence, *Managerial and Decision Economics*, Vol. 6: 210-216.

Hill, C.W.L. (1994), Diversification and Economic Performance: Bringing Structure and Corporate Management Back into the Picture, in R.P. Rumelt, D.E. Schendel, and D.J. Teece (eds.), *Fundamental Issues in Strategy. A Research Agenda*, Boston, Mass.: Harvard Business School Press.

Hill, C.W.L. and R.E. Hoskisson (1987), Strategy and Structure in the Multiproduct Firm, *Academy of Management Review*, Vol. 12: 331-341.

Hill, C.W.L. and J.F. Pickering (1986), Divisionalization, decentralization and performance of large UK companies, *Journal of Management Studies*, Vol. 23: 26-50.

Hoskisson, R.E. and M.A. Hitt (1988), Strategic Control Systems and Relative R&D Investment in Large Multiproduct Firms, *Strategic Management Journal*, Vol. 9: 605-621.

Iversen, M. & J.F. Christensen (1996): Danfoss - Strategi, struktur og teknologiledelse. Center for Inter-disciplinary Studies in Technology Management, Copenhagen Business School & Technical University of Denmark (in Danish).

Kaufman, A., M. Merenda and C. Wood (1996), Corporate Downsizing and the Rise of “Problem-solving Suppliers: the Case of Hadco Corporation, *Industrial and Corporate Change*, Vol 5, No. 3.

Kim, Dong-Jae and Bruce Kogut (1996), Technological Platforms and Diversification, *Organization Science*, Vol. 7, No. 3.

Loescher, S.M. (1984), Bureaucratic measurement, shuttling stock shares, and shorte - ned time horizon: implications for economic growth, *Quarterly Review of Economics and Business*, 24: 1-23.

National Science Board. National Science Foundation. Committee on Industrial Support for R&D (1992): *The Competitive Strength of U.S. Industrial Science and Technology: Strategic Issues.*

Nelson, R. and S. Winter (1977), In search of a useful theory of innovation, *Research Policy*, Vol. 6: 36-76.

Oskarsson, C. (1993), *Technology Diversification - The Phenomenon, its Causes and Effects*, Göteborg: Chalmers University of Technology, Department of Industrial Management and Economics.

Patel, P. and K. Pavitt (1991): Large Firms in the Production of the World's Technology: An important Case of "Non-Globalisation", *Journal of International Business Studies*, Vol. 22: 1-21.

Pavitt, K. (1991), Key Characteristics of the Large Innovating Firm, *British Journal of Management*, 2: 41-50.

Pavitt, K., M. Robson, and J. Townsend (1989), Technological accumulation, diversification and organization in UK companies 1945-1983, *Management Science*, 35, 1: 81-99.

Prahalad, C.K. and Y.L. Doz (1987), *The Multinational Mission*, New York: Free Press.

Prahalad, C.K. and G. Hamel (1990), The Core Competence of the Corporation, *Harvard Business Review*, May-June: 79-91.

Rubenstein, A. (1989), *Managing technology in the decentralized firm.* New York: Wiley.

Taylor, W. (1991), The Logic of Global Business: An Interview with ABB's Percy Barnevik, *Harvard Business Review*, March-April: 91-105.

Teece, D.J., R. Rumelt, G. Dosi, and S. Winter (1994), Understanding corporate coherence. Theory and evidence, *Journal of Economic Behavior and Organization*, 23: 1-30.

Twiss, B. (1992): *Managing Technological Innovation*, London: Pitman (fourth edition)

Wagstyl, S. (1996), An open market in industrial research, *Financial Times*, October 22.

Whittington, R. (1990), The Changing Structures of R&D: From Centralization to Fragmentation, in R. Loveridge and M. Pitt (eds.): *The Strategic Management of Technological Innovation*, Chichester UK: John Wiley & Sons.

Williamson, O.E. (1975): *Markets and Hierarchies: Analysis and Anti-Trust Implications*, New York: The Free Press.

Danish **R**esearch **U**nit for **I**ndustrial **D**ynamics

The Research Programme

The DRUID-research programme is organised in 3 different research themes:

- The firm as a learning organisation

- Competence building and inter-firm dynamics

- The learning economy and the competitiveness of systems of innovation

In each of the three areas there is one strategic theoretical and one central empirical and policy oriented orientation.

Theme A: The firm as a learning organisation

The theoretical perspective confronts and combines the ressource-based view (Penrose, 1959) with recent approaches where the focus is on learning and the dynamic capabilities of the firm (Dosi, Teece and Winter, 1992). The aim of this theoretical work is to develop an analytical understanding of the firm as a learning organisation.

The empirical and policy issues relate to the nexus technology, productivity, organisational change and human ressources. More insight in the dynamic interplay between these factors at the level of the firm is crucial to understand international differences in performance at the macro level in terms of economic growth and employment.

Theme B: Competence building and inter-firm dynamics

The theoretical perspective relates to the dynamics of the inter-firm division of labour and the formation of network relationships between firms. An attempt will be made to develop evolutionary models with Schumpeterian innovations as the motor driving a Marshallian evolution of the division of labour.
The empirical and policy issues relate the formation of knowledge-intensive regional and sectoral networks of firms to competitiveness and structural change. Data on the structure of production will be combined with indicators of knowledge and learning. IO-matrixes which include flows of knowledge and new technologies will be developed and supplemented by data from case-studies and questionnaires.

Theme C: The learning economy and the competitiveness of systems of innovation.

The third theme aims at a stronger conceptual and theoretical base for new concepts such as 'systems of innovation' and 'the learning economy' and to link these concepts to the ecological dimension. The focus is on the interaction between institutional and

technical change in a specified geographical space. An attempt will be made to synthesise theories of economic development emphasising the role of science based-sectors with those emphasising learning-by-producing and the growing knowledge-intensity of all economic activities.

The main empirical and policy issues are related to changes in the local dimensions of innovation and learning. What remains of the relative autonomy of national systems of innovation? Is there a tendency towards convergence or divergence in the specialisation in trade, production, innovation and in the knowledge base itself when we compare regions and nations?

The Ph.D.-programme

There are at present more than 10 Ph.D.-students working in close connection to the DRUID research programme. DRUID organises regularly specific Ph.D-activities such as workshops, seminars and courses, often in a co-operation with other Danish or international institutes. Also important is the role of DRUID as an environment which stimulates the Ph.D.-students to become creative and effective. This involves several elements:

- access to the international network in the form of visiting fellows and visits at the sister institutions
- participation in research projects
- access to supervision of theses
- access to databases

Each year DRUID welcomes a limited number of foreign Ph.D.-students who wants to work on subjects and project close to the core of the DRUID-research programme.

External projects

DRUID-members are involved in projects with external support. One major project which covers several of the elements of the research programme is DISKO; a comparative analysis of the Danish Innovation System; and there are several projects involving international co-operation within EU's 4th Framework Programme. DRUID is open to host other projects as far as they fall within its research profile. Special attention is given to the communication of research results from such projects to a wide set of social actors and policy makers.

DRUID Working Papers

96-1 **Lundvall, Bengt-Åke:** The Social Dimension of the Learning Economy. (ISBN 87-7873-000-7)

96-2 **Foss, Nicolai J.:** Firms, Incomplete Contracts and Organizational Learning. (ISBN 87-7873-001-5)

96-3 **Dalum, Bent and Villumsen, Gert**:Are OECD Export Specialisation Patterns Sticky?' Relations to the Convergence-Divergence Debate. (ISBN 87-7873-002-3)

96-4 **Foss, Nicolai J:** Austrian and Post-Marshallian Economics: The Bridging Work of George Richardson. (ISBN 87-7873-003-1)

96-5 **Andersen, Esben S., Jensen, Anne K., Madsen, Lars and Jørgensen, Martin:** The Nelson and Winter Models Revisited: Prototypes for Computer-Based Reconstruction of Schumpeterian Competition. (ISBN 87-7873-005-8)

96-6 **Maskell, Peter:** Learning in the village economy of Denmark. The role of institutions and policy in sustaining competitiveness. (ISBN 87-7873-006-6)

96-7 **Foss, Nicolai J. & Christensen, Jens Frøslev:** A Process Approach to Corporate Coherence. (ISBN 87-7873-007-4)

96-8 **Foss, Nicolai J.:** Capabilities and the Theory of the Firm. (ISBN 87-7873-008-2)

96-9 **Foss, Kirsten:** A transaction cost perspective on the influence of standards on product development: Examples from the fruit and vegetable market. (ISBN 87-7873-009-0)

96-10 **Richardson, George B.:** Competition, Innovation and Increasing Returns. (ISBN 87-7873-010-4)

96-11 **Maskell, Peter:** Localised low-tech learning in the furniture industry. (ISBN 87-7873-011-2)

96-12 **Laursen, Keld:** The Impact of Technological Opportunity on the Dynamics of Trade Performance. (ISBN 87-7873-012-0)

96-13 **Andersen, Esben S.:** The Evolution of an Industrial Sector with a Varying Degree of Roundaboutness of Production. (ISBN 87-7873-013-9)

96-14 **Dalum, Bent, Laursen, Keld & Villumsen, Gert**: The Long Term Development of OECD Export Specialisation Patterns: De-specialisation and "Stickiness". (ISBN 87-7873-014-7)

96-15 **Foss, Nicolai J.:** Thorstein B. Veblen: Precursor of the Competence-Based Approach to the Firm. (ISBN 87-7873-015-5)

96-16 **Gjerding, Allan Næs:** Organisational innovation in the Danish private business sector. (ISBN 87-7873-016-3)

96-17 **Lund, Reinhard & Gjerding, Allan Næs:** The flexible company Innovation, work organisation and human ressource management. (ISBN 87-7873-017-1)

97-1 **Foss, Nicolai J.:** The Resource-Based Perspective: An Assessment and Diagnosis of Problems. (ISBN 87-7873-019-8)

97-2 **Langlois, Richard N. & Foss, Nicolai J.:** Capabilities and Governance: the Rebirth of Production in the Theory of Economic Organization. (ISBN 87-7873-020-1)

97-3 **Ernst, Dieter:** Partners for the China Circle? The Asian Production Networks of Japanese Electronics Firms. (ISBN 87-7873-022-8)

97-4 **Richardson, George B.:** Economic Analysis, Public Policy and the Software Industry. (ISBN 87-7873-023-6)

97-5 **Borrus, Michael & Zysman, John:** You Don't Have to Be A Giant: How The Changing Terms of Competition in Global Markets are Creating New Possibilities For Danish Companies. (ISBN 87-7873-024-4)

97-6 **Teubal, Morris.:** Restructuring and Embeddeness of Business Enterprises-Towards an Innovation System Perspective on Diffusion Policy. (ISBN 87-7873-025-2)

97-7 **Ernst, Dieter & Guerrieri, Paolo:** International Production Networks and Changing Trade Patterns in East Asia: The case of the Electronics Industry. (ISBN 87-7873-026-0)

97-8 **Lazaric, Nathalie & Marengo, Luigi:** Towards a Characterisation of Assets and Knowledge Created in Technological Agreements: Some evidence from the automobile-robotics sector. (ISBN 87-7873-027-9)

97-9 **Ernst, Dieter.:** High-Tech Competition Puzzles. How Globalization Affects Firm Behavior and Market Structure in the Electronics Industry. (ISBN 87-7873-028-7)

97-10 **Foss, Nicolai J.:** Equilibrium vs Evolution in the Resource-Based Perspective: The Conflicting Legacies of Demsetz and Penrose. (ISBN 87-7873-029-5)

97-11 **Foss, Nicolai J.:** Incomplete Contracts and Economic Organisation: Brian Loasby and the Theory of the firm. (ISBN 87-7873-030-9)

97-12 **Ernst, Dieter & Lundvall, Bengt-Åke:** Information Technology in The Learning Economy – Challenges for Developing Countries. (ISBN 87-7873-031-7)

97-13 **Kristensen, Frank Skov.:** A study of four organisations in different competitive environments. (ISBN 87-7873-032-5)

97-14 **Drejer, Ina, Kristensen, Frank Skov & Laursen, Keld:** Studies of Clusters as a Basis for Industrial and Technology Policy in the Danish Economy. (ISBN 87-7873-033-3)

97-15 **Laursen, Keld & Drejer, Ina.:** Do Inter-sectoral Linkages Matter for International Export Specialisation? (ISBN 87-7873-034-1)

97-16 **Lundvall, Bengt-Åke & Kristensen, Frank Skov.:** Organisational change, innovation and human ressource Development as a response to increased competition. (ISBN 87-7873-036-8)

98-1 **Præst, Mette.:** An Empirical Model of Firm Behaviour: A dynamic Approach to Competence Accumulation and Strategic Behaviour. (ISBN 87-7873-037-6)

98-2 **Ducatel, Ken.:** Learning and skills in the Knowledge Economy. (ISBN 87-7873-038-4)

98-3 **Ernst, Dieter.:** What Permits Small Firms to Compete in High-Tech Industries? Inter-Organizational Knowledge Creation in the Taiwanese Computer Industry. (ISBN 87-7873-039-2)

98-4 **Christensen, Jens Frøslev.:** The Dynamics of the Diversified Corporation and the Role of Central Management of Technology. (ISBN 87-7873-040-6)

Information for subscribers.
Subscription price for 1997 is 600 DKR (about 20 papers). The rate for single issues is 40 DKR. It is possible to make a commitment to an exchange of papers from related departments or research teams. All correspondence concerning the DRUID Working Papers should be send to.

Pernille Wittrup
Fibigerstræde 4
DK-9220 Aalborg OE
Tel. 45 96 35 82 65
Fax. 45 98 15 60 13
E-mail: druid-wp@business.auc.dk