TRANSNATIONAL TECHNOLOGY NETWORKS

by

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Abstract

The era of the management of technology on a global scale is being heralded along with the advent of third generation R&D and the blossoming of transnational business alliances. Yet our understanding of the diverse forms of transnational technology management is fragmentary. There are significant gaps in our knowledge which preclude a comprehensive model. This paper identifies some of these gaps and considers how they might be filled.

TRANSNATIONAL TECHNOLOGY NETWORKS

3M is a US$ 14 billion diversified manufacturing company headquartered in the USA that is generally acknowledged to be a leader in the commercialization of technology on a global scale (Nicholson, 1994). More than 50% of its sales are generated outside of the USA. It sells some products that are essentially the same world wide, others which are generically the same but have modifications for local markets, and others which are unique products for local markets. A global technical network supports this global business strategy. Over 2,500 of 3M's 8,000 technical employees are located outside of the USA. 3M established its first overseas lab in Harlow England in 1963 and has never looked back.

3M is the prototype of the global corporation based upon the commercialization of technology but it is not the only one. The other names in the club are a virtual who's who of blue ribbon companies, IBM, AT&T, Philips, Xerox, Hitachi and Glaxo, to name just a few. Issues in the transnational management of technology are becoming more and more important as more and more organizations become globalized, a larger and

larger proportion of the world's commercial activity takes place on the global stage and technology continues to play an increasing role in commercial activity.

This paper will examine one aspect of the general move towards globalization, the so-called globalization of technology management. Some significant issues in the literature on the subject will be discussed, focusing upon what is known, where gaps in our understanding lie, and how they might be filled.

Globalization?

Although the globalization of technology management is a much heralded trend, one might ask how pervasive it is. Dunning (1994) has presented some revealing data. Table 1 shows the geographical distribution of R&D spending. It shows that 46.3% of global R&D spending takes place in North America, 31.2% in western Europe and 17.2% in Japan. In short, 95% of global R&D spending takes place in the triad (North America, Western Europe and Japan). It is hardly a global phenomenon. Table 2 shows historical trends in the location of R&D activity. By two measures, the location of R&D expenditures and the location of R&D personnel, R&D activity is shifting out of the US, primarily to Japan but also to some

western European countries. So there is some shifting of R&D activity among the triad. Other data indicate, however, that non-triad countries are gaining some ground. UNESCO data (Dunning, 1994) show that between 1970 and 1987 the contribution of developing countries to world R&D expenditures rose from 2.4% to 6.2% and their share of scientists and engineers grew from 8.5% to 11.2%. Dunning also showed that although multi-national firms do 30% of their production off-shore, they do only about 12% of their R&D.

Insert Tables 1 and 2 about here

Numbers such as these show that the much touted globalization of technology management is not as pervasive as one might gather from some commentators. It is confined largely to the triad and to a relatively small percentage of firms' R&D expenditures. This suggests that it may be misleading to talk of the globalization of technology management. This paper will use the term transnational rather than global to indicate that firms do spread their R&D across a number of countries but that it is not truly globally dispersed. Also, the term transnational is used by Bartlett and

Ghoshal (1989) to describe the mode of operation of many of the firms who do significant amounts of R&D off-shore and so its use here will be consistent with theirs.

Although it is not truly global, the expatriation of R&D is still a significant phenomenon. R&D expatriation is increasing in amount and degree of dispersion. It is very much a part of the activities of the world's largest, most innovative and most powerful corporations.

Transnational Internal Technology Networks

One component of the literature on the transnational management of technology concerns firms' management of several R&D units which they wholly own but which are located in a number of different countries. A number of large firms, such as 3M, have such R&D networks and have developed management systems to coordinate the activities of these dispersed units. Since these networks are wholly owned by their firms they will be called here, internal networks. This contrasts them to networks that involve the participation of outsiders, such as other firms or government agencies.

Much of the research on internal networks has attempted to delineate their extent, nature, functions, causes and consequences. This research came to an important focus in 1990 at a conference titled "Technology

Management and International Business". The contributors included most of those doing important work in this area and their papers have been made available in a volume edited by Granstrand, Hakanson and Sjolander (1992). In that volume, the editors have presented a simple but comprehensive model which gives an organizing structure to the varied contributions.

As seen in Figure 1, the Granstrand et el (1992) model organizes the findings of the conference participants into four categories. Part A, Contexts, includes factors which set the framework which has fostered the transnationalization of technology management. These include the internationalization of economies, science and technology, companies and technology acquisition. Part B, Internationalization of R&D, includes various manifestations of the transnationalization phenomenon, including geographical location and dispersion of R&D, types of foreign R&D labs and activities, and international patenting. Part C, Determinants, includes the forces that have directly caused or impeded transnationalization. Stimulating forces include such factors as favourable government regulations overseas, local ambitions of subsidiaries, and desire for access to foreign science and technology. Inhibiting forces include costs of communication and control, historical inertia and economies of scale with home-based

R&D. Part D, Effects, includes outcomes such as increased costs of coordination and control, reverse technology transfer to the home country and some denationalization of firms.

Insert Figure 1 about here

Granstrand et al (1992) have done an excellent job of organizing this tremendous body of data and ideas into this simple but comprehensive model. It brings a necessary coherence to the varied research streams. Unfortunately, they were unable to bring it so far as to provide a tight integration of the parts. In their own words, (Page 423, Granstrand, Hakanson and Sjolander, 1993) "Although the findings presented here about the internationalization of R&D are not clearly conflicting, it is yet premature to make a coherent synthesis and to offer overall conclusions." This lack of a coherent synthesis of the literature on internal transnational networks leaves an important gap in our understanding. It is worthwhile to enquire how it might be plugged.

A first step towards integration can be taken by focusing more explicitly upon some of the causal linkages among the four elements shown in the

Granstrand et al (1992) model. As shown in Figure 2, a strong and direct causal link can be drawn between "C. Determinants" and "B. Internationalization of R&D". This is because these are the causes and effects which are most concrete and which are most tangibly related to each other. "A. Contexts" is primarily a causal factor but its connection to "B. Internationalization of R&D" is not as strong as that of "C. Determinants". "D. Effects" are primarily effects but their connection to "C. Determinants" is not as strong as that of "B. Internationalization of R&D". While these are the strongest and most direct causal linkages, they are certainly not the only ones, as Granstrand et al (1992) point out. For example, "D. Effects" can feed back into "A. Contexts" to provide a context even more favourable for transnational R&D. So, although there are multiple causal linkages among most of the variables in the Granstrand et al (1992) model, by assuming certain of these to be primary an integrating model may be possible. The problem is to provide a linking causal logic between the causes and effects.

Insert Figure 2 about here

The intervening causal link is the management decision making which goes on between the causes and effects. The causal factors are turned into the effects by managers who make decisions about the deployment of R&D resources. Managers, taking into account the current business context (A. Contexts), make decisions during which they consider the operative centrifugal and centripetal forces (C. Determinants). Those decisions, presumably, involve some sort of R&D deployment strategy which informs the decision makers. The consequences are that R&D has a certain complexion, manifest in "B. Internationalization of R&D". The more indirect consequences of "D. Effects" follow. If we can understand in more specific terms why managers decide to put what, where, we will have a more detailed, theoretical connection between the elements in the broad categories provided by Granstrand et al (1992).

R&D Deployment Strategy

To integrate the available data and ideas on internal networks, as they are outlined by Granstrand et al (1992), will require the articulation of a general, coherent R&D deployment strategy which underlies the activities of many organizations. An examination of the literature shows that not a great deal has been written about transnational R&D deployment strategy.

The topic gets passing mention in a good many publications but there are very few attempts to discuss it systematically. Three papers which do give it significant attention are those by Perrino and Tipping (1989), Howells (1990) and Pearson, Brockhoff and Boehmer (1993).

On the basis of Perrino and Tipping (1989) and Howells (1990) it seems clear that at least three factors need to be included in a model of deployment strategy. The first is the general business and technology strategies of the firm deploying the R&D units. Second, the distinctions among research, development and customer service will have to be articulated and the different factors influencing their deployments will have to be understood. Third, the historical development of R&D management and of international business will have to be understood because, in different decades, the rationales for R&D deployment have varied. Perrino and Tipping (1989) and Howells (1990) are not the only writers who discuss these considerations. However, they do describe them in ways which suggest that they will be useful for organizing the Granstrand et al (1992) material.

Pearson et al (1993) suggest that a modification of the Porter (1990) model of competitive advantage can be used to understand R&D deployment strategy. They first do a literature review, which includes some material not

arising from the Granstrand et al (1992) tradition. They then make a convincing argument that a Porter-type strategy model would fit technology deployment. They then draw some implications for management which, although valid, are very, very general. They fail to show explicitly how their model explains and organizes the material they covered in their literature review. What would have been the most convincing part of their paper is left out. Also, of course, they fail to provide the specifics necessary to integrate the findings of Granstrand et al (1992). Despite this, it seems that Pearson et al (1993) have made a good beginning which can be combined with Perrino and Tipping (1989) and Howells (1990) to provide the linkages lacking in the Granstrand et al (1992) model.

In summary, one important weakness in the literature on transnational internal technology networks is the lack of an integrating theory to organize the available data about their causes, nature, dispersion and effects. It has been suggested that a model of the R&D deployment strategies of managers in transnational firms may provide the nexus of an integrating model. There is not a great deal written about such deployment strategies (another gap in the literature) but what is written seems to provide a good beginning for the task of integration. There is a precedent for the value of this kind of

approach. Cusomano and Elenkow (1994) have discussed technology transfer and its effects upon host and home countries. They found that by including ideas about strategy and management in their analysis they were able to resolve a number of the previously unresolved issues in the literature on technology transfer.

Operational Management of Transnational Internal Technology Networks

Another subject which has received relatively little attention in the literature is how to operationally manage transnational internal technology networks. What discussions there are tend to focus upon two subjects, communications and the effects of cultural differences.

Communication

Those who have written about the operational management of transnational internal technology networks have stressed the need for a high level of communication among the scattered R&D centres of a firm. Strong communication links are needed to ensure that the centres are well coordinated with each other and with the strategic objectives of the firm.

"Technical network" is a term sometimes used to designate the organizational structures established to maintain those communications.

There are several descriptions of such networks in the literature. That of Hughes Aircraft will be used as an example here.

Hughes has seven technical networks, each covering a particular technical area within the firm, such as electro-optics sensors or software (Chester, 1994). Each network covers a set of critical technologies and most have sub-networks focused upon particular sub-technologies. In principle, each network consists of all of the technical experts employed by Hughes whose expertise is encompassed by a technology. This is not strongly formalized so that not everyone participates in the networks to which they might be expected to be attached. Each of the seven networks has a half-time facilitator who is paid from corporate funds. Each also has a Network Management Committee (NMC), consisting of high level technical managers from each of the six sectors of Hughes and its research labs. The seniority of these managers is reflected in the fact that each supervises several hundred engineers. A Network Executive Committee (NEC) oversees the activities of all seven networks. It consists of senior executives of the sectors plus vice presidents of research and technology.

Networks perform a number of roles. They foster communication, firm-wide, on technical issues through seminars and other activities. They

develop R&D projects involving multiple businesses and laboratories. They coordinate the content and mile-stones of R&D projects across different sectors and maintain a five-year planning chart for them. They help move people and projects across organizational boundaries.

The networks in other firms have some characteristics similar to those of Hughes but do have differences (Chester, 1994). Martin Marietta Corporation, for example, puts a higher emphasis upon IT links than does Hughes. At 3M the network is more informal than at Hughes.

The literature stresses that, for networks to work, high levels of face-to-face contact and interpersonal trust must be maintained (Chester, 1994; Krogh, 1994; DeMeyer, 1993; Nicholson, 1994). Although IT is an important tool for networking, it is no substitute for face-to-face contact. High travel and IT costs are to be expected.

Culture

Another theme in the literature on the operational management of transnational internal technology networks concerns the management of the cultural differences that are inevitably found in geographically dispersed organizations (Cheng, 1994; Hoppe, 1993; Shane, 1994). For example, Shane (1994) explains that although having a project champion is generally

considered essential for innovation, what constitutes a champion varies from culture to culture. A champion's style must be crafted to suit the culture in which the championing is being done. Then, of course, there are cultures in which the very idea of a champion, in any shape or form, is anathema.

This completes the discussion of the literature most directly concerned with transnational internal technology networks. Two major gaps have been identified in this literature. The first is the lack of an integrating model to pull together the considerable data on their causes, nature and effects. The attempt to provide an integrating model for this material is hindered by the dearth of writing on strategies for R&D deployment. A second gap in the literature is in the area of how to operationally manage these networks. The literature that is in the area provides excellent discussions of communication and cultural issues but we do need to know more.

At this point it is useful to move on to an area of study which has grown in parallel to the literature on wholly owned technology networks. That area describes third generation R&D.

Third Generation R&D

Third generation R&D (Roussel, Saad and Erickson, 1991) refers to a way of managing R&D which emerged during the 1980's and which was

originally described in the literature in the very late 1980's and very early 1990's. The Roussel, Saad and Erickson (1991) book, called Third Generation R&D, will be used as the primary source for discussion in this paper. Other descriptions of the same type of management approach can be found in Coombs and Richards (1993) and Ransley and Rogers (1994).

The definitional essence of third generation R&D is that it is an approach that integrates technology strategy with business strategy in a seamless whole. The strategy is to identify those technologies that are at the core of what the firm does and to nurture and exploit them.

Third generation R&D is best understood by contrasting it to first and second generation R&D, as shown in Figure 3. First generation R&D, the strategy of hope, consisted of resourcing R&D from corporate level coffers, at arbitrarily chosen levels, in the hope that it would, from time to time, produce results of commercial value to the firm. There was little interference with R&D from other parts of the firm, including from top management. This approach was taken after World War II and persisted through the sixties. During the seventies, second generation R&D emerged as a more rational approach focused upon project evaluation. There were control systems for evaluating individual research projects but no corporate-

wide strategy to coordinate them all. Third generation R&D involves a corporate strategy which funds and controls R&D as an important, integrated, aspect of corporate activity.

Insert Figure 3 about here

The literatures on third generation R&D and the management of transnational internal technology networks both stress the importance of a firm-wide technology strategy which is integrated with the firm's general strategy. The Granstrand et al (1992) model and the papers it encompassed give attention to strategy. Pearson et al (1993), Perrino and Tipping (1989) and Howells (1990) have all addressed strategy issues explicitly. Firm wide strategy also gets attention in the practitioner articles describing technology networks (eg. Chester, 1994; Nicholson, 1994). The third generation approach gives even more attention to strategy, with fully two-thirds of the Roussel et al (1991) book devoted to the analysis of the "R&D portfolio", with the aim of making effective strategic decisions. The four models of R&D practice described in Ransley and Rogers (1994) all have strategy as their cornerstone.

Another feature common to both the internal technology network literature and the third generation approach is an emphasis upon the organic, holistic approach to technology development and exploitation by the firm. As described above, the technology network approach advocates frequent communication, organization wide, on technology issues, preferably face-to-face but with IT support. In the third generation approach, Roussel et al (1991) spend about one-third of their pages on issues other than technology portfolio management. A prominent theme in that one-third of the book is the necessity of a seamless communication web amongst R&D people and among R&D and non-R&D people. There is a clarion call to bring R&D people in from the cold, as it were. That communication web should facilitate an integrated operational and strategic approach to technology and other aspects of the firms activities. Regrettably, the third generation book presents mainly well worn ideas about how to accomplish all of this with little reference to the possibility that R&D people may be transnational.

The networks and the third generation approaches have other points of conceptual contact. The third generation book provides a good model of the history of R&D since WW II. That model of historical evolution could provide the historical framework needed in the model of deployment

suggested for plugging the conceptual gap in the Granstrand et al (1992) model. The third generation model of R&D portfolio management could also fit into the model of R&D deployment strategy.

In summary, the literatures on the management of transnational internal technology networks and third generation R&D management are compatible with each other and stress some common themes, most importantly the strategic approach to technology management. However, neither body of ideas is, as currently articulated, capable of enveloping the other. Neither provides a framework into which the other could fit. However, it may be possible to use the historical perspective, portfolio management model and ideas about technology management from the third generation approach, in the development of an R&D deployment strategy model for the integration of material about transnational internal technology networks.

Transnational External Technology Networks

Another area of literature concerned with transnational technology networks is that dealing with inter-firm collaborations. Two-partner and multi-partner collaborations for purposes of technology management are increasingly common (Gomes-Casseres, 1994). Some commentators forecast that they are the prototype of the organizations of the future (Freidheim,

1993; Hinterhuber and Levin, 1994; Larsson, 1993). A varied vocabulary has been used in the literature to refer to these various kinds of networks, partnerships and alliances and there is no broadly accepted usage. To facilitate the discussion here, the following usage is adopted. The complete set of a firm's external collaborations will be called its "external network": A collaboration involving only one partner, a "partnership": A collaboration involving multiple partners, an "alliance". There is a very large literature on external networks which does not focus particularly upon technology management. In this paper the focus is upon technology networks.

The literature on technology management in transnational external technology networks is characterized by two primary themes. The first is that such networks are a method of technology acquisition (Granstrand, Bohlin, Oskarsson and Sjoberg, 1992; Granstrand and Sjolander, 1990; Kleinknecht and Reijnen, 1992). The second theme is that the modes of external acquisition can be arranged on a continuum according to the degree to which they are integrated with the acquiring firm (Garrette and Quelin, 1994; Granstrand and Sjolander, 1990; Pisano, 1990).

The technology acquisition theme begins with the assumption that technology management should be driven from the strategic level. Once a

strategic decision has been made that a particular technology is needed by a firm, the next question is whether it should be developed in-house or be obtained externally. There are a number of external acquisition modes (eg. joint venturing, licensing, sub-contracting), any of which can be pursued in either partnerships or alliances.

The second theme, that the modes of external acquisition can be arranged on a continuum according to the degree to which they are integrated with the acquiring firm, often uses Williamson's (1975) transaction cost model as the conceptual basis for the continuum. Williamson distinguished between markets and hierarchies. The different modes of external acquisition can organized according to the degree to which they have the elements of markets or hierarchies. At the hierarchy end of the continuum is the acquisition technique which is most integrated into the structure of the acquiring firm, technology acquisition by developing it in the firm's own R&D labs. At the market extreme of the continuum are the acquisition techniques which are most like market transactions, such as the sub-contracting of technology development for a set price. Between these extremes are those with mixtures of markets and hierarchies, such as technology acquisition through a joint venture organization. These

acquisition modes involving aspects of both markets and hierarchies have been dubbed "hybrid forms".

Operational Management of Transnational External Technology Networks

There are two major sets of issues to be considered in the operational management of transnational external technology networks. The first involves the management of the external network itself. The second involves the strategically guided coordination of the internal and external networks of the firm. There is not a great deal written about the operational management of external technology networks, transnational or domestic. One might, therefore, turn to the literatures on partnerships and alliances, or to that on internal technology networks, for advice on the operational management of external networks.

Although a great deal has been written about the management of partnerships and alliances (Bronder and Pritzl, 1992; Business International Corporation, 1987, 1992; Forrest and Martin, 1992; Gates, 1993; Littler, Leverick & Bruce, 1995; Kanter, 1994; Troy, 1994), and that advice is sound and has enduring value, it is limited in the context of external technology network management. First, it does not generally discuss issues

specific to technology management. Second, it tends to focus upon dealing with one partner at a time, and little attention is given to managing multiple partners, even when the advice is ostensibly about alliances as well as partnerships. The advice has limitations, therefore, if applied to alliance management or to the management of a technology network which includes multiple partnerships and/or alliances. Third, it tends to focus on the start-up phase of partnership and alliance activity and gives little attention to on-going operational management. Finally, no attention is given to the coordinated management of the internal and external networks of the firm.

The literature on internal networks is also limited in its application to external networks, due to the significant differences between internal and external networks. For example, an important aspect of managing internal networks is to maintain open communications among all involved. Good internal network management, therefore, includes such mechanisms as free disclosure of ideas and information, high levels of trust, unbridled access on IT systems, and regular face-to-face meetings at which emerging ideas are shared and discussed in an open and sometimes playful manner. With external networks, in which the leakage of proprietary information to outsiders is a significant risk, such mechanisms may not be feasible.

Consider the following complexities that may be involved in the management of technology networks. First, a firm may have an internal network of R&D units. Reliable ways of managing such networks have been developed, as discussed above, but it is a complex task. Next, a firm's external network, its collaboration portfolio, so to speak, may involve a number of complexities. It may include a number of single partner arrangements and a number of multiple partner arrangements. For example, IBM has single partner linkages with SSI, Thinking Machines, and Micron Technology; and multi-partner arrangements with Apple and Motorola as well as with Nissan Motors and Nippon Steel, to name just a few of the collaborations in IBM's external network (Lei, 1993). The purposes of these collaborations can vary widely, from producing economies of scale in manufacturing to overcoming legal and trade barriers (Mason, 1993). The focus here has been on only one such purpose, the acquisition of technology. The arrangements in the external networks may take a variety of different forms. For example, one partnership might be a joint venture, another might be a licensing agreement, another might be a subcontract to develop a particular piece of technology. As with partnerships, alliances can take different forms. A firm can be a licensee in one alliance and a joint venture

partner in another. In some alliances a firm may be the primary initiator and in others merely a bit player.

The integrated management of the internal and external networks is a complex task about which little has been written. We do not even have a widely accepted vocabulary to describe various collaboration forms, let alone an articulated, organized set of ideas about management. The good advice available for managing internal networks (discussed above) has limited applicability to external networks and does not say anything about the coordinated management of both. The good advice available for managing partnerships and alliances (referenced above) focuses mainly upon setting them up, does not really address operational management, generally does not consider the complexities of managing multiple partners, and does not say anything about the coordinated management of the internal and external networks. The little which has been written which truly addresses alliance issues (eg. Gomes-Casseres, 1994) normally has little to say about the integrated management of internal and external networks. One paper which does discuss the relationship between the internal network and the collaboration portfolio is that by Sen and Rubenstein (1990). They describe the role that in-house R&D can play in the external acquisition of

technology. Another paper which gives attention to both networks is that by Hausler, Hohn and Lutz (1994) which traces the evolution of a complex alliance over several years.

Conclusions

The available material on the management of transnational technology networks has not been brought together into a single organized framework. However, coherent sub-areas of study have been identified.

One sub-area focuses upon the description of the extent, nature, functions, causes and consequences of networks of wholly owned R&D labs, called here, internal networks. Lacking within this area is a theoretical model to integrate the diverse data and ideas that are available. It has been suggested that a model of R&D deployment strategy could be used to integrate this material. Some work in this area has already been done.

Another sub-area focuses upon the operational management of internal technology networks. The literature available here stresses communication and cultural issues as key in the effective management of such networks.

A related sub-area focuses upon third generation R&D. This sub-area, like those concerned with internal networks, emphasizes the need for the strategic management of technology and for the close integration of

technology management with other firm activities. Ideas about technology portfolio management and the historical evolution of R&D from this sub-area may be useful in developing an integrating theory for the sub-area on internal technology networks.

The sub-area on the management of transnational external technology networks focuses upon technology acquisition from external sources and the variety of arrangements for doing so. There is very little written about the operational management of external networks or about coordinating them with internal networks. The available literature on internal networks, partnerships and alliances is of limited value in this context.

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Table 1

Geographical Distribution of R&D Expenditures

	$billion	%	$billion	%
Developed countries				
North America of which			105.6	46.3
US	100.8	44.2		
Western Europe of which:			71.1	31.2
West Germany	19.4	8.5		
United Kingdom	13.8	6.1		
France	13.7	6.0		
Italy	7.4	3.2		
Sweden	4.0	1.8		
Japan			39.1	17.2
Other developed countries			2.2	1.0
Developing countries [a]			9.9	4.3
of which:				
India	1.5	0.7		
Brazil	1.4	0.6		
South Korea	1.3	0.6		
Argentina	1.1	0.5		
All countries			227.9	100.0

Notes. In constant (1982) $ billions, 1986-1987.

From Dunning (1994), Table 1, page 68.

Table 2

Distribution of (Indicators) of Innovating Capability

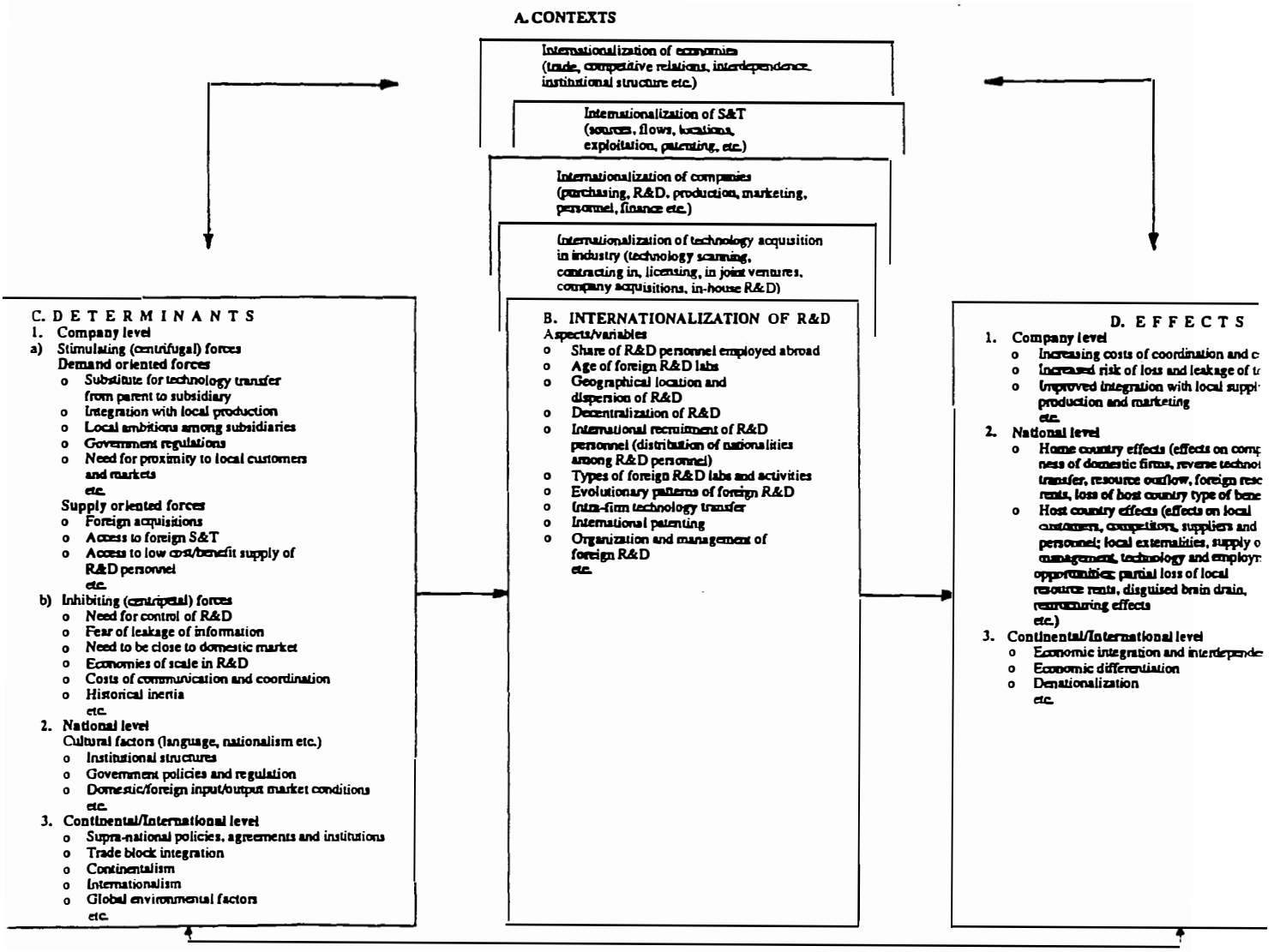
between Five Leading Innovating Countries

	R&D expenditure constant 1982 $ (billion)				R&D personnel (thousands)			
	1970	%	1987	%	1970	%	1887	%
US	62.4	61.7	100.8	54.0	543.8	59.8	791.1	50.9
Japan	12.4	12.3	39.1	20.9	172.0	18.9	405.6	26.1
West Germany	9.9	9.8	19.4	10.4	82.5	9.1	151.5	9.7
France	7.1	7.0	13.7	7.3	58.5	6.4	108.2	7.0
UK	9.4 [a]	9.3	13.8	7.4	52.8 [a]	5.8	98.7 [b]	6.3
	101.2	100.0	186.8	100.0	909.6	100.0	1555.1	100.0

Note. From Dunning (1994), Table 3, page 67.

Figure 1

Overview of Internationalization of R&D



Notes. From Granstrand, Hakanson and Sjolander (1992), Figure 1.1, page 13.

Figure 2

Primary Causal Linkages in the Granstrand et al (1992) Model

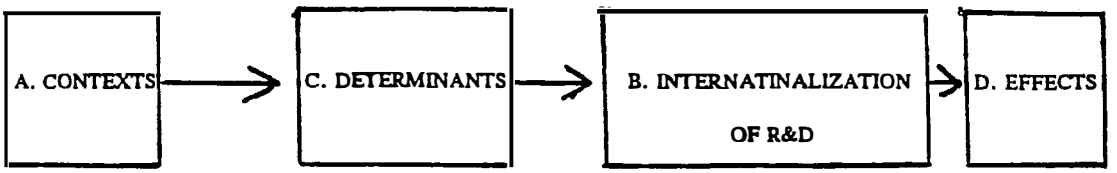
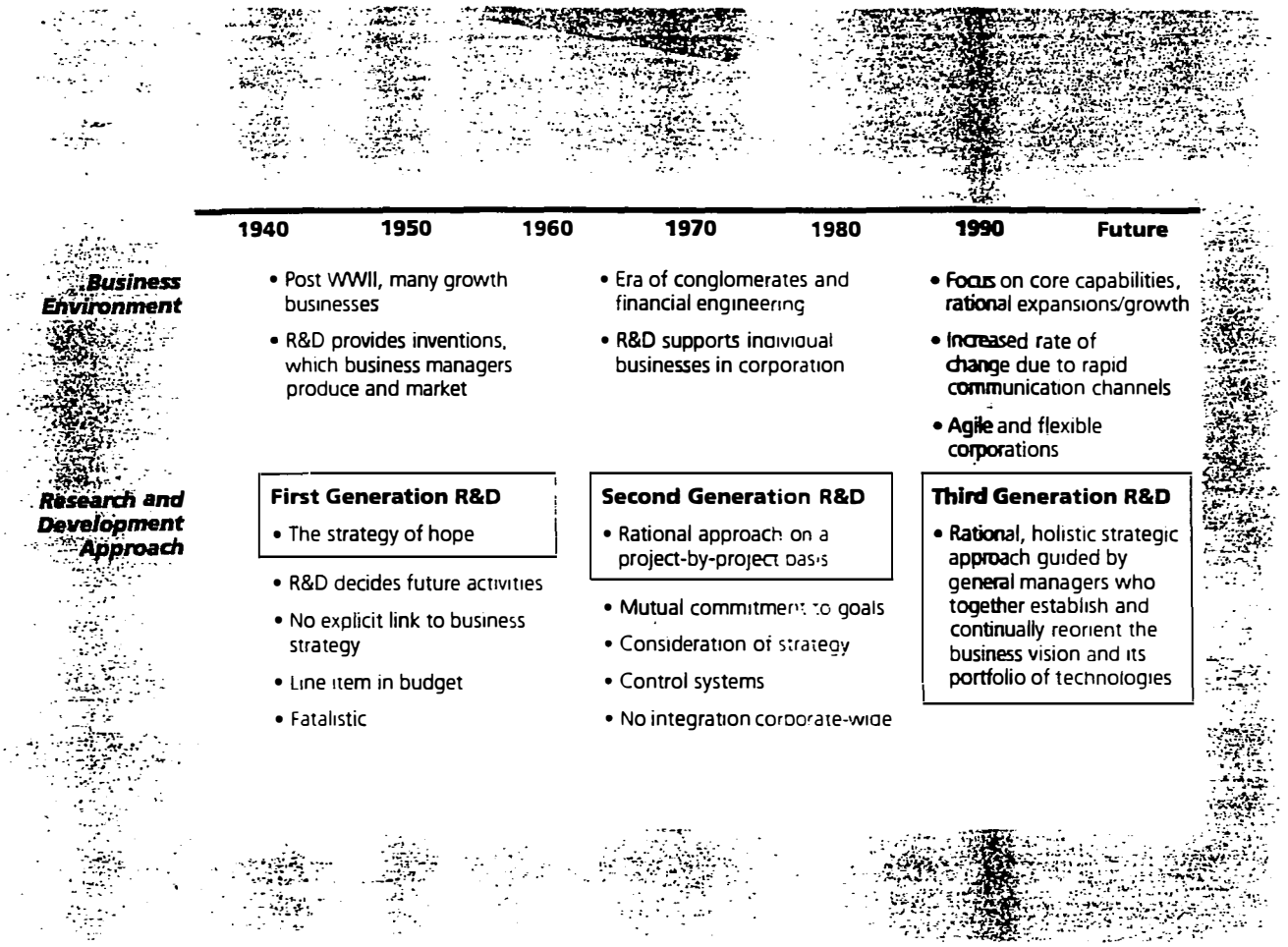


Figure 3

Three Generations of R&D



Note. From Roussel, Saad and Ericson (1991).

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