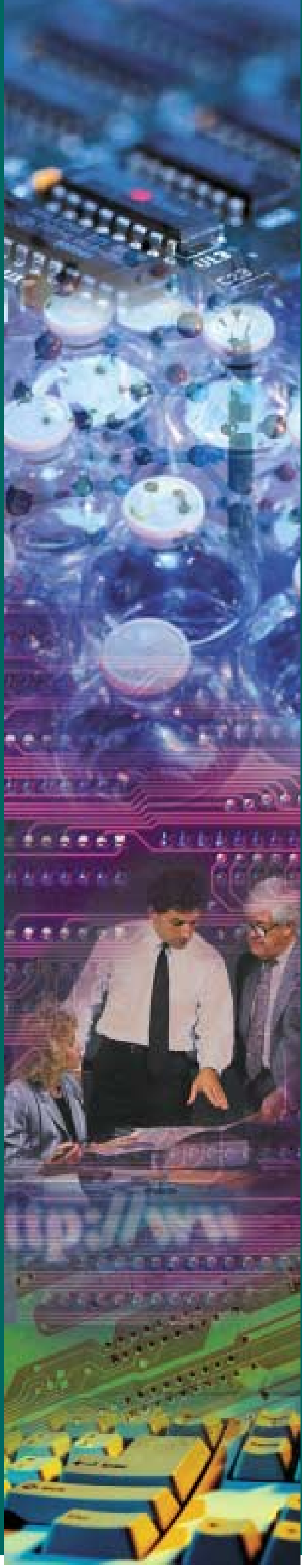

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USER INVOLVEMENT IN R&D CONSORTIA: ISRAEL AS A SHOWCASE

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Consortia, and in particular R&D consortia, are one of the clustering forms used to bring together various relevant parties, in order to foster innovation and economic growth. Consortia have been, and still are, widely mobilized in different geographical (international, national, regional) and thematic areas by private or public operators. Often, their design restricts the participation to innovation producers (big and/or small, academic and/or private). Our previous work showed the interest and potential of user involvement as a driving force in the innovation process. Building on that, we now take into perspective the diversity of the whole set of consortia established by the Israeli Magnet program. Four forms of user involvement (no user involvement, external user involvement, secondary user involvement, primary user involvement) are identified and analyzed through case studies. These cases are discussed in relation to an "ideal type" classification that has horizontal integration industry building consortia on the one hand, and vertical integration complex system consortia on the other. This division helps to define two models and their respective implications for user involvement. The first one, similar to a fountain or a spray, starts from one or a small set of technologies and proceeds to address many different users. In this case, user involvement can only be obtained through an external body, and/or a one-to-one relation between a specific user and a specific producer. Thus, focus and direction in the consortia requires strong motivation and integration on the part of one of the R&D producers. The second one, similar to a point-focused funnel, starts from many technologies to address a very small number of different users, sometimes only just one type. In that case, user involvement can act as a key driving force for the consortium, in its definition, construction and operation. Thus, consortia would benefit from user involvement at the starting point of their activity. In conclusion, some potential user involvement developments for R&D consortia management are proposed.

Keywords: R&D, innovation, high-tech, consortium, users, public policy

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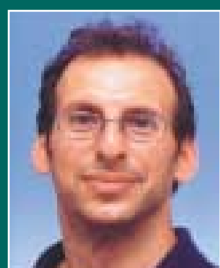

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INTRODUCTION

In knowledge economies, both governments and commercial organizations see innovation as a driving force for economic and business growth. Consortia are one of the possible forms of clustering that can help foster innovation. Consortia are intended to help participants achieve goals that would otherwise be unreachable individually. Indeed, consortia have been widely developed and used by several countries, sometimes but not always in relation with R&D, and thus have received much academic coverage (Evan & Olk, 1990; Aldrich & Saski, 1995; Sakakibara, 1997; Dogson 2000).

Consortia can take various forms, depending on their aim, sector, high or low-tech component, size, budget, participant number and respective size, institutional background and operating procedure. They are considered to provide various advantages that can be categorized as hard benefits (sales, exports, valuation, patents, publications, jobs, etc.) on the one hand and soft benefits (learning, information sharing, long term relationships, etc.) on the other. These consortia raise the key issues of innovation success and benefit appropriation, which may receive different answers when network schemes are implemented in large geographical areas (Japan, USA, Europe, "big" European countries) or in more limited ones (small countries or regional areas within large countries). In particular, for small countries with limited market proximity, there may be a strong commercial incentive to delocalize production and marketing after the initial R&D stage, thus limiting the potential return for the national economy. On the other hand, user participation in consortia is one of the possible ways to increase innovation success and local appropriation of benefits.

In Israel, the consortia scheme has been used in order to support industrial R&D through a government-sponsored program called Magnet. What makes Israel's consortium experience interesting from a small country perspective is the key position attributed to high tech in Israel's economic growth and the successful involvement of government in relation to innovation, often through original forms of intervention (Kahane, a, b, in preparation). Israel has also often been described as an ideal "laboratory case" for innovation policy since the strong government involvement is mirrored by the small size of the country, which makes observation easier, and the important variations of geopolitical and economic contexts, which make reaction time shorter. Thus, we have taken the Israeli Magnet program of R&D consortia as a showcase to describe and discuss the forms and potential of user involvement in such consortia.

In this paper, we first describe the Israeli Magnet program through its main characteristics and evolution, and provide an overall view of the various consortia that have been established within its framework over the last ten years. We then provide some of the rationale and drawbacks often associated with R&D consortia schemes and user involvement. We proceed to show that consortia established through the Magnet program can be classified under two principal types: ex-nihilo industry building on the one side, and complex product system on the other. Finally, we describe various forms of user involvement in these two types of consortia and, from this user involvement perspective, we explore further what it has to offer to R&D consortia management in Israel and in other countries.

THE ISRAELI MAGNET PROGRAM OF R&D CONSORTIA

Israel as a showcase of successful government intervention

The 4.2% of its GDP that Israel spent on civilian R&D in year 2000 attests to the importance of R&D, high tech and innovation in relation to its economic growth[1]. Indeed, in the last 15 years, Israel is one of the countries which can be considered to have successfully taken advantage of the high tech wave, mainly in the information technology and electronic sectors (Teubal & Andersen, 2000). High tech related exports rose from $2278 million in 1990 to $11,188 million in 2000 (State of Israel, 2000). US patents per capita climbed from five to 10, reaching the same level as Finland and placing Israel in third place after Japan and Canada but ahead of the UK, Germany and France (Tratjenberg, 2001). At its peak, venture capital locally invested reached a level of $1270 million. Until the economic crisis related to the NASDAQ crash, the renewal of the Intifada and the September 11th, attack, Israel was positioned as one of the hubs and high technological powerhouses of the knowledge economy.

Israel is distinguished by strong government intervention in relation to R&D and in particular to R&D operated in the business sector. In 1998, national civilian expenditure in R&D was nearly NIS 13 billion (around $ 4 billion) with two thirds of it spent in the business sector. Government funding of R&D in the business sector still remains important, (although its relative proportion decreased due to the increased spending of the business sector itself) reaching NIS 1143 million (around $370 million), with 13% of total civilian R&D operated in the business sector. On the other side, R&D expenses in the academic sector, while funded by the private sector, are still limited to 1.3%, showing a strongly asymmetric flow of funding (CBS, 2001a). All government funding devoted to industrial R&D in the business sector is administered through the Office of the Chief Scientist (OCS) of the Ministry of Trade and Industry. In the last 10 years, the OCS budget has nearly tripled in size to reach its current level of nearly $370 million. Two thirds of this budget is spent on industrial grants disbursed on a non-competitive and neutral basis to firms, which meet the criteria of the OCS (Tratjenberg, 2001b).

Israel as a small but powerfully innovative country

Although the level of Israeli spending on civilian R&D attests to its national importance, Israel is still a very small country and its absolute spending cannot match that of larger countries such as the US, Japan, UK, Germany or France[2]. Thus overcoming its limited size and making the best use of its disproportionate but nevertheless limited scientific and technological resources, is a critical issue for government policy. Furthermore, Israel is characterized by the existence of a very large number of small to medium-sized firms, and a handful of very large ones (only a few with sales of over $1 billion) (Tratejenberg, 2001b). The vitality, daring, and several spectacular successes within this sector provide favorable conditions for an accelerated Darwinian process. Israel must also deal with the fact that relevant markets for its products are geographically distant, mostly in the US and in Europe, because of the Middle-East conflict that prevents normal relations with its neighbors.

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[1] A share that would be significantly increased if defense related R&D, traditionally strong in Israel due to its geopolitical context, was incorporated.

[2] In 1997, the total civilian R&D national budget of $3,129 million was less than that of General Motors, Ford Motors or IBM, the first three leading companies in the US for R&D expenditures. Similarly, Israel's total business sector R&D budget of $2,006 million was less than those of each of the eight top companies in the US (Tratjenberg, 2001b).

Fragmentation of the Israeli high tech sector was perhaps unavoidable, certainly in its initial stages of development, since the overwhelming majority of high tech firms evolve out of start-ups established by individual technological entrepreneurs, and since most of these firms target (at least initially) narrowly defined market niches. Yet relying only on technology is a difficult and fragile strategy, which does not allow much resilience and sustainability when sectors become more mature and consolidate. At a certain point, size and complementary assets become critical and achieving them is difficult for start-ups; then they either fold or are acquired by larger partners, often foreign, interested in their expertise. These same sectorial characteristics call into question the ability of the Israeli high tech sector, and of the Israeli economy as a whole, to reap the long-term economic benefits from its own success. The recent sale of a series of highly successful Israeli companies to foreign corporations is just one of the manifestations of this syndrome. How Israeli firms can go beyond the initial stage of R&D in order to position themselves better financially, and acquire manufacturing and distribution capabilities is thus an open issue.

In order to approach larger markets and take on the requisite longer-term projects, there is a need for larger entities, which in turn calls for various forms of cooperation, joint ventures, mergers and acquisitions. Failure to cooperate is common in fragmented sectors since potential partners are often unaware of each other's existence and of the potential for mutually beneficial cooperation. They may often see competition more as one against the other in their local environment rather than as one with the other in relation to external competitors and/or markets. Furthermore, since some Israeli high tech companies have already achieved significant size, often, but not always through their expertise in the security and defense markets, they could offer a way to help others expand their local added value and international penetration.

The Magnet program - main characteristics

The Magnet program of the OCS (OCS, 2003), implemented in the early 90's, was established with the goal of overcoming R&D fragmentation in the high tech sector in Israel. The Magnet program supports consortia of industrial firms and academic institutions in order to develop "generic, pre-competitive technologies" common to the members of the consortia. Magnet, as an agency of the OCS, finances two-thirds of the R&D budget of the industrial members of the consortia, and 80% of the academic partners. Contrary to the main program of the OCS which is operated through individual grants (Kahane, in preparation a), in the Magnet program there is no payback obligation and selection is made under a competitive basis.

Magnet (OCS, 2003) has the following defining characteristics:

- ➔ Magnet operates under a neutral and competitive basis: When considering applicants, no attempt is made to promote any specific scientific fields and/or industrial sectors as a result of national policy considerations, while the potential of consortia and their technologies in relation to future sales and exports takes priority.
- ➔ Magnet supports generic technology while product development responsibilities remain at the level of the participating firms.
- ➔ Consortia established by Magnet are export oriented due to the limited size of the internal market.
- ➔ Consortia are less oriented toward cost and risk sharing but rather toward combining various and complementary skills, resources and competencies in order to achieve synergy.
- ➔ Magnet represents a significant venue of government support to industrial R&D. Magnet's budget since 1997 represents between one-fourth to one-fifth of OCS' budget for investment in industrial R&D as shown in the table below. Support from

the Magnet program is concentrated on a limited number of consortia. Most consortia are in the $ 25 million overall budget range over an average of three-five years and comprise less than ten participants.

➔ A typical consortium includes both small and large corporations as well as academic institutions.

➔ The consortia create cooperative technological pools encompassing a combination of knowledge from the industrial sector and the academic world.

➔ Promotion of user involvement is both an issue and a target for the program and happens in some of the consortia.

Table 1: Budget of OCS investment in industrial R&D (in $ million)

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Magnet	0.3	3.7	4.6	10	15	36	53	61	60	70
Incubators	3.6	16	23	28	31	30	30	30	30	30
Net individual grants	159	174	198	274	290	269	295	283	289	267
Magnet % of Total	NS	2%	2%	3.6%	5%	13%	18%	21.5%	21%	26%

The importance of Magnet is not only in supporting generic R&D but also in fostering cooperation. Putting related parties together in consortia can help disseminate information about possibilities for joint ventures, and it encourages individual firms to seek such information. In fact, even in a closely knit society and economy such as Israel's, one cannot just assume that, if there are profitable opportunities for cooperation, they will necessarily be realized. Thus, creating an institutional framework can have a definite impact in that regard. Nevertheless, useful and/or needed cooperation is not easily achieved, as will be discussed further on. Efficient ways to achieve this cooperation require prior identification of relevant partners for collaboration and the understanding of how to manage such cooperative efforts.

Magnet - evolution and realization

The Magnet[3] program was launched at the beginning of the 90's, but it took the program a period of four years to define its operational procedures, adapt to its environment and for potential partners to find a common ground that would allow them to engage in consortia. This shows how networks of firms experience difficulties in establishing themselves, and the necessity for a mutual, organizational learning process in order to lead from potential to realization. At the initiation stage of the program, interested parties came mainly from the most developed sector of local technology, namely the defense industry. As this industry was shrinking as a result of considerable reductions in R&D investment by the defense system, spin-offs from this industry looked for ways that would allow them to enhance their future possibilities.

During the three years from 1994 to 1997, the program experienced a situation of go/no-go that was characterized by a hands-off approach: no priorities were made, assessment of consortium final

[3] The description of Magnet's evolution is the result of interviews with key figures inside the program

proposals was done by the program staff, and proposals were encouraged but the founding groups had to work on the proposals alone. This produced only limited results, in particular since potential firms were reluctant to cooperate. Around 1997, when Israel's, and the world's economies were in the midst of the high tech bubble, a third period started for the Magnet program, during which time its staff learned how to better promote and "sell" its activity, and the program became better advertised. Many potential consortia came for funding. At this point, the program decided to adopt a hands-on approach, taking an active role in helping companies from the very start, as soon as they displayed an initial serious intent, all the way through until a consortium was established. It was also decided to switch from a first in, first selected, first funded approach, where each consortium was considered independently when it was ready with its proposal, to a competitive approach where a group of six-nine consortia would be invited to present their proposals at the same time. In a first screening stage, the three best proposals were chosen and received initial approval. Then, through a subsequent, more formal evaluation, the consortium plans were approved and budgeted. The three consortia selected had nearly 100% insurance that they would be funded if they met the administrative and management criteria. This resulted in a quasi auto-selection of good projects while at the same time the program started to experience a steady flow of consortia (one finishes another starts). The program decided to adopt a standardized period of activity of three years for each consortium (with funding given on a yearly basis with reassessment each year) after which it was possible to apply for an extension of two-three more years.

In time, Magnet introduced additional channels for funding with different characteristics: **Magneton** for the transfer of technology from academia to industry and **Users Association** for helping with the distribution and implementation of technology. The program also started to develop new schemes to address research in special sectors at an earlier stage of its application such as **Nofar,** which funds advanced academic applied research in biotechnology, with potential applications that can be developed later in industry.

Since the beginning of the program, 29 consortia have been established by Magnet, of which nearly half are still running. Each operates on an average of $ 6-7 million per year for an average of seven participants. Magnet covers 2/3 of the expenses of firms and 80% of those of participating groups from academia that are related to the consortium. Consortia that have been part of Magnet are listed in the table below.

Table 2: Consortia in the Magnet program

Name of Consortium	Industry sector	Years of activity	No of firms	Large firms	*SMEs	**No of Academic groups	Budget in m$
0.25 Micron/ 300 mm	Electronics	95 - 01	5	1	4	17	27
ALGAE	Biotechnology	93 - 98	3	1	2	3	5
Consist – Consortium for Industrial Software Tools	Software/services	1998 -	6	1	5	3	22
Consolar - Ultra Concentrated Solar Energy Applications	Energy	95 - 00	6	4	2	3	20

DA'AT - Drug and Kits Design and Development	Biotechnology	96 - 01	8	2	6	13	49
DMTC - The Israeli Consortium for the Development of Magnesium Technologies	Chemical/ materials	97 - 01	10	1	9	8	20
DNA Markers	Biotechnology	94 - 00	4		4	1	3
DPIC - Digital Printing Consortium	Multi-domain	98 - 03	9	2	7	17	45
EDCoT - Emerging Dielectrics and Conductors Technologies	Electronic industry	2001 -	8	2	6	9	36
Ground Stations - Ground Stations for Satellite Communication	Communication	93 - 98	5	4	1	14	27
Hybrid Seeds- Hybrid Seeds and Blossom Control	Biotechnology	93 - 98	4		4	2	2
IAEPC - Israeli Advanced Electronic Packaging	Electronics	96 - 01	6	3	3	4	16
ISIS - Information Super Highway in Space	Communication	1999 -	6	2	4	13	36
IZMEL – Development of Generic Technologies for Image Guided Surgical Therapy	Multi-domain	1998 -	11	1	10	12	33
Kite - Knowledge Inference Technology	Software/ services	1999 -	5	1	4	3	15
LESHED - Diode Lasers & Diode Pumped Lasers	Electronics	96 - 01	6	2	4	4	15
LSRT - Rural & Remote Areas Communications	Communication	2000 -	5	1	4	10	28
MMIC - Microwave Monolithic Integrated Circuits	Electronics	94 - 99	8	6	2	1	18

MOEMS - The Israeli Consortium for the Development of Micro-Opto-Electro-Mechanical Systems	Electronics	2002 -	9	4	5	17	50
MOST - Multimedia Online Services Technologies	Multi-domain	96 - 00	23	7	16	20	110
NFM – Nano size Functional Materials	Chemical/ materials	2003 -	13	4	9	11	33
NMS - Network Management systems	Communication	95 - 00	8	1	7	1	17
OptiPac - Optical Packaging		2001 -	12	3	9	4	38
PharmaLogica	Biotechnology	2002 -	8	2	6	23	15
STRIMM - Streaming Rich Media Messaging	Multi-domain	2000 -	9	2	7	4	38
SWR - The Israeli Software Radio Consortium	Communication	1999 -	13	3	10	14	50
TEVEL - Bio-technical Infrastructure For Enhancing Flora	Biotechnology	2000 -	4	0	4	6	12
The Digital Communication Consortium	Communication	94 —99	6	4	2	8	11
WFCM - Wafer Fab Cluster Management	Electronics	1999 -	8	3	5	9	21
Wide Band Communication	Communication	94 -99	5	3	2	4	25

* We have used the number of employee criterion: < 250 for SMEs
** Number of academic groups involved during the activity period coming from different academic institutions.

Classification of Magnet consortia

Mike Hobday (Hobday, 2000) proposes a classification of Innovation models based on “two ideal types” that we found useful and adapted to analyze consortia supported under Magnet. As Hobday comments on Cawson’s (Cawson, 1986) argument, “ideal types are not intended to be accurate descriptions of the real world, they can be useful yardsticks, helping to compare real world observations and are often deduced from rough approximations of empirical data. The two innovation types correspond to end points on a scale, where actual cases will tend to fall between the two poles or somewhat outside the continuum". Mike Hobday differentiates between a conventional innovation model on the one hand and a complex production system/project model on the other. Here, taking into consideration the collective characteristics of networks and the niche, high margin/limited volume products to which most Israeli firms aim, we propose the following ideal types in an adaptation of Hobday's classification:

- "Horizontally integrated networks" are aimed at "local industry building". In horizontally integrated networks, participating firms share and upgrade resources and/or join forces to improve their competitive position vis-à-vis their (potential) clients or suppliers. Industry building consortia are a specific form of horizontal integration, which also join together several players, each with their own set of skills and competences. However, in this model, the aim is either to increase the potential involving a unique technology, or to pool several together. As they share scientific and technological resources, each player will then have to develop it in a specific way. Depending on individual choices and other assets, each will aim at a specific (product) market niche that will be different from those of other consortium members. Thus, in this context, users are much more oriented towards a specific firm. In Magnet R&D consortia, the aim is to build a local industry where firms put together their own limited technologies, skills and competences in order to achieve a critical mass, develop a common, larger pool that can complement their respective ones, and allow them to develop products for their own respective targeted niches. This type of consortia is similar to a fountain or a spray, starting from one or a small set of technologies and proceeding to address many different applications and users.

- "Vertically integrated networks" are aimed at introducing complex product systems (CoPSs), sometimes called large technical systems. Complex product systems consortia are a specific form of vertical integration, which combines several players, each with their own set of skills and competences. They join in order to build systems which are based on integration, and for which individual components would lose most of their value if not joined together. Often this type of system is highly complex, very costly and sold with substantial adaptation, training and support services to accommodate the users' needs. Here, groups of suppliers are encouraged to collaborate with each other and their (potential) contractors. These types of consortia are similar to point-focused funnels; starting from many technologies that are aligned to address a limited set of different users, sometimes only just one type.

After this brief description of the Magnet R&D consortia program, we now take a look at literature that helps understand its rationale and the interest of user involvement in the innovation process.

R&D CONSORTIA AND USER INVOLVEMENT IN ACADEMIC LITERATURE

"New" model of innovation

"The mental models we carry around with us shape the way policy is made" (Arnold, 2001). In the traditional model, innovation goes from basic science to the market in an orderly, sequential way, where, impetus comes either from "science-technological push" or from "demand-pull", limiting the possibilities for interaction and co-evolution. During the 1950's, the science-push model of innovation dominated, yet by the end of the 60's and beginning of the 70's, the role of the marketplace in innovation gained growing acceptance (Rothwell 1992). However, the traditional model fails to address the issues of different players, often not linked together, who nevertheless need to interact in order to achieve innovation. Thus, in the late 70's, Mowery and Rosenberg (Mowery & Rosenberg, 1978) effectively laid the intellectual argument between "push" and "pull" to rest by stressing the importance of coupling between science, technology and the marketplace. They introduced feedback loops and variations over time in the primacy of "push" and "pull" mechanisms.

These earlier innovation models often emphasized the link between the flow of new knowledge and economic innovation but they ignored the huge importance of the stock of existing knowledge, whether scientific and technological or managerial and commercial. Over time, results obtained from field observations came to show that previously accumulated knowledge indeed played a crucial and central role in innovation. Indeed, the vast majority of knowledge used in any innovation comes out of this stock and is not created afresh in the projects that give rise to the innovation. Countless surveys of OECD firms show that their main sources of technology come from their internal knowledge and from other firms. Thus, in this perspective, innovation does not involve inventing everything from scratch but in large part makes use of and reinterprets what already exists at hand or in another place or context. This allows for reinterpreting and recombining existing knowledge with new knowledge created (sometimes but not always) ex-nihilo in an opportunistic way (Arnold, 2001).

Important elements of the knowledge stock derived from previous experience can sometimes even be very old. Working and reworking the existing stock of knowledge is the dominant activity in innovation – a fact that is readily obscured by the focus on novelty in the linear models and in the value given to the research (as opposed to R&D) community. In such a perspective, connections matter. Thus, empowering these players and increasing their connection internally and externally may be a relevant target for government intervention. New models of innovation emphasize the iterative learning dimension of the innovation process, and its trajectory/path dependency as well as its irreversibility (Lundvall, 1992). Under these models, innovation became strongly dependent on previously acquired knowledge, its access and reutilization in new contexts. They offered legitimization of government intervention such as the type exemplified by the Magnet R&D consortia.

R&D consortia through three streams of academic literature

R&D consortia, in their most common form, aim at putting together firms, and often firms and academic institutions, in order to form strategic technology partnerships or simply collaborative innovation networks. They have been the subject of a growing body of scholarly literature (Levy & Samuels, 1991; Hagedoorn, 1996; Vonortas 1997; Mora Valentin 2002), and several streams of arguments can be identified.

The first stream originates with theoretical economics (Spence 1984, Katz & Ordover 1990, Kamie et al 1992). It tends to focus on the "spillover" effects of R&D linked to the creation of a socially useful externality. According to this reasoning, firms enhance social welfare through their research activities but cannot appropriate full benefits from research results unless a form of R&D collaboration can internalize such an externality. These arguments are couched in cost terms, with consortia seen as pooling costs and sharing risks. One of the assumptions related to spillovers is that cooperation should either involve all firms in an industry or none. Otherwise, spillovers may diffuse to non-participating firms that would benefit from a free-ride situation. Related is the situation of firms that may participate without contributing. This assumption should be compared to a reality of network implementation where cooperation usually involves a small subset of firms and academic groups, with different, often asymmetric levels of participation. Particularly, but not only, for small countries, this should also be seen in the context of a global world where development made in some regional or national area could be captured by others who enjoy better complementary assets and/or proximity to relevant markets and users. Although empirical testing of these points is scant, especially for small countries, clear benefits have been demonstrated to participants and to R&D expenditure levels in large countries such as Japan and the US. (Branstetter & Sakakibara, 1997, Link et al 1996).

A second stream has its origins in network innovation theory, which encompasses a different view of innovation. First, in contrast to the previous economic perspective that tends to consider knowledge as information (thus, indivisible and inappropriable), this approach looks at knowledge as more than merely information, with tacit knowledge and knowledge beyond R&D as crucial components of innovation. Science is not a public good that could easily be appropriated and thus often needs close social interactions in order to be disseminated (Callon, 1994). Second, in this perspective, R&D can be described as Janus who embodies two "faces" of the same coin: a knowledge generating face and a learning or knowledge using face. This is at the core of the argument made by Cohen and Levinthal under their "absorptive capacity" concept (Cohen & Levinthal, 1989), which states that firms develop R&D capacity not only to produce new knowledge but also in order to be able to understand and derive benefits from what has been developed by others. Third, and counter-intuitively, the knowledge-using face of knowledge may be the more important one because it deals with the huge stock of knowledge already present in productive activities or that can be exploited for them. The knowledge-generating face is qualitatively important because it provides additions to that stock. These arguments have three important implications:

a) Science, technology and innovation do not disseminate so easily, and local institutional arrangements may be able to exploit them or capture them, where external players may recognize their value, but still be unable to construct such arrangements. The relative interest of such institutional constructions may vary from one sector to another depending on the extent of the tacit component of knowledge, legal protection, specificity and difficulty of reproducing relevant assets and the complexity of achieving their combination in a meaningful way.

b) Science and technology-producing organizations and science and technology-using ones are often the same, recombining existing knowledge they can access and if necessary adding their own production to it. The reverse process is also true, starting from internal knowledge production and then adding and recombining it with existing knowledge taken from other sources. Thus, integration of disseminated knowledge is a key issue for innovation.

c) Innovation is more than R&D (MacDonald, 1986) and organizations do not hold the same skills, resources, competences and assets. It is the combination of these different components, whether inside one firm or with others, that may hold the key to long lasting and sustainable innovation success (Teece, 1986). Thus, aggregation of differentiated and complementary assets in a meaningful way is crucial in order to achieve sustainable competitive advantage.

In this regard, density and variety of networks, both internally within one geographical area and externally in relation to other geographical areas are important. Thus, one possible role for government intervention is to help networks emerge and foster them, in order to help integration of disseminated knowledge and aggregation of its differentiated forms, as well as of the assets that allow the best use of them to be made. Along with others (Rosenberg, 1982; Lundvall, 1992), Callon (Callon, 1994) argues that, over time, due to historical path dependence, national economies, organizations and networks have a tendency to lock themselves in existing configurations. What one can do today or will do tomorrow depends upon what it could do yesterday and what it has learnt in the meantime. Thus, "cumulative causation, and virtuous and vicious circles are characteristics of systems and sub-systems of innovation" (Lundvall, 1992).

Callon argues that one of the important roles of government intervention is to provide incentives for organizations to unlock themselves from unproductive networks, in order to engage in new ones with more potential. In his view, markets will have a tendency to progressively dry up existing potential on the more obvious existing tracks, where mechanisms and incentives (not necessarily governmental) are needed to build and aggregate differently in order to explore new ones. This is to say that, on the one hand, national/regional economies and organizations benefit from riding existing technological and market opportunities waves, but on the other hand, they have to take an active part in potentially interesting future ones. To do so, taking into consideration their capabilities and possible differentiation, they have to take a chance on what these future trends could be and to prepare for reconfiguration of their actions if these trends do not materialize. Forming consortia is one of the possible ways to face these risks and to put together the various players needed in order to improve the chances to maximize them.

A third stream comes from the institutional economic literature and strategic management literature. Here, the emphasis is more on internal processes inside the consortia and governance mechanisms that focus on matters such as:

- ➔ how firms formulate and achieve strategic goals through the formation of research consortia (Vonortas, 1997; Martin 1996; Link & Bauer 1989),
- ➔ how firms and agencies combine to enhance their resource base (Mowery & al, 1998),
- ➔ how they can actually manage the complex processes of building inter-firm collaborative routines (Powell et al, 1996; Sakakibara, 1997, Doz et al 2000, Sawhney & Prandelli, 2000)

These strategic goals include gaining access to technical capabilities otherwise not easily accessed, particularly complementary technological resources which generate new business opportunities (Link & Bauer, 1989, Vonortas, 1997). Similarly, the creation of value through interorganizational relationships, and the capturing of "relational advantages" has become the topic for sustained inquiry (Saxenian, 1991; Dyer & Singh, 1998; Child & Faulkner, 1998; Barringer & Harrison, 2000). Small firms in particular have been able to take advantage of R&D consortia in order to overcome diseconomies of scale (Kleinknecht & Reijnen, 1992; Sigurdson, 1998) by enhancing their access to a wider range of technological options. But, as emphasized by network theories and discussed above, resources are not limited to the scientific and technological side of innovation, but extend as well to its business and commercial side. Thus, analyzing how and through which forms incorporation of other types of players (such as users) in consortia can be achieved is a relevant issue for this stream of literature.

Difficulties and drawbacks of R&D consortia

Networking literature suffers from a fair amount of uncritical romanticism, as if all problems could be solved through collaboration between firms. However, there are also pitfalls to networking, which are often confirmed by the evaluation studies. Indeed, most of the detailed case studies conducted to date on R&D consortia reveal the immense difficulties that advanced firms face in sustaining meaningful collaboration, even when the payoffs are clear (Boekholt & Arnold, 1999). Often, public brokers underestimate the inherent risks and efforts for organizations to engage in formal networking. All too easily, initiatives are launched to bring together firms for collaboration on very strategic parts of their business. Indeed, setting up a firm-to-firm network is a complicated process, which involves extensive, costly professional mentorship of those who want to promote it, and time-consuming learning curves. On their side, companies and particularly SMEs need to build trust with their potential partners, something which requires time and commitment which are more difficult to achieve when goals appear uncertain (will the technology and the markets prove themselves?) and long term (will we be able to keep our interests aligned on a long term basis as parameters and contexts evolve?).

Division of benefits within the consortia is often problematic, particularly because over time, participants will have to periodically adjust their tradeoff between gaining a larger part of the common "pie" or extending it. In this context, potential partners are reluctant to spend valuable time and effort on a network if the objectives and potential benefits are not clear. In fact, there seems to be a clear antipathy of organizations toward collaborations for reasons such as information asymmetry, reluctance to modify internal routines, difficulty and time needed to align interests, etc. Some of the risks they legitimately foresee are (Boekholt & Arnold, 1999):

- ➔ The initial (human) investments are high compared to uncertain outcomes,
- ➔ Fear of losing strategic assets and information to other network members, particularly if these are larger or direct competitors,
- ➔ Having varying needs and expectations of networking depending on their own (technological) capabilities,
- ➔ The fear of free rider behavior of firms stepping in at a later stage.

Companies can be disillusioned if their first experiences with networking were negative and therefore they may prefer to start with more straightforward alliances before entering into complicated R&D collaborations.

Moreover, as is the case in Israel, environments and organizations (in particular SMEs) evolve, in particular when they relate to the high tech sector. Conditions of success may also change rapidly as consortia created before the high tech crisis experienced. Furthermore, firms are living entities, which, during the consortium lifecycle, could disappear, merge or be bought by one of the consortium members or by external firms, whether national or foreign.

All this provides a useful antidote to the economic analysis, which seems to assume that consortia will be formed when firms have interests in doing so. The real world is much more complicated than that theory would imply.

User involvement - interest & potential in R&D consortia[4]

Gibbons (Gibbons & al, 1994) has shown that, in the new knowledge economy, various players participate in order to bring science to the market. Moreover, present scientific production usually combines various scientific fields, but also various types of players take part in it (academic laboratories, industrial laboratories, hospitals, etc.) both at national and international levels. Furthermore, in knowledge-based economies, innovation is considered, first of all, as information and a learning process. Thus, diversity of players' participation allows various stakeholders to bring their own elements of information and knowledge to the innovation process. This has implications on the nature and on the number of those who participate in the innovation process, as well as on the density and number of links that characterize these exchanges and on the rules that govern them.

[4] This part is taken out of Kahane & Getz, 2002

The Triple Helix model (Etkowitz & Leydesdorff, 1997) argues that institutional differentiation and links between university-industry-government are crucial in fostering the innovation process and can imply the reshaping of the institutions that take part in it. Integration and diversification forces provide its dynamism and expansion and allow its endless progress. As long as the interaction and communication among the helices are organized properly, they pull the system. On the one hand, each stakeholder has his own interests, values and culture. On the other hand, integration of different stakeholders around a mutual aim occurs and is needed. In their first study, Etkowitz and Leydesdorff identified three main institutional spheres or sub-dynamics, namely: university, industry and government (Etkowitz & Leydesdorff, 1995), and each of them is considered as being one of the helices. In their more recent studies, they added the emergence of network organizers and coordinators as “knowledge brokers and academic research centers”. These are considered to be integral parts of the network system in bridging the helices and translating the different values between them. The model was further extended when it was shown that not only producers of innovation (academy-industry-government), but also its users, were essential parts of the innovation process.

By what is called “learning by using” (Rosenberg, 1982), users reinterpret new technologies, products and services that are proposed, and reshape them, sometime surprisingly, to fit their needs. Following this approach, increased involvement from users in the innovation process has been emphasized and various ways to achieve this were proposed (Thomke & Von Hippel, 2002). Nevertheless, the literature, as well as government intervention on R&D consortia, still places an emphasis mainly on R&D producers and not so much on users, often delaying the involvement of the latter to a stage where the technology and the products are already stabilized. User participation at an early point in the innovation networks is still usually perceived and mobilized as a marginal, complementary asset in networks created by R&D producers, whether academic or industrial, and has not yet taken a central stage in R&D consortia implementation. Thus, original experiences implemented in this regard through the Israeli Magnet R&D consortia program are now analyzed.

FORMS OF USER INVOLVEMENT IN THE MAGNET PROGRAM

Four forms of user involvement are identified in the various R&D consortia established through the Magnet program:

- ➔ No user involvement: This is the case of a consortium with no form of user involvement.

- ➔ External user involvement: In this situation, a structured collective, external to the consortium, is created. Users can refer to a specific consortium or to all of those that meet their needs, but they are nevertheless not involved directly in the R&D production process. One could characterize them as external clients lobbying or interacting with the consortium in order to answer their needs.

- ➔ Secondary user involvement: In this situation, users are mobilized in a later phase of the consortium activity. This takes place once the R&D carried out by the consortium has achieved most of the results and there is a need to go further in order to come closer to its markets.

- ➔ Primary user involvement: In this situation, the user(s), whether a firm, several firms or a collective of fragmented players enter(s) the consortium at the initial phase and may even be its initiators. Thus, the market needs/demands are integrated in the consortium from the beginning.

No user involvement: The Digital Printing Image consortium (DPI)

DPI is a typical example of the type of consortium Magnet envisioned and wanted to encourage at the beginning of the program. The rationale was to put together various players that share an interest in a generic technology and allow them to exploit a common development process in their respective markets. This is a typical horizontal supplier consortium where respective technologies, skills and competences of participants are pooled together and where market exploitation is specific to each of them. In this case, the generic technology focus is digital image printing. This technology expedites the information transfer process from the conception of an image to its printing, and the relevant support. Even before the start of the consortium, Israeli companies had taken a strong competitive position in some specific niches of the global digital printing market. In particular, two companies, Indigo and Scitex were at its forefront, each in their respective market[5]. These two companies realized that they were facing similar technological issues and challenges. Before the consortium, these two companies did not have working relations, although, since being both Israeli, they knew of each other. They were in a known situation where companies have to trade-off between cooperation and competition; taking advantage of the Magnet scheme, they decided to emphasize the first dimension. During its life, the consortium composition evolved and came to incorporate nine firms, since one of the original partners later split into three companies. Further on, a foreign company bought one of these latter companies, as also happened to another of the original companies. Thus, this consortium experienced the quite typical fate of consortia in Israel, where companies disappear, are bought, or merge during the life cycle of the consortium.

DPI was established in 1998 (five years after the start of the Magnet program) for a period of five years with a budget of $45 million. It involved more than 120 persons in nine companies and seventeen academic groups.

Innovation success in digital printing is, as always, dependent on a business/commercial component (brand and marketing issues for example) and a scientific/technological one. The consortium is focused on the latter, while the former is the responsibility of each participant. Through the consortium, several companies and academic groups were brought together, combining various components and techniques in order to improve digital printing for their respective products. Seen from the technological side, innovation success in the digital printing industry requires for each of its targeted markets/products an ad-hoc fit/integration between three types of parameters and components (ink, machine, paper/substrate). In each of the possible markets, products may require different technologies but nevertheless share some common technological issues. All companies share a common interest in these issues but, at the same time, might not compete since they are focused on different markets/applications, which require a different kind of integration and techniques, related to ink, printers and paper/substrate.

Like many other Magnet consortia, DPI has a managing director who is assisted by a board comprising representatives of each company and academic institution participating in the consortia. Five technological committees, each of them incorporating representatives of the participating firms, were established. Integration of issues and results occurs at the level of the whole consortium, as well as in each technological committee and, of course, in each company. In order to meet Magnet requirements, these committees mobilized academic groups to help solve various technological issues they faced. Academic faculty members were asked to submit proposals on different technologies and problems they thought the industry members might have on digital printing which they could potentially help solve. Numerous proposals were received and consortium members (firms) selected 12 (at a later stage five more academic groups joined)

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[5] One of the differentiators being the size of the printing (1 to 2 meters vs. 3 meters and more)

research partners from academia at the technological working group level, so the academic partners were related directly to the companies through these various committees.

As this description shows, this consortium is a “purely” R&D one. Common work on innovation is restricted to scientific and technological subjects, while everything that relates to commercial applications is the companies’ responsibility. Thus, user issues and their possible involvement are outside the sphere of the consortium and treated by each company separately. Whether users share any common issues or challenges that would benefit from a common treatment at the consortium level is unknown. In fact, looking at the web site of the consortium, it is difficult even to figure out who the users are, whether they relate to several industries or not, or whether they are large companies or end consumers.

Several Magnet consortia were established according to this model. These consortia are built on the “traditional” model of separation between innovation producers and innovation users. The “new” models of innovation suggest that putting together R&D producers and users helps the innovation process, and there are no obvious reasons to prevent this from happening, at least for some of the consortia.

External user involvement: The Israeli Users Association of Advanced Technologies for Design and Manufacturing in the Electronics Industry (ILTAM)

ILTAM is an association of companies that all use electronic components and technologies in their own products. Like other Magnet consortia, ILTAM is focused on technologies, not on products and thus deals only with issues related to the former and not the latter (marketing, internationalization). Yet unlike the typical Magnet consortium that aims at developing new technologies, ILTAM’s goal for its members is identifying, exchanging and disseminating relevant knowledge linked to existing and/or new and developing technologies.

Two main features differentiate ILTAM from more typical Magnet consortia:

a) The aim is not to develop new technologies but to “milk” existing ones. This is done in two ways: First, they import knowledge from outside Israel by identifying and inviting relevant experts (whether national or international) on technologies considered of interest by the members; Second, they enable information exchange between companies that face common technical problems (e.g. acquisition of a new software or equipment for which several options exist), thereby reducing risks. For this exchange of information to be successful, these latter exchanges must be operated at the level of companies’ technical staff, (the decision makers on these kind of issues) and must not deal with core technologies.

b) No R&D activity is taking place and no permanent subsidies, income, organization and/or facilities are budgeted or operated between participating companies. Companies who choose to participate have to pay[6] for their participation while Magnet acts only as a catalyst, providing administrative staff and part of the global budget.

[6] Fee for member is: $17 per $1 million sales with a minimum of $160 and a maximum of $4300, supplemented by seminar participation cost of $250 on average. Depending on their internal policy, foreign companies can be members or their participation is restricted to seminar participation.

ILTAM was created in response to a challenge faced by several unrelated companies at the same time (the change of technology in a PC assembly board) that entailed major equipment investment and also implied maintenance issues. After an initial informal period (six months) where relevant experts in several companies met in order to make and optimize their choice, participants recognized that the need for these kinds of meetings was a recurring one. At the same time, however, they had difficulty convincing their firms to commit resources for that purpose since the exchanges were not directly related to production of new technologies and/or products. Thus, they approached Magnet, which agreed to help cover the expenses, considering that the Iltam Users Association could be seen as another form of consortium, although not the typical R&D type.

Today, ILTAM has an operational budget of $400.000 per year[7], half coming from Magnet, and the rest from member companies[8]. ILTAM is able to support, yearly, some 35 technical activities[9] (two or three per month), including the participation of eight to 10 international experts in some of them. Company members elect a board of nine representatives (volunteers) every two years. Magnet provides a general manager with a technical background, which allows the board to concentrate on technical issues while the manager handles the budgetary issues. Under them, six working groups operate, dealing with a selected range of technical issues (system design, software development, hardware development, microelectronics, assembly/testing, quality standard at present). Every three years, ILTAM convenes a general meeting to assess its evolution (why do we need ILTAM? What steering committees should be established? What subjects should be addressed in each of these committees?). Thus, ILTAM operates mainly under a bottom-up approach, with each working group acting as a forum, exchanging information on relevant technological issues/novelties/companies in the subject area and providing recommendations to the manager and to the board on possible seminars to be organized and experts to be invited. Industry need is the consortium's driver and it emerges, with no predetermined annual planning, out of the working groups and demands raised by the members.

The inclusion of ILTAM in Magnet offers several benefits:

a) An OCS label that provides visibility and credibility and makes it easier to attract local companies to join the association and to invite experts, whether national or international.
b) Financial security, which allows organizing activities on a longer, and more sustainable basis, and allows projection capacity from one year to the next. Otherwise, companies would often participate on a per seminar basis but would not commit themselves to an annual budget that would support the needed infrastructure/administration.
c) Operational management and administrative infrastructure, which actively carries out the decided agenda. ILTAM would not be able to work without the presence of a general manager that "makes things happen".

Over time, ILTAM has experienced and/or been linked to several developments that have led to an increase in its activities in relation to user issues:

Academic participants can attend seminars freely and institutional connections at the level of working groups exist as well

[7] a typical Magnet R&D consortium would run a budget of $25-30 million for three to five years.

[8] 10 large companies, 15 mid-size, 60 small firms. The added value is considered greater for SMEs which otherwise would have difficulty gaining access to the relevant knowledge, where larger firms would be able to do so although at a larger cost and with access to less people.

[9] On average, 80 to 100 participants per seminar representing some 30 companies

a) "(In)-dependent" emergence of a typical Magnet R&D consortia: In parallel to one of the technical working groups, a typical R&D consortium was established with the support of Magnet. No direct formal links are mentioned between the two groups, but in small countries like Israel, some participants will participate in both groups, allowing informal information exchange and integration between them.

b) Emergence of a users group linked to a former R&D consortium: Such a scheme is now happening with the consortium for the development of magnesium technologies that has been active for five years, developing new magnesium alloys, "Green technologies", magnesium casting, forming and machining technologies as well as finishing and corrosion protection technologies. The 10 member companies of the consortium, having had productive research collaboration, decided to continue their association for further development and dissemination of current know-how. They were joined by more companies who are users of magnesium products, and together have recently established the Israeli Magnesium User Association (MUA) for the utilization of metallic magnesium alloy products within the Magnet framework.

c) "Organizational incubator": Three years ago, Israeli experience in integrating electronic components in arms systems (tanks, drones, etc) provided an incentive to some of those active in this field to explore the possibility of translating this competitive advantage to the automobile industry. These Israeli firms invited experts from various automakers and related firms in order to start looking at issues such as quality standards, trends in electronic products for cars, etc. within a 10-year time frame. Thus, an ad-hoc working group (Autotronic) was formed for which ILTAM now acts as an "organizational incubator", helping them to initiate and carry out their activities.

d) "Umbrella": ILTAM acts as an "umbrella" for two to three R&D projects which are somewhat similar to typical Magnet consortia activities but which aim not at developing new technologies but at assimilating them. For example, one of these projects was established with an annual budget of $700,000, in order to define common parameters to promote the use and assessment of some software of interest to its participants. In this case, ILTAM provided the administrative support, dispatched results to all members and in some way considered this project as an additional steering committee, related at the same time to on-going work inside a more typical Magnet consortium.

e) "International entry gate": Through its visibility and logistical support systems, ILTAM established formal links with other, similar international non-profit organizations. In the case of the Institute of Electrical and Electronics Engineers (IEEE computer) local computer society branch, ILTAM operates the Israeli chapter of the EMC (ElectroMagnetic Compatibility), thus helping to bring together Israeli academics and industry figures, giving local and international recognition to ILTAM members and allowing them access to a network of international experts. Further, ILTAM, as a member of IEEE, is also working to offer direct access for its members to the digital library of the IEEE.

Although ILTAM has proven itself successful both for its participants and for Magnet, attempts to duplicate this type of association in other sectors (mechanical manufacturing, telecom, etc.) have had limited results. The reasons given illustrate some of the success factors that such users groups need in order to achieve legitimacy and successful performance:

- ➔ Subjects that are too competitive for its member companies should be avoided. The association should restrict itself to subjects where common interests are not connected to members' core technologies.

- ➔ A sufficiently wide spectrum of activities should be included in order to attract a critical mass of firms. These activities should be sufficiently represented locally in order to target Israeli firms.

- ➔ The association should be able to address rapidly evolving issues. Otherwise sufficient levels of interest and activity cannot be sustained in a meaningful way.

If these factors are not met, a critical mass of participants, activity and budget will not be achieved, and the users association will disintegrate.

Similar to the previous type of consortia described through DPI, an organization such as ILTAM is built on the model of separation between innovation producers and innovation users, but this time the emphasis is on the users' side instead of being on the producers'. Nevertheless, as Magnet experienced in relation to ILTAM, R&D consortia may evolve from, and link to, user working groups, although often on an informal basis. On the other hand, recent experience in Magnet shows that such users associations may emerge from a specific R&D consortium, as was the case with some consortia (software use, magnesium use).

Contrary to the former type, the interrelations between the users associations and the R&D consortia start to bring together innovation producers and innovation users, although innovation user integration happens once innovation producers have ended their course inside the program. Until recently, besides the developments reported above, where ILTAM acts as an umbrella, no users association specific to a given R&D consortium has been established from the start or during the life of the latter. Recently, an R&D consortium on data storage networks has been established and, together with it, a users association that will put together a testing lab to examine and analyze data storage networks using dedicated equipment and software.

Secondary user involvement inside consortia: The Consortium for Industrial Software Tools (CONSIST)

If DPI is a typical representative of R&D consortia as envisioned at first by Magnet and matching the "ideal type" of horizontal industry building, Consist constitutes a typical representative of the alternative vertical complex system. Consist (www.consist.org) was established in 1998, a few month after DPI, and involves 80 people from six different firms and three academic groups.

Consist is a vertical consortium that aims at easing integration of several technologies into a common platform, acting as a single complex product system that will benefit products developed by each participant partnering in the project. Products, technologies, skills and competences of each partner relate to different stages in the vertical chain.

Consist focuses on product life cycle management (PLM) into which digital handling and communication of data help ease real time communication and adaptation at each stage and from one stage to the other. PLM includes various stages such as conception (CAD), product development (PDM), manufacturing (MPM), and workflow/shopfloor management (including enterprise resource planning, manufacturing executive system and customer related management). The aim is to help coordinate and simplify later stages by top-down integration of manufacturing at the conception / design stage in order to allow real time process planning, analysis, validation and optimization. This also allows concurrent collaborative workflows between different process planning teams. Through Consist, all information related to a specific integrated development process can be correlated, interrelated and controlled. This allows increasing density of interactions between the various partners and, by distributing a global view to each partner, helps assess and deal with modification introductions and their consequences. It is part of a trend towards electronic vertical distribution and integration of data linked to the design and manufacturing processes.

Integration between the various steps is thus a main issue, since the industry is characterized by vertical fragmentation where different companies are strong in different parts of the vertical chain. Although users may have a specific need located at any specific stage of the vertical chain and would need to be integrated into what they already have, there is also a trend of users to demand integrated packages that require of the various companies to join, whether through integration or alliances, in order to answer the user's need. Whatever the case, on the one hand, users want the products to be technology transparent (serve their use) and on the other, they want scalability (the ability to add newly developed parts and functions to an existing platform in order to protect their initial investment). Consist was created as a way to offer a common IT platform, allowing each supplier company to more easily develop onto it with its own products (in a similar way to what happens with the Operating Systems of computers or in Game Consumer Products where applications are branched on a backbone layer[10]).

Applications are aimed at "discrete" industries such as aeronautics, automobile, naval industries and electronic products. Clients are mainly "large accounts" that often also entail orders from second-tier clients and/or production line builders that they mobilize and would like to see integrated in their management of data. Some of the companies that are part of the consortium, such as Tecnomatix and SAP, are main players in the field, each at different stages of the vertical chain. Others will bring their own expertise and skills in order to complement or link them.

After an initial three-year stage supported by Magnet, Consist already developed a (demo) platform that was considered successful by its partners and by Magnet, and the need to proceed with the development towards implementation of the platform/system was identified. This required bringing in a user (an "innovative adapter") in order to get its input and feedback which would compress the time (two-three years instead of four-five) necessary to reach mainstream markets.

The situation often faced by users can often be described as a "classical mess" with "islands of information", (sometime redundant, sometime not) which are not able to communicate with one another ("No one knows exactly what is happening in another part of the company because different systems are existing one beside the other"). Commercialization of the platform developed by Consist was intended to serve as a practical lesson in how this kind of mess could be avoided and to address other requirements (security, etc.) on which only users have the relevant knowledge and experience. Internationalization was not the main selection criterion since partners involved in Consist already had established relations with European automakers who already participated in European user group meetings. To have a local strategic partner "present in the backyard" was seen as more important, since it could more easily provide the relevant information needed by the suppliers.

IAI (Israeli Aircraft Industry), the largest manufacturing firm in Israel with 16 divisions, was approached and incorporated in the Consist consortium that Magnet decided to support for two more years. IAI is considered to be a very innovative firm with a good reputation and high visibility

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[10] The analogy goes even further because, like in these systems, timing of introduction is a main issue. The hardware, OS and applications need to be able to sustain one another. Thus coordination and compatibility between the different suppliers is needed.

abroad[11], and could be used as a relevant reference to approach other potential customers of technology and products developed by the consortium. In IAI, two different divisions were selected to start working with the consortium (the aerospace and electronics divisions). With the incorporation of IAI, the focus of the consortium is now on the review of visible gaps between the platform and user requirements (in security for example) and on the implementation and installation of the beta form through a joint experimental process.

As one of the R&D producer participants states, there is a different perspective between the producers and the users. "The latter have their own business pressure which is focused on improving the competitive position of their products, that will not allow them to engage in the development of processing equipment/software for their own use. Thus, we had to go through the first stage of the Consist consortium, to develop the platform which we could demonstrate in order to interest users in joining the consortium. Once the users were incorporated, it enabled us to start addressing new and different issues (security, landscape, computerization, etc), something we could not have done three years ago. During the first stage of the Consist consortium, there was nobody we could have approached successfully since before interesting potential users, there is a prior need for:

1) User maturation regarding our vision, which takes time and industry evolution (to bring it from "very early adopters" to "early adopters" and then "main adopters"),

2) A demo version which shows that the concept works and can be presented to users in order to capture their interest and make them eager to come into the picture".

Here, contrary to the previous schemes reported above, innovation producers and users are no longer kept separate, but are commonly involved in technology/product development. Nevertheless, user involvement is a sequential step that came only following an initial stage where R&D producers had already achieved the realization of a demo. As one of the R&D producer participants states, "Users are more difficult to convince at the conceptual stage (which was what the first stage of the Consist consortium addressed) because the maturation of industries takes time and nothing works better than a demo when you have to approach potential users".

Initial user involvement: The Wafer Fab Cluster Management (WFCM) & The Image Guided Therapy Consortia (IZMEL)

We now report on two situations where user involvement was present from the beginning, and even served as the driving and integrating force for their respective consortia. The first consortium (WFCM) was initiated by a "traditional" industrial partner while the second one (Izmel) was started by a non-industrial partner, a specificity that was more fully discussed in our previous paper (Kahane & Getz, 2002).

WFCM (Water Fab Cluster Management)

WFCM is a consortium for the development of manufacturing equipment for the electronics industry itself, mainly equipment used in the semiconductor industry to manufacture chips, or at

[11] Automakers would have been another option but, because they are based abroad, it was not possible to formally integrate them into Consist). It should also be noted that, because regulation and methodology for car and aircraft makers are not the same, a different "learning by doing" process is needed to adapt the platform from one industry to the other.

least in some stage of this manufacturing process. Like Consist, WFCM is also a vertical integrated consortium aimed at developing a complex product system. Nevertheless, where Consist is mainly organized around a software platform that commands virtual process, WFCM is based on integration of software and manufacturing from the virtual stage to its consequences on equipment operation. Thus, software is embedded in equipment, which was not the case in the previous consortium. Equipment and software need co-development, where software development was enough in the previous consortium. As a result, WFCM saw the incorporation of users from the beginning of the consortium as a necessity, where for Consist, this incorporation was seen as possible only at a secondary stage.

WFCM was established in 1999, a year after Consist, and similar to Consist, in WFCM each firm brings its own competences and skills. It involves about the same number of people (70) coming from eight different firms and nine academic groups gathered around 10 industrial projects.

WFCM aims at developing a manufacturing cluster, linking together the equipment involved in several steps (etching, lithography, metallization, dicing) of wafer manufacturing. The aim is to introduce software management to help coordinate the different steps, where at present each step requires complex calculation and adaptation of manufacturing parameters by a qualified individual. Through WFCM, all information related to a specific integrated cluster product process would be correlated, interrelated and controlled automatically. In WFCM, each of the companies provides its own competences and skills as well as specific equipment in the manufacturing process. They are nevertheless competitors in the market, a situation that indeed created difficulties in the consortium.

This consortium has strategic, national economic implications. The semiconductor industry is a key component of Israel's competitive position, which is strongly associated with the electronics industry[12]. One of the characteristics of Israel's semiconductor industry is that it is mainly a fabless industry. This is to say that in most cases, design and development of chips are locally performed but manufacturing is then transferred abroad, mainly to Taiwan, which is defined as a chip manufacturer but non-developer country. Of course, one of the questions related to this industry addresses the desire of Israel to go downward to the manufacturing process in order to create more jobs, and to the desire of Taiwan to go upward to the design and development process in order to reap more of the product added value. Furthermore, being able not only to design and develop but also to produce locally has implications in particular, but not only, in relation to the defense industry that often needs to order small scale production of very specific chips. Thus, the Israeli government has developed a two-way policy (B. Kahane, in preparation a):

- ➔ On the one hand, it has been eager to attract, thanks to its design and development potential, multinational companies that would invest not only in development plants but also in production plants. This has met some success, as can be seen from investments made by companies including Intel and Motorola.

- ➔ On the other hand, the Israeli government is very interested in the development of local manufacturers and is supporting companies, like Tower, which take a user role in this consortium.

Tower is the main local manufacturer of semiconductors and produces locally for companies like Intel and Motorola as well as for many Israeli electronics companies, which need electronic

[12] Other strong industries are in computing, telecommunications, defense and security, and medical equipment.

components for their systems[13]. Tower, looking for more efficient ways to perform the manufacturing process, is a demanding customer for the equipment developed and produced by WFCM members, and to answer its needs, joined WFCM from the beginning, making a consortium that brings together firms that are developing equipment and firms that use it.[14].

IZMEL (Image Guided Therapy)

The motivation for establishing IZMEL came not from an industrial firm but from doctors supported by their medical institutions. Surgeons, seeking to improve their routine work in the operating room (OR), aspired to bring surgery and imaging together, both in time and space. To that end, they created a center aimed at developing new strategies for integrating imaging into surgical procedures so that images could be seen in "real time," enabling better control and evaluation as well as improving the surgeon's performance. Thus, a consortium was set up in accordance with the program's stipulations, consisting of a number of clinical centers, academic centers and Israeli industrial companies, all willing to work together toward a shared objective.

The projects taken on by the consortium are dedicated to developing and integrating the various technologies and products, in order to prepare the OR of the future. The construction of real-time, high quality intra-operative medical imaging capabilities, the development of minimally invasive surgical tools and technologies, and the implementation of real-time computer imaging were all imperative capabilities for the realization of the future OR. Only through a collaborative effort could the vision of many experts from different disciplines and the strategies of various players be aligned. No useful product could come out of these developments if they were not designed, implemented and tested under the supervision of clinical partners. This required close collaboration of multiple academic, industrial and clinical partners, each bringing their expertise and know-how, in order to achieve leadership and innovation in this field of medical treatment.

The IZMEL consortium is structured around six collaborative and interacting projects. Each of the projects links participants from the industry with collaborators from an academic institute and/or a clinical site. The integration between the various players within one project and between the various projects is a crucial issue. User involvement is a main asset for this purpose and was fostered by the way the consortium was created, that is, by users wishing to overcome limits of existing techniques, who mobilize other players to achieve their aims.

In both IZMEL and WFCM, it was the users' needs and vision that motivated the establishment of the respective consortia, and their presence assured that the various participants respect their needs. Ultimately, the users understood that full integration of relevant equipment and software could cause fundamental changes in strategies, approaches and methodologies related to their practices and/or business. To achieve their goals, they had to put together potential skills and competences of various R&D producers and academics on the one hand, and to identify and mobilize the relevant funding source that Magnet could provide on the other. In these situations, users and producers of innovation are present and interacting together from the start.

CONCLUSION AND SUGGESTIONS

[13] Recently, users of Tower products have engaged in funding a facility for 0.2 micron chip manufacturing, receiving preferential access in exchange. Thus, Tower is currently a manufacturer where users are also involved in its own operation.

[14] The later incorporation of the local branch of an important user (Applied Materials) in turn led to the incorporation of another local Israeli equipment manufacturer (Applied Material Israel).

Although innovation and R&D networks may look nice on paper and in theory, they nevertheless experience serious difficulties that need to be overcome in order to implement them successfully. True, proximity between members matters and can be achieved through social contact, previous shared experience and common localization, a context in which a closely connected country like Israel benefits (B. Kahane, in preparation a). All studies on network programs also report that a majority of the organizations involved have benefited from entering them, either through soft benefits (learning to work together, sharing information) or through hard benefits such as cost savings and business expansion. However the impact on the firms differs enormously. Assessment studies reported by Arnold (Boekholt & Arnold, 1999) provide a list of key lessons to overcome traditional difficulties of network programs. Here, we show how user involvement may help answer some of them:

- ➔ Clear definition of the firms' individual and common objectives in the consortia. Networks that had very clear opportunity goals also showed tangible commercial impacts in terms of cost savings and business expansion. User involvement helps R&D producers focus on a common objective.
- ➔ Strategic collaboration, especially when focused merely on technology, takes time in terms of trust building, where focusing on commercial activities and quality improvement is easier. User involvement helps put technology in perspective with the demand side of innovation.
- ➔ Public agencies can be catalysts or co-initiators of networks, but once in operation, networks should be led by the industry. Non profit seeking brokers can act as catalysts in getting networks started, but should delegate the lead after the first stage. Users can act as knowledge brokers and play a catalytic role, and if they are industrial firms, they meet the above-mentioned requirement and thus would qualify to remain the leaders of the network.
- ➔ Trust building is a key component and can be achieved through several ways: Some form of common background; limited size; open communication between the network partners on their goals, strategies, capabilities, and common tools and procedures; similar level of competence; and first short term achievements. Relating to a common customer is a way to help suppliers get access to a "neutral" voice that could smooth tension and ease trust building.
- ➔ Clear leadership is an important prerequisite for success, thus finding a "project champion" is an important issue. In some situations, this champion can be on the user's side.

Furthermore, user involvement can help firms move from R&D to the market and thus may help them capture a larger part of the value chain. This is true in particular for SMEs that tend otherwise to sell themselves or license their products at an early stage because of lack of financial and managerial resources needed to access global markets.

Last, we have shown that user involvement is not and cannot be addressed in the same way when dealing with consortia of the horizontal integration type and consortia of the vertical integration complex system type. We now discuss this issue in the context of Magnet intervention.

User involvement in horizontal consortia type

- ➔ Horizontal integration industry building consortia can be characterized by having many R&D producers facing many R&D users (many to many). Here, integration and direction inside a consortium needs a strong drive that would better come from one of the R&D producers. So what are the possible roles and forms of involvement for users in such a context?

A brokerage intervention that allows closing the gap between R&D producers and R&D users is needed. Entities and mechanisms that could connect, recombine and disseminate otherwise disconnected pools of knowledge, including scientific and technological as well as business and commercial knowledge, should be encouraged. Two possibilities are already identified within Magnet that could be broadly applied:

- User involvement could be obtained through an external body like ILTAM, relating to several consortia, or through a connected body linked to a specific consortium. ILTAM shows, through some of its developments, that user associations may give rise to traditional R&D consortia, although "umbrella" or "incubation" stages are needed for this to happen.

- Horizontal consortia could be encouraged to conduct market analyses in order for partners to collectively identify and share business and commercial knowledge in a more explicit way. The Magnesium consortium has experienced this kind of fruitful development and it attributed part of this reorientation (and success) to a market study ordered by the consortium at mid term.

These modalities would provide a basis for exchanges and contacts on clients and users that, although linked to each producer on a specific niche, may nevertheless share common challenges. Magnet is still reluctant to address the product dimension and seems to prefer that consortia focus on the technological component. Nevertheless, developments already experienced, whether through ILTAM or through market studies commissioned by the Magnesium consortium, show that borders are not so clear-cut and that market studies as well as access and exchanges with relevant users are, in fact, important issues for consortia. Indeed, there is no reason to think that where common challenges on science and technological issues for R&D producers exist, there could not be similar ones on commercial, marketing, maintenance issues for R&D users.

Actually, linking R&D producers and R&D users in such ways fits "new models" of innovation previously described (Kahane & Getz, 2002) which emphasize the crucial importance of user involvement in the innovation process.

Two main options are possible for interactions between several R&D producers and R&D users:

➔ "one to one" relations between a specific user and a specific producer,

➔ "many to many" collective interactions between R&D producers and R&D users.

When several types of users are relevant to a consortium, the choice between "one to one" vs. "many to many" interactions implies different consequences. One to one interaction emphasizes access to knowledge coming from an individual user taken separately, while “many to many” interaction allows access to knowledge generated through interactions among users. Whatever the choice, these interactions could be implemented either physically or by using the Internet (as is already done by the Matimop[15] for one to one contact between SMEs, both locally and internationally), giving a new role to Magnet as a knowledge broker. The brokerage role may even go further, to have certain sets of R&D users come with problems in need of solutions and organize interactions with relevant sets of R&D producers. The R&D producers may register, and then choose a specific problem to work on and propose collective solutions. Thus, clusters of producers would compete locally for traditional Magnet funding or, alternatively, look for funding on an international basis through already existing institutional frameworks[16].

User involvement in vertical integration consortia type

➔ Vertical integration complex system consortia are characterized by many R&D producers to one (or a limited number of) user(s), a relation that we will label as “many to one”. In this case, user involvement can act as a key driving force for the consortium, in its definition, construction and operation. Thus, the consortium would benefit from user involvement at the starting point of its activity. It is no surprise that it is in this type of consortia that users have taken the lead in initiating and driving the consortium (Izmel, WFCM), or have been subsequently incorporated (Consist). Indeed, according to Hobday (Hobday, 2000), the complex system makes it nearly mandatory to incorporate users at some stage. Different situations encountered, for Consist on the one hand and for Izmel and WFCM on the other, show that there are relevant reasons to choose between earlier or later incorporation.

Nevertheless, our opinion is that here again, Magnet could go further, by duplicating what has been successful in Israeli arm systems’ development. In this case, success has been partly attributed to strong and dense connections to the user who clearly sets its preference and then works closely with R&D producers on the academic as well as on the industrial side. In the same way, although the initial local market is small, Israel has the advantage of offering a dense, highly developed, dynamic and sometimes integrated market that may offer potential for local development before exporting. Here, one may think of HMOs (health management organizations) in Israel that are well developed and vertically integrated from the individual doctor to the funding agency and that may be able to express needs that could engage firms in development of technology related services and/or service related technologies. Another example is the Egged bus company[17] which covers Israel in a very dense manner and could also provide opportunities to link local R&D producers on development initiatives driven by the users. Here again, this would mean increasing the role of Magnet as knowledge broker in relation to users, a role it may not have

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[15] **MATIMOP (**http://www.matimop.org.il/matimop.html) is the main technology clearinghouse in Israel serving businesses seeking international cooperation.

[16] The US Israeli Science and Technology Committee, Eureka or possibly the European framework program would offer relevant channels for funding if projects are able / need to go international.

[17] Although a bus company can be seen as quite low tech, it may nevertheless benefit from some high tech tools in its operation, maintenance and/ or logistics.

the capacity or will to engage in, or that may contradict its founding conceptual choices.

Altogether, we used “horizontal integration industry building” and “vertical integration complex system” as ideal types in order to draw recommendations on consortia building and their management. In relation to this classification, we suggest looking at producers vs. users as a source of integration and focus for consortia. Further, this classification allowed us to define three situations labeled as “one to one”, “many to many”, and “many to one” that we linked to the two types of consortia. Last, we suggest that, by taking into account the issue of user involvement in consortia, new roles and scopes for Magnet as well as new ways of looking at consortia formation and management should be considered. We thus argue that Magnet should emphasize not only the S&T side of innovation but address the complementary commercial/business component of innovation as well.

As a result of what can be learnt from the literature, from our work, and from what has already been experienced in Magnet, we argue that user involvement is a possible way for consortia to reap benefits from a greater part of the value chain. Therefore, we suggest a) emphasizing users issues in already existing and future consortia, b) increasing the involvement of users in R&D consortia, c) increasing brokerage intervention in relation to this issue, d) using our ideal type classifications and recommendations in order to deal with user involvement issues in a relevant way. This may be considered as an on-going work which now needs to have our recommendations assessed and adapted by their relevant users: Magnet as well as consortia managers.

References

Aldrich H.E., Sasaki T, 1995, R&D consortia in the United States and Japan, Research Policy, 24(2), 301-316,

Arnold E.& Bell M., 2001, Some New Ideas About Research for Development, SPRU & Technopolis, Brighton, UK,

Barringer B.K., Harrison J.S., 2000, Walking a tightrope: creating value through interorganizational relationships, Journal of Management, 26 (3), 367-403,

Boekholt P, Arnold E, 1999, Good practice from Inter-Firm Network Initiatives, Technopolis, internal document,

Branstetter L, Sakakibara M., 1997, Japanese Research Consortia: A Microeconometric Analysis of Industrial Policy, NBER Working Paper #6066, National Bureau of Economic Research, Cambridge, MA,

Callon M., 1994, Is Science a public good ? Science, Technology and Human Values, 19, 345-424, Cawson A., 1986, Corporatism and Political Theory, Basil Blackwell, Oxford,

CBS (Central Bureau of Statistics), 2001, National Expenditure on Civilian Research and Development 1989-2000, Jerusalem, Israel,

Child J., Faulkner D., 1998, Strategies of cooperation: Managing Alliances, Networks and Joint Ventures, Oxford University Press, Oxford,

Cohen W., Levinthal D., 1989, Innovation and learning: the two faces of R&D, Economic Journal 99, 569-596,

Dogson M., 2000, The Management of Technological Innovation, An International and Strategic Approach, Oxford University Press, Oxford, UK,

Doz Y.L., Olk P.M., Ring P.S., 2000, Formation processes of R&D consortia: which path to take? Where does it lead? Special issue: Strategic Networks), Strategic Management Journal, 21, 239-266,

Dyer J.H., Singh H., 1998, The relational view: cooperative strategy and sources of interorganizational competitive advantage, Academy of Management Review, 23, 660-679,

Evan, W.M., Olk P., 1990, R&D Consortia: A new US organizational form, Sloan Management Review 31, (3), 37-46,

Etkowitz H. Leydesdorff L., 1997, (Eds), Universities and the Global Knowledge Economy: A Triple Helix of University-Industry- Government Relations, Pinter, London,

Etkowitz H., Leydesdorff L., 1995, The Triple Helix: University-Industry-government relations, A laboratory for knowledge based economic Development, East Review 14 (1),

Gibbons M & al, 1994, The New Production of Knowledge, Sage, London,

Hagedoorn J., 1996, Trends and patterns in strategic technology partnering since the early seventies, Rewiew of Industrial Organization, 11, 601-616,

Hodbay M., 2000, The Project-based Organization: an ideal form for managing complex products and systems ? Research Policy, 2000 (29, 871-893,

Kahane B., in preparation **a,** National and regional innovation systems under a "hub" perspective: The Israeli case,

Kahane B, In preparation b, Managing innovation policy through external links: The Matchmaker Israeli approach,

Kahane B. & Getz D., 2002, How users build the Innovation Partnerships they need, Proceeding of the 33rd EFMD/EISB Conference, Sophia Antipolis, France,

Kamien M., Muller E., Zang I., 1992, Research joint Ventures and R&D cartels, American Economic Review 82(5), 1293-1306, Katz M.L., Ordover J.A., 1990, R&D cooperation and competition, in Baily M.N., Winston C. (Eds), Brookings Papers on Economic Activity: Microeconomics, Brookings Instittution, Washington D.C, p 137-203,

Kleinknecht A., Reijnen J.O.N., 1992, Why do firms cooperate on R&D ? An empirical study. Research Policy 21 (4), 347-360,

Levy J.D., Samuels R.J., 1991, Institutions and Innovation: Research Collaboration as Technology Strategy in Japan. In Mytelka, L.K. (Ed), Strategic Partnerships and the World Economy: States, Firms and International Competition, Pinter, London,

Link A.N, Bauer L.L., 1989, Cooperative Research in US Manufacturing: Assessing Policy Initiatives and Corporate Strategies, Lexington Books, Lexington MA.,

Links, A.N., Teece D.J., Finan W.F., 1996, Estimating the benefits from collaboration: the case of Sematech, Review of Industrial Organization, 11, 737-751,

Lundvall B.A, National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning, London, Pinter, 1992,

MacDonald S., 1986, Theoretically sound, practically useless ? Government grants for industrial R&D in Australia, Research Policy, 15, p 269-283,

Martin S., 1996, Public policies towards cooperation in research and development: the European Union, Japan and the United States In: Comanor W. Goto A., Waverman A (Eds), Competition in a Global Economy, Routledge, London,

Mora Valentin E.M., 2002, A theoretical review of co-operative relationships between firms and universities, Science and Public Policy, 29, 37-46,

Mowery D.C. & Rosenberg N., 1978, The Influence of Market Demand upon Innovation: A critical Review of Some Recent Empirical Studies, Research Policy,

Mowery D.C., Oxley J.E., Silverman B.S., 1998, Technological overlap and interfirm cooperation: Implications for the Resource-based view of the firm, Research Policy, 27, 507-523,

OCS (Office of the Chief Scientist), 2003, Magnet Web site (www.magnet.org.il),

Powell W.W, Kogut K.W., Smith-Doerr L., 1996, Inter-organizational collaboration and the locus of innovation: networks of learning in biotechnology, Administrative Science Quaterly, 41, 116-145,

Rosenberg N., 1982, Inside the black box: Technology and Economics, Cambridge University Press, Cambridge,

Rothwell R., 1992, Successful industrial innovation: critical factors of the 1990's, R&D management, 3, p 221-239,

Sakibara, M., 1997, Evaluating government-sponsored R&D consortia in Japan: who benefits and how ? Research Policy 26 (4/5), 447-473, Sawhney M., Prandelli E., 2000, Communities of creation: managing distributed innovation in turbulent markets. California Management Review 42 (4), 24-54,

Saxenian A.L., 1991, The origins and dynamics of production networks in Silicon Valley, Research Policy, 20 (5), 423-438,

Sigurdson J., 1998, Industry and state parnership: the historical role of the engineering research associations in Japan, Industry and Innovation 5 (2), 209-241,

Spence, A.M., 1984, Cost reduction, competition and industry performance, Econometrica 52, 101-121,

State of Israel, Ministry of Industry and Trade, 2000, The Israeli Economy at a glance 2000, Jerusalem, Israel,

Thomke & Von Hippel E. (2002), Customers as Innovators: A new way to create value, Harvard Business Review, April, 74-81,

Tratjenberg M., 2001a, Innovation in Israel 1968-1997: A comparative Analysis using Patent Data, Science, Technology and the Economiy Program (STE), Working Papers Series, The Samuel Neaman Institute, Technion, Haifa, Israel,

Tratjenberg M., 2001b, R&D Policy in Israel: An Overview and Reassessment, Science, Technology and the Economy Program, (STE), Working Papers Series, The Samuel Neaman Institute, Technion, Haifa, Israel,

Teece D., 1986, Profiting from technological innovation: implications for integration, collaboration, licnsing and public policy, Research Policy 15, 285-305,

Teubal M., Andersen A., 2000, Enterprise Restructuring and Embeddedness: A policy and systems perspective, Industrial and Corporate Change, 9 (1)

Vonortas, N.A., 1997, Cooperation in Research and Development, Kluwer Academic Publishers, Boston MA.