Innovation networks in sensor technology development

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Abstract

Although the national performance of scientific research is high in The Netherlands, the innovativeness of the economy seems to be rather low. It has been said that due to inadequate cooperation and weak links between public and private R&D, scientific knowledge is not converted into economic value. One industry in the Netherlands in which this paradox is relevant is the sensor technology industry. The Netherlands holds a strong position in fundamental sensor technology research, but this is not obviously translated into an internationally competitive sensor industry. In order to reach such a competitive position this problem has to be resolved. In this paper we investigate whether sensor technology firms collaborate with external organizations, especially those related to public R&D. This would provide insight into the nature of the problems of knowledge transfer between organizations in the sensor technology industry, and enables us to provide policy recommendations regarding the cooperation and links between public and private R&D in this industry. After an overview of the sensor technology innovation system we will analyze the innovation networks and collaborative new product developments of sensor technology firms in the Netherlands. We will end with some tentative conclusions and policy recommendations.

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Introduction

Recently the Dutch Ministry of Economic Affairs (2002; 2003) published two documents in which the Dutch innovative performance was analyzed. It showed that the Netherlands is "losing momentum" and the present international competitive position is not as strong as it used to be. This analysis was largely based on Porter's analyses of clusters and competitiveness of nations (Porter 1990; 1998) and on policy discussion papers of the OECD (2001). An important issue concerns the paradox that, although the national performance of scientific research is high, the innovativeness of the economy seems to be rather low. It has been said that due to inadequate cooperation and weak links between public and private R&D, scientific knowledge is not converted into economic value (Soete 2002).

One industry in the Netherlands in which this paradox is relevant is the sensor technology industry (Middelhoek 1998; NLRO 1998). The Netherlands holds a strong position in fundamental sensor technology research. However, this strong position in fundamental research is not obviously translated into a strong internationally competitive sensor industry. It has been shown that small countries, like the Netherlands and Israel are very well able to establish a competitive sensor industry with quality comparable to that of their much larger competitors (Koschatzky et al. 1996). In order to reach such a competitive position the problem of commercializing the results from fundamental research has to be resolved. In this paper we investigate whether sensor technology firms collaborate with external organizations, especially those related to public R&D. This would provide insight into the nature of the problems of knowledge transfer between organizations in the sensor technology industry, and enables us to provide policy recommendations regarding the cooperation and links between public and private R&D in this industry. The main research question is:

To what extent do sensor technology firms collaborate for innovation with external organizations, and how important are localized networks in this collaboration?

We will first present a conceptual framework in which the literature on innovation networks and regional clusters will shortly be reviewed. In order to answer the main research question we will start with a description of the sensor technology innovation system in the Netherlands. After this overview of the sensor technology innovation system we will analyse the innovation networks and collaborative new product developments of sensor technology firms in the Netherlands. We will end with policy recommendations and some tentative conclusions.

Conceptual framework

Systems of innovation

In order to analyse the development of sensor technology in the Netherlands we will use a systems of innovation approach A national system of innovation is the interactive system of existing institutions, private and public firms (either large or small), universities and government agencies, aiming at the production of science and technology (S&T) within national borders. Interaction among these units may be technical, commercial, legal, social and financial as much as the goal of the interaction may be development, protection, financing or regulation of new S&T (see e.g. Carlsson and Jacobson 1997; Edquist 1997; Freeman, 1987,1988; Lundvall, 1992; Lundvall et al. 2002 ; Malerba 2002; Nelson, 1988, 1993). With this approach we can trace the various actors that are involved in sensor technology and the relationships that exist between them. In the next section we will focus on one aspect of a system of innovation, namely innovation networks.

Innovation networks

Interactions between firms in a market can be limited to transactions in which goods or services are exchanged for a certain price. However, many interactions between firms involve more than

just a transaction in which property rights are exchanged. Relations in innovation networks involve the exchange of information outside market transactions. This predominantly involves cooperation for innovation. These innovation networks enable firms to complement their internal resource base with external resource bases, which improves their innovative performance (Oerlemans et al. 1998; Freel 2003). In his discussion of a number of sources of innovative success, Freeman (1991) concludes that external collaboration with users and external sources of technical expertise are very important in achieving successful innovations. These success factors demonstrate the importance of formal and informal networks. Formal networks include official co-operative agreements such as joint ventures, technology exchange agreements, sub-contracting, and government-sponsored joint research programmes (Freeman, 1991). According to Freeman (1991) various informal networks are usually behind every formal network. These are the personal and cultural networks in which entrepreneurs reside.

DeBresson and Amesse (1991) argue that localised networks are often more stable and durable than international strategic alliances. In general, the geographic concentration of a network appears to offer advantages over geographically scattered networks, because localised networks are reinforced by personal, cultural and symbolic networks (DeBresson and Amesse, 1991). Saxenian (1994) and Bianchi and Bellini (1991) mention the importance of social solidarity, shared-educational and professional experience, trust, and “clan” relationships for the success of networks. Localisation of inter-firm networks enables a better functioning of these success factors.

Regional clusters

Michael Porter is generally considered as the founder of the ‘cluster concept’. Clusters are defined as “geographic concentrations of interconnected companies and institutions in a particular field” (Porter 1998). Firms in a regional cluster are held together by "buyer-supplier relationships, or common technologies, common buyers or distribution channels, or common labour pools” (Enright 1996, p.191). Although many scholars emphasize the role of trust and cooperation among firms in a cluster, this is not a necessary condition. As Enright (1996) states: competitive firms make a competitive cluster and economic self-interest (economic value) is ultimately the glue that binds the cluster together. The cluster concept has been promoted as an analytical tool as well as a policy tool.

The cluster approach is obviously related to the systems of innovation and network approaches, which makes it an interesting concept for the analysis of co-operation in the sensor technology sector. First of all, it emphasises that a cluster can be seen as a geographically concentrated network of firms. This idea is rooted in the cluster and network approaches. However, not only networks of firms are relevant, also institutions like universities, research centres, and network brokers and other intermediaries are important for the success of a cluster, especially for a knowledge intensive field like sensor technology.

Research design

This study is based on a survey on a representative sample of 37 sensor technology firms in the Netherlands, complemented with 12 in-depth interviews with managers of sensor technology firms and policy makers of bridging institutions.

The survey was held in 2004 among the population of sensor technology firms in the Netherlands. The population has been constructed on the basis of data of STWs Sensor Technology Platform, which identifies 54 companies or institutions that are involved in sensor production, sensor development and/or sensor consultancy. The main disadvantage of this list is that it has not been updated since January 2000. So we searched for more recent data at other organizations. The branch organisation FHI has introduced a sensor technology club, which currently has 22 members. Half of these 22 companies are not included in the STW list, which makes the total number of sensor companies in the Netherlands 58. During the survey it turned out that some of these 58 companies had seized to exist, had merged, or had changed their

name. Furthermore, some companies where traced that are not mentioned in the two lists of STW and FHI, but are involved in sensor technology. The final list of sensor technology companies counts 54 companies. All the sensor technology firms in the Netherlands that were known via these data sources have been contacted by telephone, of which 43 companies agreed to receive and fill out the questionnaire (80% response). The response rate on the total number of sent questionnaires has been 79% (34 firms). Out of the response of 34 companies, two questionnaires have not been processed in the research results. One entrepreneur had started a new company in the mean time and this new company did not fit the profile of a sensor company. The returned questionnaire of another firm was very poorly answered, and it was decided that this questionnaire would not provide enough relevant input. The sample of the questionnaire represents 59% of the total known population of sensor technology firms.

The respondent firms are quite diverse in their size and age. Over 85 % of the respondent firms have had an annual turnover in 2003 below € 5.000.000. Almost a quarter of the respondent firms earned less than € 100.000 in 2003, which also includes some firms that have not yet created significant turnover. Close to 45 % of the respondent firms earn less than € 500.000, and all of these firms except one had less than 5 employees in 2003 (including the owners). If we take a look at the age of the firms, almost 42 % was not older than 10 years in 2003. The remaining 58 % includes firms that have been founded decades ago and have evolved into sensor technology firms.

There is an apparent concentration of firms and research institutes in the sensor technology field in the province of South Holland. Focused policy efforts on a strong region could be very useful. Therefore, a case study has been performed on the province of South Holland in order to determine whether the group of actors in this geographical area can be regarded as a regional cluster. Cluster policy could prove to be effective in order to stimulate the innovative capacity of firms in this region. This case study involved semi-structured interviews with entrepreneurs of sensor technology firms and with representatives of related institutions in South Holland. For this case study, 8 entrepreneurs have been interviewed, which represent almost 40% of the total number (22) of sensor technology firms in South Holland. Furthermore, interviews have been conducted with representatives of the Delft University of Technology (2), TNO-TPD (1), SenterNovem (1), EZ (2), Twinning (1), and with a sensor expert of Syntens (1).

The sensor technology system of innovation in the Netherlands

An innovation system can be analysed with three components: the technology field, all relevant actors and their specific role in the system, and the relations between the actors. The latter component will be focused on in the next section.

Sensor technology

Sensor technology is the technology behind sensors. A sensor is a piece of equipment that is able to measure a specific analogue quantity. Sensors can measure quantities such as temperature, electricity, gasses and light. A distinction is usually made between two categories of sensors: physical and chemical sensors. The former sensors include electrical, optical, mechanical, magnetic and thermal sensors. The latter are all the sensors that translate the presence of bio (chemical) substances to an electrical signal.

Sensors shape an important component of micro systems. According to NEXUS (The Network of Excellence in Multifunctional Microsystems), a micro system “combines several micro components, optimised as an entire system, to provide one or several functions, in many cases including microelectronics”. A sensor is one of these micro components functioning within the micro system. It produces an electronic signal, which is processed into information or a regulative action by a microprocessor. An actuator is a system that creates energy or a movement. The function of the actuator often implies sending a light signal or a small air or fluid current, on the basis of which further action can be taken.

Sensors can be used for process measurement and as such they are often a part of a (automatic) regulation system. Sensors are currently used in a large variety of applications: within industrial processes, in the transport sector, in agriculture and also in the food industry. Since sensors are often used within the broader concept of a micro system, end markets for micro systems could also be seen as end markets for sensors. Potential growth areas for micro system technology are IT peripherals, biomedical systems, automotive applications, domestic appliances, telecommunications, and the machine industry.

Actors in the sensor technology system of innovation

The most important actors involve the sensor technology firms, technical universities, research institutes (such as TNO), and various bridging and networking initiatives.

The activity in sensor technology research in the Netherlands is concentrated around three types of organisations: universities, TNO (contract research) and companies. The Netherlands holds a strong position in international sensor research. According to Middelhoek (1998), the Netherlands was amongst the first countries to recognise the future importance of sensor technology. The initiation of government supported technology programmes in the 1980s has resulted in the present strong position of Dutch academic research. The expertise mainly concentrates around two research institutes: DIMES (Delft University of Technology) and MESA+ (UTwente). These institutes focus on the broader research field of Microsystems technology (MST). Besides DIMES and MESA+, an increasing amount of quality research is being conducted at various faculties of the technical university in Eindhoven (TUe).

Figure 1. The geography of the sensor technology industry in the Netherlands

TNO is the largest contract research institution in the Netherlands. Sensor research is conducted within various institutes of TNO, such as Industrial Technology, TPD (Technical Physics), PML (Defence and protection), and FEL (Physics and Electronics Laboratory). TNO TPD, for instance, has a specific division involved in instrumentation, which has a strong expertise in the field of Electronic Systems and Sensors. The fact that the sensor research within TNO is performed at such a variety of institutes indicates how diverse the applications of sensor technology are, as well as the very many disciplines that are involved.

The Netherlands belongs to the top of the world in sensor research. This strong position in international research has not resulted in an obvious increased activity in the relevant Dutch

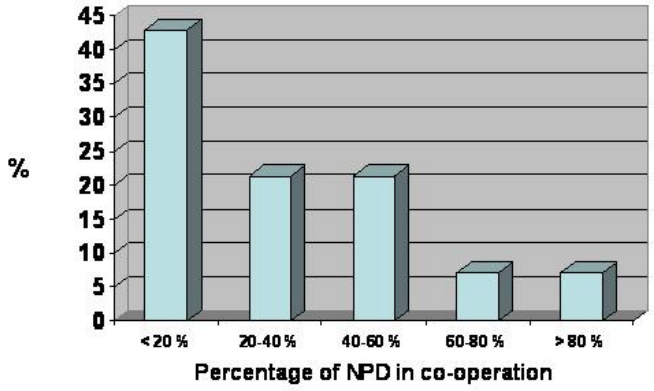
industries. The academic sensor programs did not receive the necessary industrial follow up and therefore the contribution to the GNP by business activity involved in sensor technology is lagging behind expectations (Middelhoek, 1998).

The sensor technology industry in the Netherlands is rather young and of limited size. There is a strong geographical concentration of firms in the province of South Holland, and in particular around the city of Delft (see figure 1). This concentration is probably related to the strong representation of sensor technology research in the province. The Delft University of Technology, and more specifically its research institute DIMES, belongs to the top sensor technology research institutes in the world. The largest technological contract research institute in the Netherlands, TNO, is also strongly represented in the province. This suggests that the collection of firms and research institutes in South Holland could be seen as a *cluster*.

Innovation and networks of sensor technology firms in the Netherlands

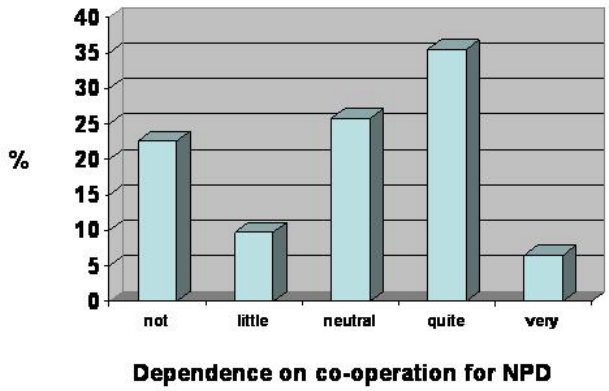
The largest part of the respondents has developed (a) new product(s) in the last three years (88%). This suggests that the respondents are quite innovative (if measured as new product development). We expect that co-operation is necessary for new product development (NPD), especially for high–tech SMEs. However, a large share of the firms involved in NPD (43%) has hardly cooperated with other organizations (less than 20% of their NPD). Co-operation only seems to be crucial for NPD for a 14% of the firms involved in NPD: more than 60% of their NPD has been accomplished with a partner (see figure 2).

Figure 2. Percentage of NPD in co-operation with a partner in 2001-2003



These results appear to be somewhat contradicting with the respondents' perceived importance of co-operation for NPD: 42% of the respondents say that they are quite or very dependent on co-operation for NPD (see figure 3).

Figure 3. Perceived importance of co-operation for NPD

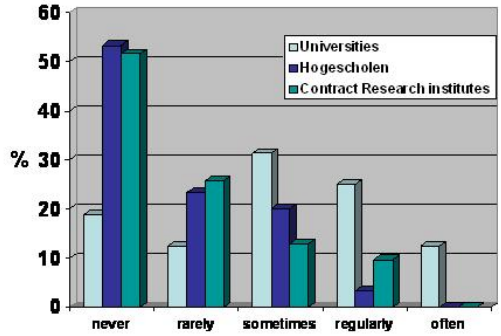


If sensor technology firms co-operate it involves new product development in most cases. Three quarters of the firms' co-operative agreements involves NPD. The sharing of R&D facilities is quite popular amongst sensor technology firms as well. Due to the large investments that are involved with R&D facilities, shared facilities spread the risk for firms. Almost 35% of the respondents are sharing these facilities with other firms or institutions. Only a small part of the respondents co-operates with other firms in joint marketing (16%). Although it is not specified, joint marketing is expected to involve the approaching of potential customers in co-operation with another company. Since end users are often looking for total solutions, it might very well be useful for smaller specialised firms to join forces and approach these customers together to improve their chances of acquiring an order. The respondents' experience (regarding the added value) with co-operation is largely neutral (35%). Such a large percentage is quite surprising, because this could imply that these respondents are indifferent about co-operation. A possible explanation is that the individuals that have responded to the questionnaire might not have been the right persons to value co-operation. This could have urged them to choose neutrally. For 28% of the respondents co-operation has some added value, whereas 14% has very good experiences with co-operation. Most firms co-operate within as well as outside their home region (58%). Only 7% of the firms co-operates mostly within their own region, whereas 19% mostly co-operates with firms outside of their own region, which is defined here as the province South Holland. The fact that most firms co-operate both within and outside of their own region could very well imply that it is not very important to sensor technology firms where a partner is located. These networks of co-operating partners (firms or knowledge institutions) seem to be geographically scattered.

One of the main problems concerning innovation in the Netherlands involves the so-called knowledge paradox. The transfer of fundamental scientific knowledge to the industry is problematic, and the application of fundamental knowledge is not sufficient. The questionnaire involves a section in which the firms are asked about their innovation networks with knowledge centres like universities and research institutes. The majority of the firms stated that they at least sometimes interacted with universities, but also the majority stated that they never interacted with other institutes of higher education or research (see figure 4). The reported intensity of interaction

with universities is quite high in comparison with other research on high-technology SMEs (see Wever and Stam 1999).

Figure 4. Interactions with knowledge centres



The questionnaire involved a section on the role of the so-called intermediaries or innovation agents in co-operative projects. It turns out that intermediaries are hardly used in co-operative agreements. Over one third of the respondents have never been involved in a co-operative project where an intermediary acted as an independent third party. It should be noted that this also involved companies that have never co-operated with other firms at all. 39% of the respondents have only used one incidentally. Some cluster literature (e.g. De Langen, 2002) stresses the importance of the presence of large firms within a cluster for cluster success. According to the respondents large firms (> 100 employees) are mostly interested in co-operation with SMEs (< 100 employees) when it involves product development. Large firms are regularly willing to develop new products with SMEs according to 34% of the respondents. Another area in which large firms and SMEs co-operate is the sharing of R&D facilities: 39% of the firms indicate that larger sensor firms and SMEs sometimes share their R&D facilities. This finding is strongly related to the previous one, because joint product development is expected to involve the sharing of R&D facilities.

The case study of South Holland has resulted in some interesting findings. In contradiction to some expectations and assumptions of this paper, it is not clear that the sensor technology firms and knowledge institutions in South Holland can be regarded as a regional cluster. The firms and institutions are not strongly interdependent and are often operating individually. There is not much co-operation in joint innovation trajectories aimed at the creation of economic value. Furthermore, most of the important networks in which the sensor technology firms in South Holland are active are not. They are active at a national or international level.

Conclusions

Our main research question was to what extent sensor technology firms collaborate for innovation with external organizations, and how important localized networks are in this collaboration. Although a large part of the firms (42%) state that they are dependent on innovation networks for the development of their new products, the majority of the new products are developed without collaboration with an external partner. Next to collaboration for new product development (75% of the collaboration for innovation), also a large group of firms (35%) collaborate via the sharing of R&D facilities. Most firms co-operate within as well as outside their home region (58%): only 7% of the firms co-operates mostly within their own region, whereas 19% mostly co-operates with firms outside of their own region.

The presence of strong demand markets is important for the development of the sensor technology industry. The Netherlands does not have a significant position in a number of industries that are of importance for sensor technology applications. This includes industries such as the automotive industry and the aerospace industry. However, there are some industries in which the Netherlands holds a strong position and in which sensor technology plays an important role (transport and logistics, the process industry, the agro food industry, and horticulture (see Jacobs et al. 1990). Policy efforts should focus on these industries in order for the Dutch sensor technology industry to develop a more distinctive character from their international competitors. Institutions such as FHI, STW and Syntens can develop business roadmaps for those industries in which a strong home market demand for sensor technology is present.

There are quite some organisations in the Netherlands that have or want to have an important mediating role in the sensor technology innovation system. There should be a better co-ordination among these institutes in order for their efforts to provide the required results. Certain initiatives should shift their focus or they should merge with others. An institution such as STW could possibly fill a gap in the current system by putting more effort into SMEs. In some cases sensor initiatives seem to be too isolated from initiatives in adjacent technology fields. There should be more cooperation and co-ordination between sensor initiatives and, e.g., MST initiatives. Finally, networking and bridging initiatives should play a more active role as information brokers. By developing an online meeting point for the actors in the sensor technology system, these networking and bridging institutions can increase knowledge transfer and co-operation.

The final recommendation concerns regional policy and cluster policy. In the case of the sensor technology industry, regional policy can only be successful if it is coordinated on a national level. The sensor technology system in the Netherlands is geographically scattered over a number of regions, and these regions neither have the size nor a sufficient distinctive character to be internationally competitive on a long term. Institutions such as the Knowledge Alliance (“Kennisalliantie”) and Syntens should not develop isolated regional policy. They must co-ordinate their efforts with their national counterparts in order to be successful.

Policy recommendations

The main strengths of the Dutch sensor technology system include the high quality of fundamental sensor technology research, and the strong international competitive position of *some* Dutch firms. Assessing the Dutch sensor technology sector along Porter’s (1998) criteria, the main weaknesses are the problematic transfer of knowledge from universities to industrial applications, the supply of labour, the access to capital, and the absence of strong home market demand. Current policy measures such as the Innovation Platform and the various subsidy measures have a stimulating effect on innovation in general. Some specific (regional) measures such as the Knowledge Alliance (“Kennisalliantie”) are directly targeted on the sensor technology system. However, the results of this research pinpoint some gaps in current policy measures. The main recommendations to policy makers concern the mentioned weaknesses of the system as

well as recommendations on the functioning of (regional) networking initiatives and regional policy.

There is a considerable supply of innovation and R&D subsidies in the Netherlands. However, there is not (yet) a suitable supply of venture capital to sensor technology firms. Firms are constantly in search of this type of capital and the Dutch government might be able to assist them to a larger extent than it does presently. The SBIR measure that the US government has installed might offer interesting opportunities for firms, governments and venture capitalists.

According to DeBresson and Amesse (1991), localized networks offer more stability than geographically scattered networks. Localised networks are not dominant in the Dutch sensor technology industry. These empirical findings could imply that this reasoning does not apply to networks in the sensor technology system; it could imply that there are not enough local possibilities to establish strong localized networks, or it could mean that the actors in the system are not aware of the possible advantages of localized networks. Public policy might be initiated to overcome this lack of localized networks.

Dodgson and Bessant (1996) discuss the importance of innovation agents within innovation processes. One of the main advices that have come forth from the NRLO report (1998) on sensor and micro system technology is that “third” parties are needed to “bring firms together, to formulate projects and to manage these projects” (NRLO, 1998). However, our research showed that intermediaries are hardly used in co-operative agreements.

The problematic transfer of knowledge between (fundamental) research institutes and industry is at the core of the knowledge paradox. A solution to this issue is not easy and it involves many policy areas. Present measures such as the Technopartner program, the Innovation Vouchers measure and the high-tech internships of Syntens affect certain elements of the innovation paradox. A measure similar to the American SBIR measure could prove to be successful in fighting the knowledge paradox. Further research into the role of technical universities’ policies on Intellectual Property and university spin-offs could result in improvement of these policies. Most of the firms that have participated in this research see the future of the Dutch highly educated technical labour pool as a problem for the continuity of their business. The Dutch government is well aware of this problem and is investing in the improvement of this situation (e.g. by granting financial incentives for PhD students). Within the constraints of this research it has not been possible to take a closer look to this issue and it is recommended that an organization such as the Innovation Platform continues to do research on this topic and devises solutions to the issue.

References

Bianchi, P. and N. Bellini (1991) Public policies for local networks of innovators, *Research Policy* 20 (5) 487-497

Carlsson, B. and S. Jacobsson (1997) Diversity creation and technological systems: a technology policy perspective. In: Edquist, C. *Systems of Innovation: technologies, institutions, and organizations*.

Castells, M. and P. Hall (1994) *Technopoles of the world: The making of 21st Century Industrial Complexes*. London: Routledge.

Cooke, P., Uranga, M.G. and G. Etxebarria (1997) Regional innovation systems: institutional and organisational dimensions, *Research Policy*, 26 475-491.

DeBresson, C. and F. Amesse (1991), "Networks of Innovators: A Review and Introduction to the Issue," Research Policy, 20 (5), 363-79.

Dodgson, M. and J. Bessant (1996) *Effective Innovation Policy: a New Approach*. London: International Thompson Business Press.

Edquist, C. (1997) *Systems of Innovation: technologies, institutions, and organizations*. London: Pinter.

Enright, M.J. (1996). "Regional Clusters and Economic Development: A Research Agenda," in Udo Staber, Norbert Schaefer, and Basu Sharma, editors, Business Networks: Prospects for Regional Development. New York: De Gruyter: 190-214
Freel, M. (2003). “Sectoral patterns of small firm innovation, networking and proximity”. *Research Policy,* 32(5):751-770.
Freeman, C. (1987) *Technology Policy and Economic Performance: Lessons from Japan*. London/New York: Pinter.
Freeman, C. (1988), "Japan: A New National System of Innovation?," in Technical Change and Economic Theory, G. Dosi and C. Freeman and G. Silverberg and L. Soete, Eds. London/New York: Pinter Publishers.
Freeman, C. (1991), "Networks of Innovators: A Synthesis of Research Issues," Research Policy, 20 (5), 499-514.
Jacobs, D., P. Boekholt and W. Zegveld (1990) *De Economische Kracht van Nederland (The Competitive Advantage of the Netherlands)*, The Hague: SMO (in cooperation with TNO).
Keeble, D. and F. Wilkinson (1999) Collective learning and knowledge development in the evolution of regional clusters of high technology SMEs in Europe, *Regional Studies* 33 (4) 295-303.
Koschatzky K, Frenkel A, Grupp H, (1996) A technometric assessment of sensor technology in Israel vs Europe, the USA and Japan. *International Journal of Technology Management*, 11 (5-6): 667-687
Lundvall, B.-Å. (1988), "Innovation as an Interactive Process: from User-producer Interaction to the National System of Innovation," in Technical Change and Economic Theory, G. Dosi and C. Freeman and G. Silverberg and L. Soete, Eds. London/New York: Pinter Publishers.
Lundvall, B.-Å. Ed. (1992), National Sytems of Innovation. Towards a Theory of Innovation and Interactive Learning. London: Pinter Publishers.
Lundvall, B.-Å., Johnson B., Andersen, E.S. and B. Dalum (2002) National systems of production, innovation, and competence building, *Research Policy*, 31 213-231.
Malerba, F. (2002) Sectoral systems of innovation and production, *Research Policy,* 31 247-264.
Middelhoek, S. (1998) Entrepreneurship in Sensor-land. In: *Proceedings Sensor Conference March 1998*, Twente University.
Ministry of Economic Affairs (2002*) Het Nederlandse innovatiebeleid: Tijd voor vernieuwing?* Beschouwingen over het Nederlandse innovatiebeleid, Den Haag.
Ministry of Economic Affairs (2003) *Innovatiebrief: In actie voor innovatie.* Den Haag.
Moulaert, F. and F. Sekia (2003) Territorial Innovation Models: A critical survey, *Regional Studies* 37 289-302.
Nelson R. (1993) National Innovation Systems: A Comparative Analysis. New York: Oxford University Press.
NRLO (National Council for Agricultural Research) (1998) *Sensor and Microsystems technology: strengths and weaknesses*, Den Haag.
OECD (2001) *Innovative clusters: Drivers of National Innovation Systems*. Paris: OECD.
Oerlemans, L., M. Meeus, F. Boekema (1998). “Do Networks Matter for Innovation? The usefulness of the economic network approach in analysing innovation“. *Tijdschrift voor Economische en Sociale Geografie* 89(3): 298-309.
Oerlemans, L.A.G., Meeus, M.T.H. and F.W.M. Boekema (2001) Firm clustering and innovation: determinants and effects, *Regional Science* 80 337-356.
Porter, M.E. (1990) *The Competitive Advantage of Nations*. New York: Free Press.
Porter, M.E. (1998) Clusters and the new economics of competition, *Harvard Business Review*, November-December 77-90.
Saxenian, A.L. (1994), Regional Advantage: Culture and Competition in Silicon Valley and Route 128. Cambridge: Harvard University Press.
Soete, L. (2002) The European Research Area: Perspectives and Opportunities. Paper prepared for the international workshop on “Research Policy: Incentives and Institutions” Rome.
Wever, E. and E. Stam (1999) Clusters of High Technology SMEs: The Dutch Case, *Regional Studies* 33 (4) 391-400.