Regional Studies, Vol. 33.4 pp. 379–389

Technology-based SMEs in the Göteborg Region: Their Origin and Interaction with Universities and Large Firms

ÅSA LINDHOLM DAHLSTRAND
Industrial Dynamics, Chalmers University of Technology, S-412 96 Göteborg, Sweden

(Received August 1998; in revised form November 1998)

LINDHOLM DAHLSTRAND Å. (1999) Technology-based SMEs in the Göteborg region: their origin and interaction with universities and large firms, *Reg. Studies* 33, 379–389. This paper investigates the local origins and continued regional interaction of a group of new technology-intensive Göteborg SMEs. The results are based on an original survey of 52 such firms. It finds that these Göteborg SMEs were almost exclusively established as spin-offs by founders who were previously working for another local firm or university. Local links and relationships – especially with the previous employer and with Chalmers University – were initially important for their development. With time, however, the importance of such links has tended to decline, and instead wider national relationships are becoming more important.

Spin-offs Göteborg region Chalmers University of Technology Collective learning
New technology-based firms Large firms

LINDHOLM DAHLSTRAND Å. (1999) PME à la pointe de la technologie situées dans la région de Göteborg: genèse et synergie quant aux universités et aux grandes entreprises, *Reg. Studies* 33, 379–389. Cet article cherche à examiner la genèse locale et la synergie continue, régionale d'un groupe de nouvelles PME à la pointe de la technologie situées dans la région de Göteborg. Les résultats proviennent d'une enquête menée auprès de 52 entreprises de ce type. Il s'avère que ces PME-là ont été établies presque exclusivement par des créateurs d'entreprise qui travaillaient autrefois pour une autre entreprise ou une université locales. Les liens et relations locaux – surtout quant à l'employeur antérieur et à l'Université de Chalmers – s'avèrent importants pour leur démarrage. Cependant, l'importance de tels liens a eu tendance à diminuer sur le temps, et à leur place on attache progressivement plus d'importance aux relations nationales plus larges.

Créations d'entreprises Région de Göteborg
Institut universitaire de technologie de Chalmers
Apprentissage collectif
Nouvelles entreprises à la pointe de la technologie
Grandes entreprises

LINDHOLM-DAHLSTRAND Å. (1999) Kleine und mittlere, auf Technologie gestützte Unternehmen in der Göteburger Region: Entstehung und Verflechtung mit Universitäten und Großfirmen, *Reg. Studies* 33, 379–389. Dieser Aufsatz untersucht Ortsursprung und anhaltende regionale Verflechtung einer Gruppe neuer, technologisch intensiv arbeitender kleiner und mittlerer Unternehmen in und um Göteborg. Die Ergebnisse beruhen auf einer eigens dazu durchgeführten Untersuchung von 52 Firmen dieser Art. Er stellt fest, daß diese kleinen und mittleren Göteburger Unternehmen fast ausnahmslos als Nebenprodukt der Tätigkeit von Gründern etabliert wurden, die bis dahin für andere Firmen oder Universitäten am gleichen Ort arbeiteten. Verbindungen und Beziehungen am Orte-besonders zu ehemaligen Arbeitgebern und der Chalmers Universität waren anfänglich für ihre Entwicklung wichtig. Im Laufe der Zeit hat die Bedeutung solcher Verknüpfungen meist abgenommen, während weiterverzweigte stattdessen im ganzen Lande an Bedeutung zunehmen.

Nebenentwicklungen Die Göteburger Gegend
Die Technische Chalmers Universität Kollektives Lernen
Neue, auf Technologie aufbauende Firmen Großfirmen

INTRODUCTION

With increasingly rapid knowledge development, it is unusual for new breakthrough discoveries to be made and technological innovations developed by researchers and scientists working in isolation. Instead teams and networks are often responsible for new findings. In areas of both generic and applied research and development, individual research projects and firms may benefit from collaboration. However, the term 'network' can often mean anything (YEUNG, 1994) and, in order to discuss local networking and collective learning, it is essential that the term is better defined. Yeung uses a broad conceptual definition of a business network as 'an integrated and co-ordinated set of ongoing economic and non-economic relations embedded within, among

0034-3404/99/040379-11

and outside business firms' (*ibid*., p. 476). Thus a network is both a structure *and* a process, and it can consist of relationships and links between both firms and non-firm institutions. In different system approaches to innovation and technological change, interaction with and links to other organizations are often seen as critical to a firm's performance. The dominant approach in the literature on innovation systems is that of national systems of innovation (LUNDVALL, 1992; MALMBERG, 1997; EDQUIST, 1997). Other approaches include different technological systems (CARLSSON and JACOBSSON, 1993; CARLSSON, 1997) and a 'system of ownership changes' (LINDHOLM, 1994, 1996a). In addition, several researchers have found that proximity is important for networking and interaction in various ways, especially for small and medium sized enterprises (SMEs) (SAXENIAN, 1994; STORPER, 1993, 1995; STERNBERG, 1996; KEEBLE, 1997). A number of different concepts and approaches have been used to describe and analyse regional networking, for example industrial and technology districts (CASTELLS and HALL, 1994; STORPER, 1993, 1995), regional systems of innovation (COOKE, 1996), and innovative milieux (CAMAGNI, 1991). Besides the importance of proximity, the firms in a regional system are often assumed to benefit from shared, or similar, cultural and institutional frameworks. Furthermore, the globalization of economies appears to be associated with a decline in the importance of traditional localized factors of production, whereas those parts of the economy that are based on knowledge and learning are subject to increasing returns (MALMBERG, 1997). In such a knowledge-based economy, regional networking, research and technology development, and collective learning may be important key processes for future local development and attractiveness.

In my earlier studies of technology-related spin-offs and acquisitions (e.g. LINDHOLM, 1994, 1996a, 1996b; LINDHOLM DAHLSTRAND, 1997a, 1997b), I found that the majority of Swedish small and new technology-based firms are involved in such ownership changes. Since the two major sources of new high technology small firm entrepreneurs are higher education institutions and well-established industrial firms (OAKEY, 1995), new firms may tend to cluster around universities, research organizations and existing firms. As a result, there is a natural tendency towards a substantial and probably growing disparity between regions that already possess indigenous high technology activities, and those that do not (KEEBLE and OAKEY, 1997). In turn, a region like Göteborg, with old research universities and some well-established large industrial firms, might then fulfil at least one criterion for generating a successful, regional, technology-intensive, SME cluster. However, there are many research universities in the world, 'but there is a much smaller number of Silicon Valleys and Route 128s' (STORPER, 1995, p. 202), and the question is still what conditions lead to the emergence of a successful regional network in one particular location rather than another. Storper argues that, in this respect, the evolutionary school of technological change leads naturally to a view of the region as a nexus of untraded interdependencies. Besides input–output transactions, such interdependencies can also 'include "soft" dimensions of technology such as know-how and organizational rationalities' (STORPER, 1995, p. 208). CAPELLO, 1998, similarly suggests that the development and sharing of common knowledge, which goes beyond the boundaries of the firm, but remains within a region, may give rise to a process of cumulative growth of local know-how. The concept of collective learning refers, essentially, to that learning which is made possible through membership of some particular milieu (LAWSON, 1997; CAPELLO, 1998). LORENZ, 1996, defines collective learning as the creation and further development of a base of common or shared knowledge among the individuals making up a productive system. He argues that the 'shared capacity which is largely rooted in tacit knowledge, facilitates the process of combining the region's diverse and complementary capabilities, either through formal or informal interfirm cooperative relations or through the mobility of technical and scientific personnel on the local labour market' (*ibid*., 1998, p. 6).

In order to have, or establish, shared knowledge and collective learning certain prerequisites or processes need to exist. Lorenz points to four different mechanisms which may result in a base of common knowledge and shared rules which facilitate the development of a regional innovative milieu: (1) there might be common on-the-job training experience gained in larger firms or universities in the region; (2) the rules of the local labour market may influence the mobility of labour across SMEs in the region; (3) spin-offs from universities and large firms may have a role in establishing a base of shared knowledge; and (4) different technological alliances and user–producer relations might give rise to collective learning processes. From this it is clear that both large firms and universities may influence collective learning and technology development by regionally clustered SMEs in several different ways. They may be important for the education and training of technical and other key personnel, but they may also be the parent organizations for new spin-off firms. When such a spin-off is generated deliberately, the private industrial firm may also be the future partner in an alliance or a user–producer relation. Collective learning mechanisms can, however, be both conscious and unconscious, and the transfer of creative and cumulative knowledge can take place even against the will of the first inventor (CAPELLO, 1998), that is, for example, when a spin-off is made against the will of the parent organization. Spin-offs may indeed be very important as a mechanism for unconscious collective learning within a region. They may even be more

frequent and significant than conscious co-operation, for example through formal research collaboration. The spin-off process is likely to enhance regional knowledge development and learning processes because it involves the diffusion and sharing of technological and managerial expertise within the region, promotes the creation of a common technology and research focused regional industrial culture, and encourages the development of interorganizational links and personal networks through which new technology and knowledge can be shared and created. In some regions links of these kinds between large organizations and local SMEs can be highly important, while in other regions the local mobility and recruitment of individuals between SMEs is more important for local learning.

This paper will focus on technology-based SMEs in the Göteborg region. Their origin and interaction with local universities and large firms will be studied in order to shed some light on the spin-off of new technology-intensive firms as a process of collective learning. Moreover, both large firms and universities are likely to have an important role in local training and SME recruitment of key personnel. For a group of technology-intensive Göteborg SMEs, links and co-operation with the spin-off parents, as well as collaboration with other organizations and firms, both local and outside the region, will be examined. The analysis will attempt to relate my earlier findings on spin-offs and ownership changes (see above) to locational factors and regional processes. The paper begins by outlining the nature of the Göteborg sample of SMEs. In the following section the region's universities and large firms will be discussed as sources of local, new, technology intensive firms. This analysis will provide some empirical evidence on the extent of regional collective learning through mobile individual entrepreneurs who leave the local parent organizations – universities, industrial corporations, or a mix of these – to establish new spin-off firms. Following on from this, the next section will present data on the extent of continued interaction and networking between new SMEs and their different parent organizations, as well as on collaboration and interaction with other organizations. The use and importance of different sources for recruitment of technical employees is also discussed in this section of the paper, with particular reference to the role and function of local universities, such as Chalmers University of Technology. The final section of the paper summarizes its findings and presents key conclusions.

THE GÖTEBORG REGION AND THE SME SAMPLE

This section outlines the nature both of the Göteborg region and the technology-based Göteborg SME sample. This involves brief consideration of the geographical extent of the area here named the Göteborg region, and also discussion of the definition and operationalization of a technology-based firm.

The Göteborg region

The definition of the Göteborg region can be based either on the EU nomenclature for territorial units for statistics, the NUTS classification, or on commonly used national definitions. Using the NUTS II classification means discussing the whole of West Sweden (SE05), while at the NUTS III classification level the Province of Göteborg and Bohus (SE052) is sometimes used to define the region. A more commonly used national definition is the Greater Göteborg area. To further complicate the picture, the Swedish statistical authorities have decided upon a new definition (starting 1998) for the Province of West Sweden. In this paper, the Göteborg region will, however, be defined as the metropolitan area of Greater Göteborg, which includes a small number of municipalities belonging to neighbouring provinces. Hereby, all firms and organizations within the region are to be found within possible daily commuting distance of Göteborg itself.

Some general information and selected data on the Göteborg region and its institutional framework is presented in LINDHOLM DAHLSTRAND, 1998. Here it is stated that nearly half of all newly started Swedish enterprises are in the country's three largest cities. Half of all Scandinavian industrial capacity is located within a radius of 300 km from Göteborg. R&D activity in the Göteborg region is concentrated among few sectors and large enterprises. In particular, there is a very high degree of expertise in companies specializing in medical technology, telecommunications, information technology and industrial electronics, as well as in the automotive industry. Göteborg has two universities: Chalmers University of Technology and Göteborg University. The latter offers the largest number of single courses of any Swedish university. The structure of Göteborg University is that of a traditional European university, with five faculties, several of which are subdivided: there are the Faculties of Medicine, of Odontology, of Arts and Fine Arts, of Social Sciences and of Science. Chalmers University of Technology is one of the largest institutes of technology in Sweden. Chalmers offers Master of Science degrees and doctoral degrees. Research is carried out in the main engineering sciences as well as in technology-related mathematical and natural sciences. Some 2,000 employees work in more than 100 departments organized in nine schools. Since 1960, over 250 direct university spin-off companies have been generated from Chalmers University of Technology in Göteborg. In total, LINDHOLM DAHLSTRAND, 1998, found the number of technology-based SMEs in the Göteborg region to be approximately 3,400 in 1995. Of these, over half are found in technology-based service sectors; for example, 1,650 SMEs are engaged in R&D consultancy and

computer services. Many of the technology-based SMEs in the Göteborg region are new firms, established during the 1990s.

The Göteborg SME sample

In this paper a more narrow definition of a technology-based firm will be used, and as a consequence of this, the sample size is reduced. The empirical sample – the Göteborg SMEs – consists of a group of new technology-intensive firms, drawn from a larger Swedish sample of new technology-based firms (NTBFs) earlier described and analysed by SAEMUNDSSON *et al.*, 1997; and RICKNE and JACOBSSON, 1999. The definition of an NTBF used here is a firm whose strength and competitive edge derives from the know-how within natural science, engineering or medicine, of the people who are integral to the firm, and upon the subsequent transformation of this know-how into products and services for a market. Thus, this refers not only to firms developing or using high technology but to all firms where natural science, medical or engineering skills and expertise are central to achieving competitive advantage. These include, of course, not only manufacturing firms but also firms in industry-related services (SAEMUNDSSON *et al.*, 1997; RICKNE and JACOBSSON, 1999). In the following discussion, the phrase 'technology-intensive SMEs' will sometimes be used in order to distinguish these firms from the more generally used terms of high-tech or technology-based firm.

The identification of firms to be included in the national sample, and thus in the Göteborg SME sample, was based on data from the Swedish Bureau of Statistics (SCB). The firms in the sample are classified in a selected set of industries and industry-related services.[1] Included here are those industries which employ the bulk of engineers and natural scientists in the national labour market, excluding public sector activities such as education and health. Second, only those firms with at least one employee (two in the service sector) with an academic degree in any of these fields were included. This means that we excluded high tech firms that had no employees with an academic degree. Third, the firm has to have been established after 1975, and have at least three employees, which means that a large number of very small firms were excluded. Finally, companies which were the result of a reorganization of existing businesses, and therefore all foreign direct investments and all divisionalization or diversification by established firms, were excluded. The firms were traced over the period 1975–93, and in 1993 the national population of surviving firms amounted to 1,352 (RICKNE and JACOBSSON, 1999). Out of these, 238 were located in West Sweden (LINDHOLM DAHLSTRAND, 1997c, 1998).

In 1998, a postal questionnaire was sent to all surviving firms in the Swedish NTBF sample. The questionnaire included questions about, for example, the background of the founders, the financing of the firm, the customers, different links and interaction with other organizations, and acquisitions and spin-offs. This paper presents the first empirical results based on that questionnaire. The data analysed comprise responses from 52 SMEs in the Göteborg region. Compared to the 238 NTBFs reported for the whole of West Sweden in 1993, the corresponding Göteborg population (in 1998) is reduced to 176 SMEs. When trying to locate these, an additional 19 firms were found to be out of business. Consequently, the final Göteborg population size was reduced to 157 SMEs, and the response rate was therefore 33%.[2]

GÖTEBORG SMEs: UNIVERSITIES AND LARGE FIRMS AS SOURCES FOR NEW TECHNOLOGY-INTENSIVE FIRMS

This section examines the origins of technology-intensive Göteborg SMEs as revealed by the Göteborg SME sample. As argued in the introduction, the two main sources of SME entrepreneurs are well-established firms and universities. In an earlier Swedish study, LINDHOLM DAHLSTRAND, 1997b, found that half of all new technology-based firms were spin-offs from universities and industrial corporations. The Swedish metropolitan areas, including the Göteborg region, were also found to generate the majority of these spin-offs (LINDHOLM DAHLSTRAND, 1997a). Table 1 presents the frequency of different types of spin-offs among the Göteborg SMEs. Based on the origin of the idea that led to the establishment of the business, SMEs are classified as: (1) university spin-offs (USOs); (2) corporate spin-offs (CSOs); (3) indirect university spin-offs (ISOs – a mix of university and industry origin); and (4) non-spin-offs. ISO firms are included here as a separate category since they can be assumed to behave differently from other spin-off companies. The ISOs are unique since the founders of these firms have a mixed background which may allow them to combine experience and learning from both university research and managerial or professional employment in a private sector company. Among the non spin-offs are four firms which are based on ideas from external inventors and earlier contacts. There are

Table 1. *The origin and classification of the Göteborg SMEs*

Origin of idea	Classification	Frequency	%
University (directly)	USO	5	9·6
Mix of university and private firm	ISO	11	21·2
Private firm	CSO	22	42·3
External	Non-SO_{ext}	4	7·7
Own idea	Non-SO_{own}	10	19·2
Total	–	52	100

Table 2. Size and localization of parent organization (last employer)

	USO	ISO	CSO	External	Own	Total	
						N	%
Size							
Small (1–49)	–	2	7	2	1	12	23
Medium (50–249)	–	4	7	0	1	12	23
Large (> 249)	5	5	7	1	7	25	48
Missing	–	–	1	1	1	3	6
Total	5	11	22	4	10	52	100
Localization							
In the Göteborg region	5	9	18	3	8	43	83
In other parts of Sweden	0	2	1	0	1	4	8
Outside Sweden	0	0	0	0	0	0	0
Missing	–	–	3	1	1	5	10
Total	5	11	22	4	10	52	101

also 10 non-spin-offs that are based on the founder's own ideas. In this group, and also among the CSOs, the founder's own idea has usually been influenced by earlier customer contacts.

Table 1 reveals that no less than 73% of the Göteborg SMEs are spin-offs from other organizations. There are only five direct university spin-offs (10%) in the sample, but instead, there is a considerable number of indirect university spin-offs: 11 firms or 21% of the sample. Taken together, almost a third of the SMEs are thus, to some extent, based on university research. Worth noting here is also the fact that all the university spin-offs in this sample originated from research at Chalmers University of Technology. Göteborg University has the structure of a traditional European university and, despite being about twice the size of Chalmers, generates relatively few technology-based firms. Chalmers, on the other hand, has a long tradition as an engineering school, focusing almost exclusively on teaching and research in the technological disciplines.

Table 2 presents data on the size and localization of the founder's previous employer. It provides powerful evidence of the importance of geographical proximity, with over 90% of respondents reporting that the founders had been employed by a local organization before the new firm was established. Only four SMEs were established by founders previously employed outside the region. Moreover, in two of these four firms, the founder gained his educational degree from Chalmers University, and returned to the region when establishing the firm. Additionally, Table 2 reveals the importance of large firms as origins of new technology-based SMEs. Excluding USOs, 43% of founders previously worked in a large firm, only 26% having been employed by a small firm. To some extent this may reflect the – nationally much debated – Swedish phenomenon of having very few university graduates employed in small firms. For example, most graduates from Chalmers University of Technology have traditionally started their working life in one of Sweden's large corporations.

A further interesting finding is that medium sized Swedish firms have generated a third of the industrial spin-offs (i.e. CSOs and ISOs) in Table 2. Since medium sized companies are as unusual in Sweden as in an average European country (JOHANSSON, 1995), this suggests that medium sized companies are particularly successful in spinning-off new firms. This may be explained by the fact that a potential new entrepreneur working in a medium sized firm probably has a relatively good insight into several different aspects of running a business, as well as a personal knowledge of an already successful founder. In line with earlier findings (COOPER, 1971; DORFMAN, 1983; LINDHOLM DAHLSTRAND, 1997b) this suggests that successful past entrepreneurship makes future entrepreneurship more likely. Both Cooper and Dorfman have found it important for future entrepreneurs to know of other founders who had taken this step.

Despite the small number of observations, the relative dominance of larger firms in Table 2 may also indicate that large firms are less successful in taking advantage of the ideas generated by their own employees. This proposition is supported by an earlier finding of over 100 unexploited inventions in three large Göteborg companies: Volvo, SKF and Ericsson MicroWave Systems (LINDHOLM DAHLSTRAND, 1997d). It can be concluded that the Göteborg region's large firms are very important as sources of entrepreneurship of the region's technology-intensive SMEs, that is, spin-offs as well as non-spin-offs. This perhaps contrasts with the prevailing wisdom on sources of new firm founders generally, which is that these are generated primarily from small firms which provide opportunities and role models for gaining experience of management and risk-taking (DORFMAN, 1983; STOREY, 1982, 1994).

There are a number of different reasons why an employee may leave his or her employment and set up a new firm. If the main reason is connected to enforced personnel reductions or internal conflicts, this might limit future opportunities for co-operative links

between the new firm and its parent. Only seven Göteborg SME sample firms claimed that no aspect of their previous employment influenced the decision to start a new firm. In over 85% of the Göteborg SMEs circumstances at their previous employer did actually influence the decision to start a new firm. The most common such circumstance, affecting about one-third of the Göteborg SMEs, was a crisis of one kind or another. In addition, nine of the founders felt their ideas were not being utilized by their previous employer, while five founders claimed to have felt unsatisfied in their previous employment. Only five founders received support to start a business of their own. An additional eight firms were established because they saw a market potential, and often also an opportunity to co-operate with earlier customers. Compared to earlier Swedish findings (LINDHOLM DAHLSTRAND, 1997b) this suggests that the establishment of Göteborg SMEs is less often influenced by corporate crises or downsizing. In line with this, compared with other parts of Sweden (LINDHOLM DAHLSTRAND, 1997b) there is also weaker support from local employers for spinning-off new firms in the Göteborg region.

DEVELOPMENT, LINKS AND INTERACTION

The analysis above has demonstrated that the majority of technology-intensive Göteborg SMEs originate in local universities and large firms. Such spin-offs arguably represent one of the most important processes of technology transfer and collective learning in a region. Other important processes for collective learning, however, include shared knowledge and collaboration. The need to source technology externally is one reason why firms participate in innovation networks (CAMAGNI, 1991). One way for a new SME to find a natural partner with whom to co-operate is, of course, to engage in a relationship with the previous employer. The next section examines interaction between the Göteborg SMEs and their parent organizations, together with the importance of other links and networks.

The continued relation with the parent organization

Data on the frequency of continued links and interaction with the parent organization or the previous employer are presented in Table 3. As can be seen in the table, Göteberg ISOs are especially active in interacting with the parent organization. However, the importance of this interaction decreases over time, such that after 10 years there is very little interaction between ISOs and their parent organizations.[3] Firms in the CSO group also frequently report initial co-operation and links with their parent organization. When comparing the ISOs with the CSOs, the CSOs are however more often engaged in a relationship in which the parent organization is a customer. Moreover, for CSOs the importance of these customer links, and of links generally, is far more likely to be maintained over time. Customer links are also important early in life among the non-spin-offs established from the founders' own ideas. Generally, the frequency of links and interaction between new firms and the founders' earlier employer declines as the firms age. For the sample as a whole, after 10 years, only two cases of links with competitors and seven cases of customer relationships persist. None the less, after 10 years, 55% of the original local links with parent organizations reported by the sample firms continued to exist. Thus, even if it seems clear that spin-offs tend to become less related to their parents over time, many still retain important links, particularly with respect to the group of corporate spin-offs. It may of course also be the case that, in addition to their parent organizations, the new SMEs find other partners – perhaps with complementary knowledge – with whom to co-operate.

The importance of other local links

Given that links and interaction with the parent organizations show a tendency to decrease over time, it seems natural to expect that the firms should instead engage in other relationships and networks. Among the potentially important new partners could, for example, be an acquiring organization, or a new Göteborg SME spin-off itself. In total, among the 52 Göteborg SMEs, only nine has subsequently been acquired. This figure is substantially lower than in earlier Swedish studies (LINDHOLM, 1994, 1996b). In addition to being acquired, eight of the 52 Göteborg SMEs have made an acquisition themselves. Moreover, these Göteborg SMEs also spin-off new firms themselves. Eleven of the 52 Göteborg SMEs have together spun-off an additional 26 new CSOs. One CSO and one non-spin-off have generated no less than six spin-offs each. Some 12 of these new firms have been set up in the Göteborg region, 10 in other parts of Sweden, and the remaining two in other parts of the world (information is missing for two firms). The relationship between the SME-parents and their own spin-offs differs considerably from that reported in Table 3 above. That table shows that only 24% of the first generation of spin-offs (CSOs and ISOs) were competitors to their parents. In the second generation of spin-offs, however, this has increased to 36%. In addition, 45% of first generation CSOs and ISOs had a customer relationship with its parent. For the second generation of new spin-off firms, no such customer relationships exist. Instead the second spin-off generation often engage in a supplier relationship. Thus, the second generation spin-offs indicate a continued transfer of technology and new links within the region, both these mechanisms perhaps being important for the development of local collective learning.

Table 3. Links and interaction with parent organization

		USO	ISO	CSO	External	Own	Total	
							No. of links	% of firms
Competitor	Start	–	3	4	1	–	8	15
	Later	–	–	1	–	1	2	4
Customer	Start	–	3	8	–	4	15	29
	Later	–	–	5	1	1	7	13
Supplier	Start	–	2	1	–	–	3	6
	Later	–	–	2	–	–	2	4
Research partner	Start	–	1	1	–	–	2	4
	Later	–	–	2	–	–	2	4
Consulting	Start	1	–	–	1	–	2	4
	Later	1	–	2	–	–	3	6
Other	Start	1	2	3	2	–	8	15
	Later	1	2	2	–	–	5	10
Total	Start	2	11	17	4	4	38	
	Later	2	2	14	0	1	21	

In Tables 4, 5 and 6 the frequency of important links with other external organizations is presented. The links reported in these tables have only been included when they are considered to be the most important ones for developing the competence of the SME. The firms in the sample were asked to include only those close collaborative links that have been, or still are, of considerable importance for the development of the company. That is, general purchasing links and 'arm's length' market relations have been disregarded and are not included in the tables. Table 4 reports on local links, Table 5 on important links in other parts of Sweden and, Table 6 on important links outside Sweden.

As can be seen in Tables 4 to 6, the most important external links for competence development reported by the Göteborg SMEs are those with Swedish customers and with local Göteborg universities. Links to local universities are, not surprisingly, most important to USOs and ISOs, but this importance declines with time. Table 4 also reveals a tendency for all local links (except with suppliers) to become less frequent with time. Table 5 clearly demonstrates that wider Swedish links are very important for competence development of the Göteborg SMEs, and there is no tendency for this importance to decline over time. While, for example, links with local universities tend to become less important, links with other Swedish universities instead become more frequent. Links with universities outside Sweden are, however, unusual for the Göteborg SMEs. Table 6 demonstrates that international links for competence development are about as important as local links. There is also a tendency for international links to decline in importance over time. There is, however, one important exception to this in that CSOs report increased activity in terms of important international customer relations Moreover, the CSOs also demonstrate a relatively high networking capacity; all

Table 4. Links[1] for competence development: local links

		USO	ISO	CSO	External	Own	Total	
							No. of links	% of firms
Universities	Start	2	5	4	0	0	11	21
	Later	1	1	4	0	0	6	10
Customer	Start	0	1	4	0	0	5	10
	Later	0	0	2	0	1	3	6
Supplier	Start	0	0	0	0	0	0	0
	Later	0	0	1	0	0	1	2
Competitor	Start	0	0	0	0	0	0	0
	Later	0	0	0	0	0	0	0
Consulting	Start	1	0	0	0	1	2	4
	Later	0	0	0	0	1	1	2
Research institute	Start	0	0	0	0	0	0	0
	Later	0	0	0	0	0	0	0
Other	Start	0	0	0	0	0	0	0
	Later	0	0	0	0	0	0	0
Total	Start	3	6	8	0	1	18	
	Later	1	1	7	0	2	11	

Note: 1. Most important links at start-up and after 10 years.

Table 5. Links[1] for competence development: Swedish links

							Total	
		USO	ISO	CSO	External	Own	No. of links	% of firms
Universities	Start	0	2	1	0	0	3	6
	Later	1	0	4	0	1	6	12
Customer	Start	0	4	6	0	1	11	21
	Later	0	1	8	0	3	12	23
Supplier	Start	0	0	4	1	1	6	12
	Later	0	0	2	0	2	4	8
Competitor	Start	1	0	0	0	0	1	2
	Later	0	0	1	0	2	3	6
Consulting	Start	1	0	1	0	2	4	8
	Later	0	0	0	0	1	1	2
Research institute	Start	0	0	0	0	0	0	0
	Later	0	0	1	0	0	1	2
Other	Start	0	1	0	0	0	1	2
	Later	0	1	0	0	0	1	2
Total	Start	2	7	12	1	4	26	
	Later	1	2	16	0	9	28	

Note: 1. See note to Table 4.

Table 6. Links[1] for competence development: links outside Sweden

							Total	
		USO	ISO	CSO	External	Own	No. of links	% of firms
Universities	Start	1	1	0	0	0	2	4
	Later	0	0	1	0	0	1	2
Customer	Start	0	2	1	1	0	4	8
	Later	0	0	5	0	0	5	10
Supplier	Start	0	2	1	0	0	3	6
	Later	0	0	1	0	0	1	2
Competitor	Start	1	0	1	0	1	3	6
	Later	0	0	2	0	0	2	4
Consulting	Start	1	0	0	0	0	1	2
	Later	0	0	0	0	0	0	0
Research institute	Start	0	1	0	0	1	2	4
	Later	0	0	1	0	0	1	2
Other	Start	0	0	0	0	0	0	0
	Later	0	0	0	0	0	0	0
Total	Start	3	6	3	1	2	15	
	Later	0	0	10	0	0	10	

Note: 1. See note to Table 4.

22 firms report having had important links at start up and, mainly because of new national and international customers, the number of important links show a tendency to increase over time.

Besides being important for networking relationships which enhance competence development, these different organizations may also represent important sources of recruitment of new technical key personnel. Table 7 thus presents the sources for recruitment of technical staff that have actually been used by the Göteborg SMEs.

This table reveals a wide diversity of recruitment sources by new technology-intensive SMEs in the Göteborg region, with all sources of recruitment being used in all three geographical areas. However, the most striking finding of Table 7 is the very high frequency of usage and the very high rating in importance of local universities. By far the most frequent single source of recruitment of technical staff is from local universities (especially Chalmers University, which is the main source of graduates with an engineering qualification) and this source is also rated significantly more highly than any other single source in the table. For recruitment from other parts of Sweden, as well as internationally, universities are again the single most used and important source of technical staff. The next most important sources are competitors and customers. As with universities, and perhaps not surprisingly, local sources are most frequently used in both cases. Indeed, Table 7 reveals that five of the top six most frequently used sources are local. This provides clear evidence of active processes of intraregional movement of technical

Table 7. The use and importance of different sources of recruitment of technical employees

	Local		Sweden		International	
	Frequency *N*/(%)	Importance	Frequency *N*/(%)	Importance	Frequency *N*/(%)	Importance
Universities	30 (58)	4·17	10 (19)	3·40	4 (8)	2·50
Customer	8 (15)	2·63	5 (10)	2·60	1 (2)	1·00
Supplier	1 (2)	1·00	2 (4)	1·50	1 (2)	1·00
Competitor	10 (19)	3·30	7 (13)	2·86	1 (2)	3·00
Consulting	8 (15)	3·25	4 (8)	2·50	2 (4)	2·50
Research institute	2 (4)	2·50	3 (6)	3·00	1 (2)	1·00
Other	13 (25)	3·46	7 (13)	2·86	3 (6)	1·00

Note: 1. Frequency = number of firms which have used the source; importance measured on scale 1 to 5, where 5 indicates a very high importance.

expertise (including movement between competitors) within the Göteborg region. In turn this supports the argument that local technology-intensive SMEs benefit from active collective learning processes in the form of movement of 'embodied expertise', competencies and technological know-how between firms and knowledge centres in the region.

SUMMARY AND CONCLUSION

The objective set out in the introduction of this paper was to explore and present some new empirical findings about the local origin and continued regional networking and interaction of a group of technology-intensive Göteborg SMEs. The origins of such SMEs, their continued interaction with their own 'parents', and the extent of collaboration and links with other local organizations and corporations, were examined as important elements of a potential regional collective learning process.

The empirical findings clearly demonstrate that there are two main sources of new entrepreneurs of technology-intensive SMEs in Göteborg region: Chalmers University and the well established large, and medium sized, industrial firms. Almost all new entrepreneurs come from within the region, or are former students returning to the region. Thus, as in Cambridge and Oxford (KEEBLE *et al.*, 1998), local Göteborg technology-based SMEs are almost exclusively established by entrepreneurial founders who were previously working for another local firm or university. Local spin-offs, and the transfer of entrepreneurs and knowledge, from a well established organization into a new independent enterprise seems to be one of the main processes of intraregional learning in Göteborg. Even without knowing how many Göteborg-entrepreneurs set up their new spin-offs and other firms outside the region, it can be concluded that the Göteborg region, like other Swedish metropolitan areas (LINDHOLM DAHLSTRAND, 1997a), has a higher frequency of entrepreneurial spin-offs than the national average. In a process which has been ongoing since the 1960s, these new start-ups are the basis of the Göteborg regional cluster of technology intensive SMEs. However, it should also be remembered that the region has an old industrial tradition with several large and dominating manufacturing firms. In contrast to several other regions, for example in the 'Third Italy' (CAPELLO, 1998) or Cambridge (KEEBLE *et al.*, 1998), it is perhaps to be expected that a relatively high share of Göteborg new firm founders (see Table 2) have had working experience in a large firm.

In order for a regional cluster to be, and function as, a regional network, local interaction and collective learning processes are necessary. The local spin-off process is only the first step in establishing a regional network; other important steps and processes can include continued second generation spin-offs, and different kinds of interaction between spin-offs and parents. Interaction with other organizations and firms, including new 'parents' acquired as a result of acquisition, could also be of importance for regional networking and collective learning. In the Göteborg region, local links and relationships – especially with the previous employer and with Chalmers University – were found to be initially very important. However, with time, this importance showed a tendency to decline. Instead wider national relations become more important. As in the Cambridge and Oxford cases (KEEBLE *et al.*, 1998) the evidence of this Göteborg study indicates that, while many technology-based SMEs are involved in national networks, direct local research collaboration is less frequent. The study also, however, provides strong evidence of the existence of two very important local collective learning processes in the Göteborg region. The first is, of course, the spin-off of new firms from local parent organizations. The second is the high level of local technical staff recruitment and mobility, and hence movement of embodied technological expertise and know-how, within the regional labour market. Both processes result in the diffusion and combination of technological competencies between local firms and organizations such as Chalmers University, and hence the development and strengthening of a local collective learning capacity. A further important finding is of the importance of Chalmers University of Technology in these processes. With its longstanding focus on engineering,

the university has generated a considerable volume of academic spin-offs (LINDHOLM DAHLSTRAND, 1997a). Besides encouraging co-operation with local universities, Chalmers' technological focus also explains the very frequent use – and valued importance – by Göteborg SMEs of recruitment of technically trained personnel from local universities. These findings suggest that local collective learning processes and fairly extensive tacit knowledge transfer do operate within the Göteborg region. It can be concluded that the Göteborg region is characterized by a high frequency of technology-intensive spin-off firms, especially from Chalmers University and from local large and medium sized firms, and by an active local labour market in technically trained mobile workers. The question is still, however, whether or not such a pattern is typical of any large town with a long industrial tradition and large manufacturing firms, or if this is what characterizes an innovative milieu involving a regional network of technology intensive SMEs.

Acknowledgements – The research on which this paper is based was financially supported by the Ruben Rausing Fund for Research on Entrepreneurship and Innovation. The author wishes to thank the referee for many valuable comments. My sincere thanks also go to David Keeble, Staffan Jacobbson and Dilek Karaömerlioglu for their very helpful and detailed comments and suggestions on an earlier draft on this paper.

NOTES

1. The industries included are ISIC (rev. 2 from 1968) 341, 35, 37, 38, 6112, 72002, 8323, 83249, 83292, 83299 and 932. This is a subset of the manufacturing and service sector.
2. Since this response rate is somewhat lower than anticipated, telephone interviews were conducted with an additional 59 SMEs in the Göteborg region. In several firms the respondent had not seen the questionnaire, and about one-third requested a new one to answer. However, over one-third (21 SMEs) of the respondents claimed that they did not answer because of a lack of time, for one-sixth the reason for not answering was that the founder(s) had left the firm and nobody else had the necessary knowledge, and the last sixth had different reasons for not answering.
3. An issue worth analysing in future research, however, is whether the high frequency of interaction at start-up between the ISOs and their parents could possibly help in explaining the rapid growth of this group.

REFERENCES

CAMAGNI R. (Ed) (1991) *Innovation Networks: Spatial Perspectives*. Belhaven, London.

CAPELLO R. (1998) Collective learning and the spatial transfer of knowledge: innovation processes in Italian high-tech milieux, in KEEBLE D. and LAWSON C. (Eds) *Collective Learning Processes and Knowledge Development in the Evolution of Regional Clusters of High Technology SMEs in Europe*. ESRC Centre for Business Research, University of Cambridge.

CARLSSON B. and JACOBSSON S. (1993) Technological systems and economic performance, in FORAY D. and FREEMAN C. (Eds) *Technology and the Wealth of Nations: The Dynamics of Constructed Advantages*. Frances Pinter, London.

CARLSSON B. (Ed) (1997) *Technological Systems and Industrial Dynamics*. Kluwer, Dordrecht.

CASTELLS M. and HALL P. (1994) *Technopoles of the World: The Making of Twenty-first Century Industrial Complexes*. Routledge, London.

COOKE P. (1996) The new wave of regional innovation networks: analysis, characteristics and strategy, *Small Bus. Econ.* **8**, 159–71.

COOPER A. C. (1971) Spin-offs and technical entrepreneurship, *IEEE Trans. Eng. Mgt.* **EM-18**(1), 2–6.

DORFMAN N. S. (1983) Route 128: the development of a regional high technology economy, *Res. Policy* **12**(6), 299–316.

EDQUIST C. (Ed) (1997) *Systems of Innovation: Technologies, Institutions and Organizations*. Pinter/Cassell, London.

JOHANSSON D. (1995) Swedish enterprises in an international perspective: a comparison of the number of enterprises in some European countries, paper presented at Wiiks Conference, Uppsala.

KEEBLE D. (1997) Small firms, innovation and regional development in Britain in the 1990s, *Reg. Studies* **31**, 281–93.

KEEBLE D. and OAKEY R. (1997) Spatial variations in innovation in high-technology small and medium-sized enterprises: a review, in COSH A. and HUGHES A. (Eds) *Innovation: National Policies, Legal Perspectives and the Role of Smaller Firms*. Edward Elgar, London.

KEEBLE D., LAWSON C., LAWTON SMITH H., MOORE B. and WILKINSON F. (1998) Collective learning processes and inter-firm networking in innovative high-technology regions, Working Paper 86, ESRC Centre for Business Research, University of Cambridge.

LAWSON C. (1997) Towards a competence theory of the region, Working Paper 81, ESRC Centre for Business Research, University of Cambridge.

LINDHOLM Å. (1994) The economics of technology-related ownership changes – a study of innovativeness and growth through acquisitions and spin-offs, Ph.D. dissertation, Department of Industrial Management and Economics, Chalmers University of Technology, Gothenburg.

LINDHOLM Å. (1996a) An economic system of technology-related acquisitions and spin-offs. Working Paper 33, ESRC Centre for Business Research, University of Cambridge.

LINDHOLM Å. (1996b) Acquisition and growth of technology-based firms, Working Paper 47, ESRC Centre for Business Research, University of Cambridge.

LINDHOLM DAHLSTRAND Å. (1997a) Entrepreneurial spin-off enterprises in Göteborg, Sweden, *Europ. Plann. Studies* **5**(5), 661–75.

LINDHOLM DAHLSTRAND Å. (1997b) Growth and innovativeness in technology-based spin-off firms, *Res. Policy* **26**(3), 331–44.

LINDHOLM DAHLSTRAND Å. (1997c) Technological specialization in the Göteborg Region, in KEEBLE D. and LAWSON C. (Eds) *Networks, Links and Large Firm Impacts on the Evolution of Regional Clusters of High Technology SMEs in Europe*. ESRC Centre for Business Research, University of Cambridge.

LINDHOLM DAHLSTRAND Å. (1997d) Outnyttjade uppfinningar och avknoppningspotential i storföretag, Working Paper 1997:93, IMIT Institute for Management of Innovation and Technology (in Swedish).

LINDHOLM DAHLSTRAND Å. (1998) The development of technology-based SMEs in the Göteborg Region, In *Regional Reports* of the TSER European Network on Networks, Collective Learning and RTD in Regionally-clustered High Technology Small and Medium-sized Enterprises, ESRC Centre for Business Research, University of Cambridge.

LORENZ E. (1996) Collective learning processes and the regional labour market, unpublished research note, European Network on Networks, Collective Learning and RTD in Regionally-clustered High Technology SMEs.

LORENZ E. (1998) Shared and complementary knowledge: the foundations for regional innovative capacity, in KEEBLE D. and LAWSON C. (Eds) *Collective Learning Processes and Knowledge Development in the Evolution of Regional Clusters of High Technology SMEs in Europe*. ESRC Centre for Business Research, University of Cambridge.

LUNDVALL B.-Å. (Ed) (1992) *National Systems of Innovations: Towards a Theory of Innovation and Interactive Learning*. Frances Pinter, London.

MALMBERG A. (1997) Industrial geography: location and learning, *Progr. Hum. Geogr.* **21**(4), 573–82.

OAKEY R. (1995) *High-technology New Firms: Variable Barriers to Growth*. Paul Chapman, London.

RICKNE A. and JACOBSSON S. (1999) New technology-based firms in Sweden – a study of their direct impact on industrial renewal, *Economics of Innovation and New Technology* (forthcoming).

SAEMUNDSSON R., RICKNE A., LINDHOLM DAHLSTRAND Å. and JACOBSSON S. (1997) Regional industrial renewal: technological specialization and employment in Swedish new technology based firms, paper presented at the conference on Industriell & Teknisk Utveckling, Fågelbrohus, Sweden.

SAXENIAN A. (1994) *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*. Harvard University Press, Cambridge, MA.

STERNBERG R. (1996) Technology policies and growth of regions: evidence from four countries, *Small Bus. Econ.* **8**, 75–86.

STOREY D. (1982) *Entrepreneurship and the New Firm*. Croom Helm, London.

STOREY D. (1994) *Understanding the Small Business Sector*. Routledge, London.

STORPER M. (1993) Regional worlds of production: learning and innovation in the technology districts of France, Italy and the USA, *Reg. Studies* **27**, 433–55.

STORPER M. (1995) The resurgence of regional economies, ten years later: the region as a nexus of untraded interdependencies, *Europ. Urban & Reg. Studies* **2**, 191–221.

YEUNG H. W. (1994) Critical reviews of geographical perspectives on business organizations and the organization of production: towards a network approach, *Progr. Hum. Geogr.* **18**(4), 460–90.