4 Science parks in Europe: flexible production, productive disintegration and R&D

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The last decade has witnessed the rise of new forms of industrial organisation and the development of new growth centres. Examples of these new growth centres include the cities of Cambridge, Milton Keynes and Bracknell which are considered as models of a flexible capitalism in England, the cities of of Toulouse, Grenoble, Montpellier and Sophia-Antipolis which are the main French technopoles, Turin and the areas of flexible specialisation in Italy and Munich and Baden-Württemberg in Germany. The dynamism of these localities lies in two factors: their flexible industrial organisation and new institutional compromises which resolve the contradictions of new production practices. This article deals with a major problem of this new articulation of accumulation, regulation and space: the contradictions between R&D and flexible production and their institutional regulation through science park policy.

4.1 Flexible production, disintegration and the R&D problem

By the mid 1970s major changes in corporate strategies and the organisation of production were under way as a result of the crisis of mass production and of the modes of regulation of national welfare states (see Gottdiener and Komninos 1989). To summarise these changes the term 'flexible production' is sometimes used to characterise an emerging post-Taylorist industrial paradigm which permits a more efficient use of resources (capital, labour, stocks, etc.) and greater market competitiveness. However, flexible production does not emerge by itself, but is based on the innovativeness of firms and their effort to introduce 'types of flexibility' into the production process, inter-firm relations and the labour market. I have tried to summarise these strategies in Table 4.1.

There is no doubt that this formalisation is oversimplified. However, like all models, it does have an explanatory value. On the left hand side, I have noted the critical issues with which flexible strategies were concerned and on the right hand side I have listed some of the forms they assumed (see also Benko and Dunford 1991, pp. 12-17).

Table 4.1 Flexible production strategies

Critical issues	Forms of appearance
Level of strategy: the production process	
Divorce of machinery and product	Global automation and Computer Integrated Manufacture
Divorce of workplaces and skills	Partial automation and workers' involvement
Multifunctional tools and labour	Artisan production
Just-in-Time management of stocks	
Level of strategy: product innovation	
Innovation versus economies of scale	R&D-intensive small firms
Quality circles: Total Quality Control	Closer integration of R&D and marketing departments in multidivisional firms
Small series, frequent changes of models	Strategic alliances of firms
Public R&D and university-industry interface	
Level of strategy: inter-firm co-operation	
Disintegration and market-mediated relations	Hierarchical network of large and small enterprises
Disintegration and vertical near integration	Stable producer-supplier relations
Changing flows between firms	Labyrinth of small firms and relations of trust
Level of strategy: the labour market	
Labour market flexibility	Advanced fragmentation of the labour market
Co-operative form of industrial relations	Upgrading of skills
	Numerical flexibility
	Plant versus sectoral unionisation

Leborgne and Lipietz (1990, pp. 11-13) have described what they see as dominant models of contemporary industrial organisation: the neo-Taylorist model which combines flexible labour contracts with hierarchical/direct control over the worker; the Californian model based on a flexible labour contract and individually-negotiated worker involvement; the Saturnian model which entails a rigid labour contract and collectively-negotiated worker involvement; and the Kalmarian model which is also associated with a rigid labour contract and globally-negotiated involvement. These models are centred upon two aspects of industrial relations: (1) the rigidity/flexibility of the labour market; and (2) factory control over the activity of workers.

Table 4.1 shows, however, that flexible production strategies have more than two dimensions (levels) and can take a multiplicity of forms in each. Included are production organisation, product innovation and R&D, inter-firm relations and the labour market. At these levels, different forms of organisation appear, and their combinations can lead to numerous forms of flexible production. Of these combinations some are inconsistent. There are however many empirical forms that flexible production can assume, of which some exist. What the critical issues, indicated on the left hand side of Table 4.1, point towards is not just one or more models but a new way of thinking about production and competition.

Those flexible production strategies that are centred on technological learning and product innovation involve high levels of expenditure on R&D and producer services (fundamental research, applied research, engineering consultancy, market research, advertising and information services). The need for these services is not just a once-and-for-all need, but increases as product cycles become shorter and shorter: whenever a new product is introduced, a new niche market is created or customised goods are produced, a new round of research and producer service activities is set in motion. In a comparison of three different new industrial spaces in South-East England, Scotland and the San Fransisco Bay Area, Oakey and Cooper (1989, pp. 352-3) stress that in these areas the R&D and skills required to develop and produce high-technology products are high throughout the life cycle of the product. Moreover, because product life cycles are frequently short, the scope for long standardised phases of production, with standardised materials and unskilled labour, is minimal.

To some degree, the rising needs for R&D and skilled labour may also explain the importance of economies of scope *vis-à-vis* the economies of scale. It does not follow that scale is not important. But, as product diversification increases and the length of product life cycles decreases, economies within a firm are centred on the intensive use of skills and know-how in the production of different products rather than on the size of individual production runs. With the emergence of these strategies there were also significant moves towards greater vertical disintegration and growth of the small-firm sector. Start-up mania, 'me-too start-ups', copycat companies, horizontal fragmentation and less and less vertical integration (see Florida and Kenney 1990, pp. 74-9) all contributed to a new industrial landscape. More analytically, there were three major processes which sustained productive disintegration and the growth of the small-firm sector:

- First larger firms pursued multiple forms of structural fragmentation. Included were: (1) the synchronic fragmentation of production of different products and in different localities and the extension of the subcontracting system; (2) the diachronic fragmentation of production associated with shorter product life cycles and the rapid succession of different products and models; and (3) the introduction of tendering arrangements so that, for example, R&D departments were required to compete for work with outside contractors to ensure that in-house R&D was cost-effective (see Roussel *et al.* 1991).
- Second, there was an externalisation of activities by larger firms. All tertiary activities without strategic importance were contracted out, and this restructuring led to a wave of new small firm creations. The small firms that resulted work in low risk environments with low entry costs and have high rates of turnover of capital.

- Third, there was a proliferation of small businesses, which proved themselves particularly effective in producing for and operating in market niches. Three types of dynamic small firms were identified (Britton 1989): (1) enterprises which specialised in market niches in mature industries such as the textile, clothing and furniture industries where, despite competition from products from low-wage countries, firms from advanced countries were capable of competing provided that they operated in market segments characterised by higher levels of performance and/or superior design; (2) enterprises which specialised in market niches in scientific instruments, electrical equipment, industrial machinery and tools where survival depended on the retention of in-house technical skills and the use of technologies developed elsewhere; and (3) small technology-based enterprises with strong internal scientific teams, innovation capabilities and in-house design and engineering. In some industries, such as scientific instruments and mechanical engineering, small firms operating in market niches accounted for an important share of total sectoral innovations.

In short, flexible counter-crisis strategies, developed at the level of production, inter-firm relations, product design and labour organisation, demand increased R&D and producer service inputs on one hand and favour the disintegration of the production and the rise of the small-firm sector on the other.

This situation is contradictory, due to the difficulties that small firms face in providing high R&D inputs. As early as 1962 Arrow argued that firms underinvest in R&D because the social benefits of this type of investment are greater than its private returns. Arrow specified three factors which, depress the level of private R&D expenditure: the indivisibility of R&D, its inappropriability, which makes it difficult to establish clear property rights and to control its diffusion and use, and its uncertainty. In the provision of R&D, markets fail and market mechanisms are imperfect.

Arrow was writing, however, during the Fordist era when product life cycles were long and the large multidivisional corporations realised important scale economies. The existence of R&D market imperfections at that time suggests an increase in their importance in an era of flexible production, vertical disintegration and rapid product changes. The practical consequence is that small flexible firms are unable to provide the required levels of innovation, product design, consultancy, engineering and market information services internally. They have day-to-day needs for applied R&D inputs, but the indivisibility, inappropriability and uncertainty of R&D do not allow them to provide these services from their own resources. Between the development of R&D and the flexible small firm sector there is a deep economic barrier.

This conflict was quickly recognised as a constraint on their growth, and different solutions were attempted. Included were networks and alliances among firms, corporate integration, public support and incubator environments.

System areas and industrial districts are examples of the co-operative solution: clusters of interdependent small firms create systems allowing costs and risks to be spread and production to be rapidly adjusted to market requirements (Amin 1989a, p. 116). What results is a 'creative milieu' (Becattini 1991) in which, as Saxenian (1990, p. 91) has pointed out, the region and not the firm is the locus of production.

Global competition and system technologies, which demand a wide range of know-how, stimulated a new round of integration. In particular, integrated Japanese corporations have become the main players in world markets, not only for mass-produced high-tech products, but also on the fringes of the markets for customised products. Referring to the case of the USA, Florida and Kenney (1990, p. 79) note that:

> The fragmentation and splintering of our high-technology capabilities make it ever more difficult to built stable companies and industries that can compete over the long haul. Even our stronger, most innovative companies are finding it difficult to grow and prosper in such a highly fragmented environment. The extreme segmentation of high-technology production drastically inhibits technological follow-through and hinders American industry's ability to meet the challenge of emerging global competition.

They argue that in these circumstances there is a need for corporate integration, which may lead away from the highly competitive, Hobbesian relationships between vertically disintegrated companies.

There is also a wide range of national and local public initiatives and interventions whose aim is to assume a part of private R&D and transaction costs and to establish networks for technology transfer, engineering and market consultancy. This trend was particularly strong in Europe and was reinforced by EC technology, competition and regional policies. These interventions were based on two simple concepts : (1) the development of incentive programmes and the subsidisation of private R&D, especially at the pre-competitive stage, and (2) the creation and spatial distribution of technology and consultancy intermediaries so as to provide direct technology transfer and producer services to small firms (see also Murray 1991, pp. 23-60).

However, the impact of these policies was questionable, as the conflict between small firms and R&D lies in the character of R&D as something with the qualities of public goods rather than commodities. It was very soon realised that the key to a solution lay in the establishment of links between universities and the R&D market. Science park policies and projects were a result of this compromise.

Science parks are one aspect of a new set of relations between the state and the market. What is involved is a revived social-democratic contract centred on the development of public environments that enhance the efficiency of individual actors. Science park policies have been supported throughout Europe by local authorities, development agencies, central governments and the European Community. Their aim is to create environments for technology transfer and the growth of technology-based small companies. This type of environmental and public solution to the 'R&D within flexible production' problem has certain advantages at least with respect to new models of corporate integration. I shall try to outline these advantages, considering the development of science parks in Europe.

4.2 Science parks in Europe

The establishment of the compromise between universities and the market took more than ten years from the first wave of science parks in 1970 or so to the second in approximately 1982.

A formal definition of a Science Park was given by the United Kingdom Science Park Association (UKSPA). It defines a Science Park as:

a property based initiative which has formal operational links with a university or other Higher Education Institution as major centre of research; is designed to encourage the formation and growth of knowledge-based businesses and other organisations normally resident on site; and has a management function which is actively engaged in the transfer of technology and business skills to the organisations on site. (Dalton 1987, p. i)

This definition also provides a set of criteria which form the basis for eligibility for membership to UKSPA. In other countries, however, there are important departures from this concept. Several terms are used to describe the initiatives to stimulate the growth of high-technology activities and to foster technology transfer between research and industry. Apart from science parks, there are research parks, technology parks or technopoles and innovation centres. According to the classification presented in the *Official Journal of the European Communities* (C186/52) a research park focuses on research and production is normally precluded; a technology park is a development to accommodate high-technology firms with R&D, production and sales activities, and is distinguished from science and research parks because of a greater emphasis on production; an innovation centre is a facility which promotes the setting-up of new businesses engaged in the development and marketing of new technological products, with high market risks. The term Science Park covers all these projects. Usually, technology parks or innovation centres are eligible for membership of European science park associations.

The university or research centre is the basic nucleus of a science park. Around it there are three major groups which together make up the population of the park: technology transfer agencies, internal companies (relocations, new start-ups, spin-offs, etc.) and external companies which are linked to the park. The technology transfer agencies may include management services, production information services, market research services, as well as some venture capital fund schemes. The companies located on a science park are usually small, mainly technology-based firms in computing, electrical engineering, chemicals, biotechnology and consultancy, and financial and business services. The external group of companies may include small and large firms with some kind of partnership arrangement with the research centres or new ventures in the park. In some cases, secondary supporting activities such as sports facilities, housing, hotels, restaurants and so on are also provided in the park. In its pure form, therefore, a science park is an environment which provides specific resources to technology-based enterprises through technology transfer relations (see Figure 4.1).

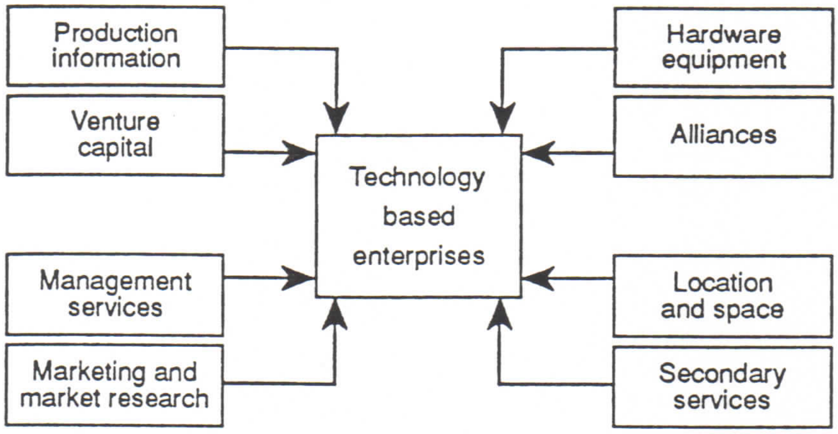

Figure 4.1 Science park technological environment

The character of science parks varies significantly from one part of Europe to another (Summan 1987). The UK, Germany, Holland and Greece follow a model of small parks orientated towards new technology-based firms, while the parks in France and Spain are larger and seek, at least in their early years, to attract established companies and multinational R&D departments. These situations are connected with the strategy for technology transfer within each country.

In the UK there were two distinct periods of science park development. In the early 1970s Cambridge and Herriot-Watt science parks were set up (Dalton 1985; Segal & Quince 1985). In 1983, after these pilot projects, there was a remarkable wave of establishment of science parks. Today, there are 38 functioning parks and 18 under construction (UKSPA 1988; Dalton 1987).

Most of the UK parks are small. Their surface area varies from 2 to 12 acres and only two parks occupy more than 100 acres. The majority of the companies located on the parks are small, local, single-plant and independent. Average employment is 8 persons. The activities of the firms fall under the headings of software (17 per cent), consultancy (19 per cent) product-related (22 per cent), contract research (7 per cent), contract design (9 per cent), testing (4 per cent) and training (4 per cent). The industrial sectors to which they belong are computing (34 per cent), electrical engineering (19 per cent) chemicals and biotechnology (12 per cent), mechanical engineering (7 per cent), consultancy and training (19 per cent), and business services (9 per cent) (Monck 1987; UKSPA 1987 and 1988). The main source of funding was the public sector: government development agencies provided 21 per cent of all science park finance, universities 28 per cent and local authorities 11 per cent. The private sector contributed 8 per cent of total investment and tenant companies 32 per cent (Rowe 1988, p. vi). The development of the parks was very uneven, with those located in the faster growing areas (in South-East England) and those containing computer-related firms growing much faster than the rest.

In Germany, local authorities and universities developed business innovation centres and nurseries rather than science parks. Innovation centres and nurseries are buildings for between 10 and 30 small enterprises, providing management, finance, marketing and technology services, as well as conference and other common facilities and technical services. Most are part of the European Network of Business Centres (Allesch 1985; European Business and Innovation Centre Network 1988). In 1987 there were 43 operating projects and an equal number under construction. A few of them were later transformed into small science parks (Berliner Innovations- und Grunderzentrum, and Technologie und Innovationspark) with an emphasis upon technology transfer and support for small innovative firms.

The French case is very different. The term Technopole covers both science parks and high-tech industrial zones. 43 Technopoles are functioning or under construction (DATAR 1988, p. 298). These centres were developed in two phases: three were developed in 1970-1, and the rest were established after 1983 (Club des Technopoles 1988). Technopoles are bigger than UK science parks. The area they cover varies considerably, lying between 8 and 2,800 hectares but with most of them occupying 300 to 400 hectares. They were developed jointly by local authorities, Chambers of Commerce and Industry and universities either as part of a strategy for the restructuring of declining cities (such as Marseille, Metz and Nantes) or as a strategy for the development of new industrial spaces (Île de France, Montpellier, Sophia-Antipolis, Cité Descartes, etc.). In their early years there were attempts to attract established companies, R&D departments of multinationals and big public R&D research institutes and to create a local network of alliances, subcontractors and spin-offs. In later years, small firms came and located in the technopoles (District de Montpellier 1988; EPAMARNE 1989; Poulit 1989). In Sophia Antipolis where this type of strategy was monitored, 11,000 direct and much more indirect employment was created in twenty years (Fache 1990; Laffitte 1985; Muller 1985).

In Belgium science parks started to mushroom in 1971 after a central government decision to support their development. Belgian universities played a dominant role in the development of the parks. There are eight parks with premises which occupy on average some 50 hectares of land (Mersier 1985; Tomas 1985). The majority of the enterprises are small: the average number of employees is 56. The managing authorities have provided investment subsidies and appropriate infrastructures to attract the research centres of multinationals in electronics and pharmaceuticals (Van Dierdonck, *et al.* 1991, p. 117). Overall, however, the activities of the firms is diverse, and does not always correspond with the expertise of the host university.

In Holland, the development of science parks is recent. As Witholt (1985, p. 39-41) argues, Netherlands is strongly stratified with university graduates starting careers in large organisations while smaller firms draw their employees from middle-level technical schools. Amongst university graduates there is not a strong entrepreneurial culture. At the same time the Dutch government created several regional development agencies to provide firms with consultancy and management services. These two factors limited and delayed science park development. Indeed it did not get under way until after 1984 when three parks were created. Of the three, Twente is a business technology centre, established jointly with Control Data. The parks of Zernike and Leiden are proper science parks funded by local authorities, the universities and private industries.

In Spain, a technology park policy was set in motion in 1983. Since then six parks of between 7 and 120 hectares have been created (Barcelona, Madrid, Basque country, Valencia, Asturia and Andalusia). Many aspects of the development strategy were copied from southern French technopoles with, in particular, a search for joint initiatives with multinationals. What is specific in the Spanish case is the effort to introduce new technologies in existing industries and traditional sectors rather than to promote new industries (Gamella 1988; Escorsa 1988).

There is just one science park in Italy: the Technopolis Novus Ortus, near Bari. The six-hectare Bari site is prepared to accept the research activities of national and international enterprises and of small businesses. In Greece, three parks orientated towards technology transfer in traditional and new industrial sectors are in their starting phase (Athens, Thessaloniki and Patras).

4.3 Science parks, institutional agreements and technology transfer

As the descriptions in the last section show, regardless of their differences, European science parks link university and research centres, technology-based enterprises and consultancy and training agencies. Between them, different types of technology transfer take place: from universities to companies, from company to company and from the park's occupants to the surrounding environment of the park. These transfers rely on institutional agreements and partnerships between individual firms, agreements over links with universities and relationships with other professional and public agencies (Chambers of Commerce, venture capital associations providing finance for new start-ups, development banks and local authorities). Three types of institutional agreements sustain the technology transfer activity of the parks: (1) the links with universities; (2) the venture capital funds for new start-ups; (3) the partnerships between firms.

4.3.1 The links between firms and universities and research centres

Universities and research institutes play a fundamental role in the concept of a science park as a major source of innovations and new technologies for existing firms and new technology-based start-ups. The links between individual firms and universities differ from one university and one science park authority to another. In general they involve (Monck, *et al.* 1988, pp. 167-8): (1) the transfer of people and staff from the university to the firm; (2) the access of firms to university facilities such as libraries, conference centres, computer centres and amenities; (3) the opening up of university and laboratory infrastructures and equipment to companies for analysis, testing and evaluation exercises; (4) contracts for or sponsoring of university research by the firms; (5) less formal contacts and the day-to-day interchanges and information flows between academics and managers.

In so far as these relationships exist, universities and public research institutes provide external economies of scale for science park firms and can attract small and large companies. A case in point is Toulouse, where it was the attractiveness of such infrastructures that led to the location of important high-tech companies (Alcatel-Espace, Matra-Espace, Thomson and Motorola) in Toulouse just after the transfer of the Centre National des Études Spatiales (National Centre for Space Research — CNES) to the city (Hirtzman and Cohen 1988).

An equally important but more immaterial factor in the attraction of firms is the prestige of being linked to the university. For many companies, the symbolic value of a relationship with the host university is more important than the direct use of its infrastructures as it enhances the high-tech image of science park companies and can give a firm a strong marketing advantage.

4.3.2 Venture capital funds for new start-ups

In recent science park projects more consideration has been given to the means of financing companies interested in the commercial exploitation of new ideas, and in many science parks the managing authorities have themselves organised a venture capital fund. What however is the meaning of this financial backing? A 1987 survey of European venture capital funds indicated, as Hustler (1988, p. 31) pointed out, that there was no shortage of funds for investment. However, only 3 per cent of tenant companies in UK science parks were financed by formal venture capital institutions (Monck 1988, p. 18). It is clear that venture capitalists were steering clear of investments in new start-ups. The problem lay in the size of the firms. The average size of venture capital investments was very large compared with the needs of the companies which were starting up in science parks. Furthermore, an important part of available venture capital funds was going to management buy-outs and later stage financing. The needs of new tenant companies on science parks were, it seemed, too small to interest venture capitalists.

At the root of this problem was the size of the market in which most science park companies were operating. In Europe, new companies achieving spectacular growth and supplying within the first five years a large international market were few and far between. On the contrary, science park companies showed a predisposition to stay comparatively small, to remain independent of external finance and to avoid the organisational difficulties accociated with growth (Dunford 1991, p. 67).

There was therefore a problem. On the one hand new start-ups constitute an important channel for technology transfer especially where scientists wish to commercialise their research. On the other it was difficult for them to get venture capital funding. To solve this problem many science park authorities established links with venture capital funds to provide capital for tenant companies. Usually these schemes were associated with the incubator concept and concentrated on high-technology start-ups. What was provided were small sums of money either in the shape of long-term loans or equity participation in the company's assets plus some kind of management guidance and assistance with the development of a business plan (see Allen 1988).

4.3.3 Partnership and agreements between firms

With the development of science parks it became clear that the tenant companies experienced the normal business problems of the small-firm sector with particular difficulties in the areas of promotion, marketing and sales. To overcome such growth barriers the management authorities of science parks tried to establish partnership agreements between the park's technology-based firms and external companies. The networking and knowledge transfer between firms that resulted is a part of the wider growth of strategic alliances, corporate partnership, joint ventures, spin-offs and spin-outs. Most of these developments involve the participation of one company in the assets and on the board of directors of another. These agreements include producer-supplier relationships, marketing-diffusion relationships, common R&D or product-design projects and new joint ventures (Radtke 1987, p. 97-8). A typology and analysis of the new developments in networking is given by Freeman (1990). He argues that the motives of the firms that enter into co-operative agreements are mainly to secure technological competence, technological complementarity and reduction of lead times. Within networks the innovative power of small firms and their market complementarity are combined with the management and marketing capabilities of larger firms.

As a result, the process of vertical disintegration is thrown into reverse, and the reinforcement of small-firm systems makes the science park a significant part of an innovative local productive system. These networks between science park and other firms, as well as networks between science parks themselves, are important issues for further research. Independently of the theoretical discussion as to whether networks constitute an intermediate situation between markets and hierarchies, they are of direct relevance to the park's management and development policy.

4.4 Evaluation: science parks, R&D and small firms

Any evaluation of science park policy and projects requires an answer to a number of questions concerning the effectiveness of technology transfer, the success of small high-tech firms and the contribution of science parks to the technological restructuring of industries. At present however there are few assessments of their role.

To assess their contribution to bridging the gap between R&D and industry, the UKSPA commissioned a survey of 284 high-technology firms on and off science parks (Monck *et al.* 1988). More than 50 per cent of all firms located on UK science park were interviewed, and the findings were compared with those for firms in similar sectors but located off a park in order to identify the 'added value' of the science parks. The survey considered: the characteristics of the individuals who have established high technology firms; the technological level of the firms; their performance and impact; and their management and financing. To evaluate the impact of the UK science parks six criteria were retained: gross job creation; deadweight; displacement; technology diffusion effects; demonstration effects; and multiplier effects. There is evidence that science parks provide business and financial support services of significant value to tenants, that the presence of the parks has provided a major stimulus to academics starting their own business, that the parks increase informal relationships between the universities and firms and that they may have a considerable long-term impact on the attitudes of young scientists toward business (ibid. pp. 239-45). The study concludes (ibid., p. 245):

There can therefore be little doubt that there have been benefits from the development of Science Parks, but it is vital that these are fully appreciated by all parties involved, and that important new steps are taken to exploit their full potential.

Van Dierdonck, Debackere and Rappa (1991) surveyed the total firm population in eight Belgian and three Dutch science parks — 208 firms in total — to see how science parks contribute to the diffusion of technological knowledge. The authors claim that their findings do not provide grounds for much optimism, that the character of the R&D environment on most of the science parks studied is limited and that science parks are not necessarily the most effective path for involvement in industrial science and technology (Van Dierdonck *et al.* 1991, pp. 120-2). This assessment is partly due, however, to misplaced comparisons of the Belgian and Dutch science parks with regions like Silicon Valley and Route 128 in the United States (ibid, p. 122). However it also identifies some major methodological problems in science park evaluation.

A study of science parks in Belgium, Germany, France, Italy, The Netherlands, Spain and the UK (Komninos *et al.* 1990) highlighted a number of critical issues concerning science park development, planning and evaluation. First, the term covers quite different situations: small incubator business centres, technology transfer parks, and high-technology industrial parks. In particular it is important to differentiate parks whose dominant function is to provide a rich technological environment from those which are simply sites even for high-technology firms. At present, a major problem is the tension between the role of science parks as technological environments for technology-based firms and as high-technology industrial areas. The difference between science parks and industrial zones is not always clear, even for science park managers and developers. However, the objective of science parks is not to replace industrial zones, as the aim is to provide an environment with specific resources for high-technology firms (venture capital, production information and management services as Figure 4.1 shows) rather than to offer land, infrastructures and external economies of scale.

Second, while some parks succeed, others fail. For every science park it is important to examine the extent to which there is or is not a growth of networking activity between research and industry. To call an area a science park does not mean that a technology transfer environment has been automatically created. Science parks fail either because the assessment of the local market potential of the park's property and non-property services was misguided, or because the conditions for local innovative growth were not appropriate. The poor performance, for example, of science parks in northern England has to be attributed to trends in regional development rather than to the character of the parks involved. The survey did, however, lead to the identification of two factors which are critical for the development of science parks: their regional context and their sectoral specialisation. The performance of parks which are located in fast-growing areas is better than that of those located in old industrial areas. The parks which are specialised in electronics grow faster than those specialised in other industries.

Third, every science park must be considered as a single project and as an outcome of a planning process. There are analytical guidelines for science-park planning. These guidelines concern the background analysis, the market analysis, the strategy to follow, the development plan and the implementation plan (see CEC-DG XIII 1991). Consequently, in any evaluation, account must be taken of: (1) the objectives of the project; (2) the type of park involved, and whether it is to provide a technology transfer environment or just premises for high-technology activities; and (3) the regional development context and technology transfer processes. Any appraisal of the 'added value' of science parks must take into account the differences between the projects and the partners involved. The evaluation of science parks is at the same time an appraisal of a local strategy for the development of small technology-based firms, spin-offs and innovative local growth.

Science parks, incubator environments and links with universities may be good solutions to the difficulties of reconciling R&D with small firms. What they offer is an emphasis on local production networks, synergies and linkages with external sources of scientific and technical information and advice. In the long term the stimulus they give to the development of new companies able to exploit new markets or to introduce new systems and products may help widen the local productive system and improve local innovativeness and adaptability. An appraisal of their long-term impact must be placed however in the framework of the fragmentation of large groups and companies — reflected, for example, in the recent proposals to transform IBM into a federation of competing companies — and the development of networking strategies (see Mansel 1991; Freeman 1990) by larger firms. The critical issue is whether or not they help consolidate the position of small independent R&D-intensive firms and therefore whether or not technology-transfer processes come to count for more than property and land speculation.

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