Technopoles: research, innovation and skills in comparative perspective

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1.1 Technopoles, innovations and new technologies

Technopoles are localised complexes of high technology and innovation-intensive activities and are seen as one of the spatial expressions of the development of the critical new technologies of the information age. In the geographical and regional development literature these innovations are often interpreted on the lines of the views of Schumpeter as the sources of a new Kondratieff upswing. In a phase of stagnation and slower growth at the end of the golden age of the postwar years a cluster of innovations (new goods, new methods of production, new markets, new sources of raw materials and new methods of industrial organisation) offers monopoly profits. These innovations then attract imitators and improvers and lead to the emergence and rapid expansion of new industries. In a wave of entrepreneurial fever the innovations diffuse, the demand for related goods and services increases, and incomes increase in a wave of expansion- though surplus profits disappear due to increased competition.

There is however another neo-Schumpeterian explanation put forward by Freeman, Clark and Soete (1982). What they proposed was a different causal explanation. In the first place it is not the number of separate innovations that matters but the interrelationships of innovations in technological systems that involve substantial inter-product and inter-process linkages. Several kinds of innovation can be identified (see Freeman 1988: pp. 9-11). Incremental innovations which produce a continuous flow of modifications to existing products and processes can be differentiated from radical innovations which involve qualitative shifts: examples of the latter include the development of nuclear reactors for electricity generation or the changeover

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from cotton to nylon. Incremental and radical innovations can occur in relative isolation. But where a constellation of technically and economically interrelated radical innovations that affect whole industrial sectors occurs, Freeman speaks of a change in a 'technology system', and where changes in technology systems have pervasive effects on the whole of economic life and involve major changes in the capital stock and skill profile of the population, following Perez, he speaks of new 'techno-economic paradigms'. A new techno-economic paradigm is a set of best practice rules and methods chosen from a range of technically feasible combinations of innovations. The diffusion of steam and electric power are historical examples, and innovations in microelectronics, computers and telecommunications a contemporary one. Second it is the existence of clusters in the diffusion of innovations rather than clusters of innovations that is the critical cause of the upswing.

These ideas do offer significant insights into the development of capitalist societies. It leads to an interpretation of the postwar boom, for example, as 'the simultaneous explosive growth of several major new technologies and industries, particularly electronics, synthetic materials, drugs, oil and petro-chemicals, and (especially in Europe and Japan) consumer durables and vehicles' (Freeman, Clark and Soete 1982: p. 20), and to the view that one of the central factors shaping the events of the 1970s and 1980s is the development of information and communications technologies. At the same time the causal connections between technical change, structural change and economic growth help explain employment change at national and regional levels.

There is however a need to explain why new products and processes and new technology systems emerge at particular moments, why a new set of innovations do not occur as soon as a technological system matures, and why structural adjustment is so drawn out. Indeed one of the central difficulties with Schumpeter's concept of creative destruction is that it implies that the devaluation of old industries and products and a wave of investments of new technical and organisational innovations is automatic: a 'hidden hand' will lead to a way out of the crisis. The radical uncertainties that actors face at present, as well as the experience of earlier crises suggest that the situation is far more complex.

To start to develop answers to some of these questions Freeman and

Perez have argued that in years of crisis there is a mismatch between new technological developments and institutional and social structures (skill structures, management practices, industrial relations and so on). The extent of the mismatch differs from one nation to another, with the result that some economies are far more successful than others. What this perspective suggests is that attention should be paid to comparative analyses of the institutional conditions in which inventions and research and development occur and to the success of different institutional conditions in stimulating the diffusion of technologies.

It seems to me that technopoles can be analysed in similar ways. Technopoles are clusters of innovative activities and spatial expressions of processes of innovation but their dynamism and the dynamism of the territories of which they are a part depend upon the strength of their innovative activities and their success in the diffusion of innovations into the economies that surround them. At this point however it is important to make two distinctions. A set of innovative activities could prove dynamic because of their success in attracting resources: one could create cathedrals in the desert simply by concentrating resources upon a few advanced activities. Attention should therefore also be paid to the extent to which the resources devoted to innovative activities are translated into a flow of innovations. A distinction should be made in other words between resource inputs and the output of innovations. There is however a second distinction between outputs which create localised opportunities for monopoly profits and innovations which are systemic and whose diffusion creates added value in a wide range of activities.[1]

The resource inputs into technopoles, their success in the translation of inputs into outputs and the extent to which the outputs are systemic in character and are diffused depend however on their institutional setting and on the social relations that characterise them.

1.2 Technopoles: activities, spaces and social relations

A technopole is made up of a set of productive and periproductive activities and a stock of often dedicated buildings and infrastructures. It is therefore helpful to think of them as spatial systems that involve two elements:

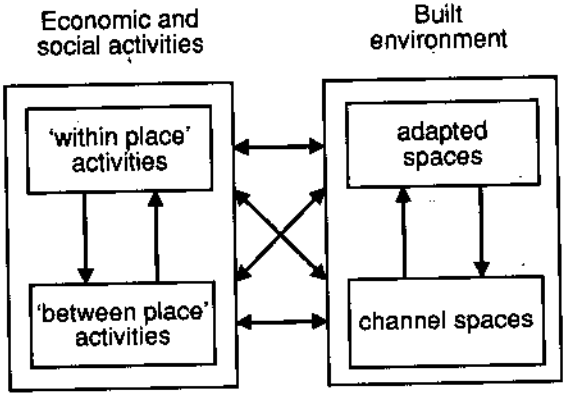
- 'within-place' economic (productive and periproductive)

activities and 'between-place' exchanges, movements, communications and logistic operations. These activities cluster together in part because the existence of similar locational requirements (labour market requirements and infrastructural conditions). Colocation may also stem however from the fact that different establishments are connected with one another in a social division of labour and the consequent existence of synergies, external economies and economies of geographical proximity; and

- a built environment made up of 'adapted spaces' (buildings adapted for particular uses) and 'channel spaces' (networks for the transport of people and goods, computer and telecommunication networks for the transmission of information, and networks for the distribution of water, gas and so on)

Technopoles can therefore be interpreted in the same way as other urban structures (See Figure 1) as the outcome of a two groups of

Figure 1:
The Urban and Regional Systems



processes: one creates physical infrastructures and other built forms; and the other allocates activities to specific sites on the other.

There is therefore a need to consider the property development side of high-tech activities as Malézieux (1991) does in his account of the development of new industrial spaces in the Paris region. Malézieux shows how image-conscious zones of multi-purpose developments were established at nodes of the region's communications networks. At first these zones were set up in line with demand in areas designated for these uses in structure plans. However from the mid-1980s, supply-side factors assumed a leading role, supply started to exceed demand, and a whole series of imbalances were created between the development of economic activities zones and infrastructural provision. Several factors explain these changes: controls were relaxed, competition amongst local authorities increased, and an industrial property development system assumed the leading role. In short there was an absence of adequate planning which led to overproduction and jeopardised the development of zones that were more remote or less well equipped. At the same time imbalances were created between the distribution of economic activities on the one hand and the development of communications and other infrastructures on the other. Congestion and environmental degradation werre among the not-unexpected consequences. What is more where the absence of adequate public action and planning allows unplanned and speculative land development and real-estate processes to unfold a whole series of social costs are generated which may act as a constraint on technopolitan development. In the end *laissez-faire* approaches, speculative and unplanned urbanisation, a lack of investment in social and physical infrastructures, a lack of environmental protection, low taxes and a lack of industrial policies generate, it seems, imbalances and disequilibria that will act as major obstacles to the economic 'success' of those regions that have tied their destinies to them.

In a similar way the character, speed and direction of development of technopolitan activities will depend on the institutional framework and the social relations which shape them. The organisation of work, and the size, structure and interrelationships of industrial firms all vary from one place to another as does the role of the state. New technologies do not impose new sets of social relations. The success of different sets of technological and social choices will however be reflected in unevenness in the character, speed and quality of development, while

what happens in areas that are more dynamic will in the end have an important impact on ones whose growth is slower. What I shall argue however is that in a number of areas relevant to the development of technopoles markets fail and more organised and collaborative relations of partnership are required. Included are the support of research and development, the development of industrial policies, the creation of skills, the relationships among firms and among activities, and the character of the wage relation. The international and interregional differences in these domains can be viewed as elements of different experiments in the construction of new institutional structures and new modes of regulation. A mode of regulation is of course multidimensional: it involves methods of wage and income determination, credit mechanisms, market structures, and so on. In this article only five elements will be considered: the institutionalisation of research and development, state-industry relations, vocational education regimes, inter-firm relations and the wage and employment relations. In each case there is no new hegemonic set of answers Instead there is a series of experiments whose outcomes have yet to be determined.

2.1 The organisation of research and development.

The first technopoles identified were in the United States: Silicon Valley and Route 128 near Boston. These two developments were very large (Chanaron, Perrin and Ruffieux 1988: 7-8). In 1955-84 240,000 jobs were created in Silicon Valley. Another 100,00 were anticipated in 1984-90. The two largest public laboratories Lawrence Berkeley and Livermore employed 3,000 and 7,600 respectively. More than 3,000 firms were created in a 300 hectare area. In scale therefore it is very large (and many times larger than European technopoles). They also received large sums of public money - associated with major national and international civil and military scientific research programmes. In 1984 California received $2.8 billion of the $5.3 billion spent on public research. In Silicon Valley 30,000 researchers and engineers (12.5 per cent of employees) work on space and arms projects. 44 per cent ($32.5 billion over 5 years) of the Star Wars programme was to be spent in California.

In general firms underinvest in R&D because of 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 (Arrow cited in Komninos 1992: p.89). In these conditions private returns lie below social benefits. In high technology sectors the volume of research and development costs is often immense so that the valorisation of these initial outlays requires very high sales volumes: in other words research and development activities are characterised by major economies of scale as the creation of the first product involves a very large fixed cost.

These characteristics of research along with the significance of research for innovation suggest that attention should be paid to different national research frameworks and their impact upon technopolitan development. The organisation of research is very different in the United Kingdom, France and Germany.

- In the UK research policy formation, funding and performance are all dispersed. The principal centres of public sector research are the universities (which are financed by general university funds and five research councils along with charities, other government departments, the EC and industry and where almost all civil public research is done) and defence establishments (responsible for Ministry of Defence but not defence development which is performed by defence firms). There is no single ministry of research.
- In France the situation is almost the mirror image of that in the UK, as there is a strong central ministry for research (Ministère de la recherche et de la technologie), strong central control, and strong public research laboratories (mainly the CNRS but also INRA and INSERM laboratories in which much public research is conducted and which provide research facilities for university teachers for fundamental research and government research laboratories and agencies including those for atomic energy (CEA), space (CNES), telecommunications (CNET) and defence. The support for these establishments reflects the high political priority for science and technology in France. (In recent years attempts have been made to strengthen research in universities and grandes écoles).
- West Germany differs in that the German political system is federal in character. The German research system does however have major features of the French and UK systems,

but much more in addition. On the one hand it has a powerful federal ministry of research (Bundesministerium für Forschung und Technologie) and a whole range of powerful research establishments and institutes (the largely independent Max Planck institutes and large government research centres). On the other it has a dispersed and independent university system whose research is well supported by general university funds from Federal and Land governments and research council (Deutsche Forschungsgemeinschaft) grants. In addition there are the Fraunhofer Institutes for applied research financed by the Fraunhofer Society, government and industry (Atkinson, Rogers and Bond 1990).

Expenditure also varies (see Table 1). The total expenditure on R&D of all types in the UK (£9.7 billion at market exchange rates in 1987/

TABLE 1

R&D expenditure and government budget appropriations in the UK (1987/8), France (1987) and West Germany (1987) in £ billion at market exchange rates

	UK	France	West Germany
Government expenditure	4.12	6.82	7.19
Government civil R&D appropriations[1]	2.40	4.67	6.43
Government defence R&D appropriations[1]	2.23	2.66	0.93
Industry	4.70	5.16	11.57
Total[2]	9.68	12.83	18.36

1. Total budgetary figures differ from the figures for public expenditure given in the first row.

2. The total includes expenditure by government and industry and expenditure aboad.

Source: elaborated from Atkinson, Rogers and Bond 1990, vol. I, pp. 24-26

88) was only about three-quarters of that in France (£12.8 billion in 1987) and half of that in Germany (£19 billion in 1987). The figures for the UK are also less at purchasing power parity exchange rates and as a percentage of GDP. Of UK government expenditure almost one-half is spent on defence. (The public civil budget of Germany is nearly three times as large as that of the UK and the French is twice as large). 83 per cent of UK defence budget is for development: while defence research may have some value for the civil economy defence development does not and yet it accounts for four-fifths of the total. German industry (£11.57 billion) funds much more research than UK industry (£4.7 billion) and French industry (£5.16 billion) (Atkinson, Rogers and Bond 1990).

The central role of research and development expenditure in the development of regional complexes of innovative activities makes these variations in expenditure and the structure of research significant determinants of the size, number and character of UK, French and German technopoles. Variations in the level and composition of expenditure help explain, for example, why the phenomenon is less pervasive in the UK than in France, while the central role of French government research institutes helps explain why the CNRS, CEA, CNET, CNES and similar organisations figure so prominently in the main French technopoles such as the Scientific City south-west of Paris, Grenoble and Toulouse.

These variations are however a result of differences in the quantity of inputs into R&D and not of the quantity and quality of outputs. (There are of course indicators of research output such as the number of patent applications in the US which show US firms losing ground to the Japanese and European firms improving slightly with Germany gaining, Britain losing and France more than holding its own). Moreover the evidence considered does not deal with the conversion of the inventions that result from research into innovations nor with the diffusion and transfer of innovations and the adjustment of skills and working practices which actually lead to productivity growth and increased competitive advantage.

Some attention has however already been paid to the significance of regional innovation and technology transfer systems for regional dynamics. Morgan (1992) has shown for example how German regions have characteristic national advantages in the spheres of education, training, R&D and capital markets. At the heart of the success of some

German regions such as Baden-Württember lies, he argues, its collaborative approach to innovation, with: (1) co-operation between firms in the same sector and between buyers and suppliers; (2) an innovative support infrastructure (with the Steinbeis Foundation for technology advice and transfer, the Chambers of Industry and Commerce for business information, the Fraunhofer Gesellschaft for technical consultancy and the Max-Planck Institutes for fundamental research); and (3) the Land government's tripartite model of collaboration between state, industry and science. Alongside these intra-regional networks the regional authority has helped forge a number of regional alliances of which the most important is the 'Four Motors' network of Baden-Württember, Lombardy, Rhône-Alpes and Catalonia (see Morgan 1992; Dunford 1991). In the French case a co-ordinated national attempt at intra-regional technology transfer was set in motion with the establishment of Regional Innovation and Technology Transfer Centres (CRITT).

2.2 Industrial policy systems and technopoles

A second important determinant of technopolitan development is the scope and character of government industrial policies. As in the case of research and development there are important differences in the character and extent of state intervention in industry. In the US and UK government defence programmes amount to industrial strategies for high-tech industries. Indeed it has been estimated that some 20 per cent of US federal spending ($8000m) goes to electronics, and pays for 35 per cent of electronics sector activities (Stoffaes 1984). In other countries (such as Japan and France) there are active strategic industrial policies for non-defence industries. Indeed a director-general of the Japanese Ministry of International Trade and Industry (MITI) once said that the 'philosophy underlying the industrial policy of Japan is the principle of free competition in the market place'. He nevertheless identified three spheres in which this dictum did not apply: public goods and services, such as social capital and industrial infrastructure; international relations and the environment; and 'achieving optimal resource allocation from a long term dynamic view point'. The identification of the first two areas of state action is characteristic of *laissez-faire* approaches. However his final point

effectively means that while the market is effective as a mechanism of short-run resource allocation and distribution it fails as a mechanism for the organisation of production and long-term modernization (Fukukawa, cited by Freeman 1987: p. 32).)

In mixed and capitalist economies institutional structures and strategies give different weights to interventionist and neo-liberal ideologies and methods. Zysman (1983: pp. 7 and 91-3) has distinguished three technical-political strategies aimed at shaping national development: state-led, market-led, and negotiated tripartite. Variations in the role of the state are a result of a variety of factors including the structure of industry, administrative organisation and the character of the ruling political coalition. Also important, however, are the mechanisms through which money and credit are allocated, as they shape not only corporate strategies but also the capacity of the state to act. According to Zysman (1983: pp. 18 and 55-75) three varieties of financial system can be dentified: a capital market with market determined prices, a credit-based system with critical prices administered by the state, and a credit-based system in which financial institutions are dominant.

Selectivity and discretionary control over the use of credit are essential instruments for a state seeking to guide industrial development (see Zysman 1983: pp. 75-95). Where a capital market dominates state interventionism is likely to find itself blocked. In the second type of financial context, executive discretion is considerable and state-led industrialisation facilitated, while in the third, the state has some discretion through negotiations with institutions supplying industrial credit.

In the German case a negotiated tripartie model goes hand in hand with a credit-based system of industrial finance In the French case the financial system was state-controlled and adjustment state-led. In the UK what predominated was a cosmopolitan capital market and an ambiguous industrial development mechanism. Attempts by UK governments to establish an interventionist framework and to shape industrial adjustment were unable to overcome the obstacles the financial system placed across the path of interventionism. Since 1979, however, a market-driven path consistent with the character of the country's financial mechanisms and the strength of rentier interests has been followed.

Over and above these differences which are rooted in the

differences in economic structures, political frameworks, and hegemonic blocs there are common elements rooted in mode of operation of capitalist societies. In particular in all epochs of crisis capitalist entrepreneurs seek more fluid ways of holding money wealth, while indirect costs associated with land and other kinds of speculation increase. In the 1960s the share of banking capital in value added increased, as did rentier incomes. In the 1970s the concepts of an aggressively assertive economic liberalism and of rentier perspectives, which reflected the interests in particular of the holders of money capital, gained ground, and in some nations achieved a hegemonic role. The ascendancy of these concepts was however not just a result of the increasing weight of their usual advocates such as commercial capitalists and financiers, owners of small enterprises, and individuals with incomes made up of interest, rents and dividends (van der Pijl 1984: pp. 8-20). Owing to the difficulties of accumulation the concepts of economic liberalism also gained ground in the ranks of industrial capitalists. The differences between the German, French and UK cases (and indeed between different places in these countries for the relative weight of rentier and productivist ideolgies also depends on the relative weights of productive, financial, commercial and landed strata in different cities and regions) are therefore differences of degree and in the relative weight of different social classes rather than differences of kind.

These distinctions nevertheless play an important role in explaining the differences observed in the development of the UK and French high-tech industries. Successive French governments have adopted strategic plans for the national electronics sector (see Table 2), and these actions have played a major role in the development of French technopoles. On the one hand strategic plans (Plan Composants, the plans to develop a filière électronique in the early 1980s and so on) have provided resources that have fuelled technopolitan growth. On the other the existence of regional professional interests permitted local responses to these initiatives.[2] In the case of the UK the attempts at intervention in the 1960s and especially in the 1970s through the medium of the National Enterprise Board gave way to disengagement in the 1980s (see Table 2) - ending with the sale of INMOS to SGS-Thomson - and a very strong emphasis on the attraction of inward investment which itself is an important determinant of the different character of high-tech development in the UK.

TABLE 2

State intervention: aid for and reorganisations of the French, German and UK electronics sectors.

France							
1968	1970	1973	1975	1978	1978-79	1981-2	1983-4
State fosters SECO (Thomson) and COSEM (CSF) merger to create SECOSEM. Thomson given major state support.	EFCIS created as a joint venture between Thomson and CEA	Creation of UNIDATA (computers) as a joint venture of CII, Siemens and Philips. (Government attitude uncertain.)	UNIDATA fails. State supports merger of CII and Honeywell-Bull.	Thomson takes over semiconductor division of LTI and SILEC.	State supports joint ventures of Saint-Gobain and National Semiconductor, Matra and Harris, Thomson and Motorola, Saint-Gobain enter CII and Olivetti. Support for RadioTechnique (Philips.) 5 poles of production.	CGE, Thomson, Saint-Gobain, CII-HB (named Bull) nationalised. Majority government stake in Matra.	Concentration of Thomson, Saint-Gobain and CGE's computer activities with Bull. Thomson takes over Saint-Gobain/ National Semiconductor joint venture (Eurotechnique) and semiconductor activities of CGE. Of 5 poles only two remain. Saint-Gobain withdraws from Olivetti. CGE takes 10% share in Olivetti.
Federal Republic of Germany							
	1970	1973	1975	1978-79	1979-80	1983	1984
	Creation of DATEL. Joint venture of state, Siemens, AEG-Telefunken and Nixdorf in computer applications.	Creation of UNIDATA. State in favour.	Siemens takes over large computer division of AEG. Approved by state.	Rescue of AEG-Telefunken by a joint consortium of banks. Indirect Federal support.	Plans for the establishment of a joint research laboratory of the 3 major firms and public agencies (Berlin Synchrotron Projekt.)	Semiconductor division of AEG merged with Mostek (United technologies) in a joint venture. Telefunken taken over by Thomson.	Joint research in Germany of ICL, Siemens and Bull in computers and IT. Philipps takes over Grundig after Bundeskartelamt's disapproval of Thomson's bid.
United Kingdom							
1968			1976-8	1978	1980		1984
Mullard (Philips) takes over its joint venture with GEC. Series of mergers results in ICL 10.5% state-owned.			NEB buys shares in Ferranti (computers, semiconductors, defence electronics) and in various small and medium-sized firms in software, industrial and consumer electronics.	NEB creates INMOS (VLSI memories and MPUs.) Wholly financed by state.	Conservative government sells ICL and Ferranti to private sector.		State sells its 75% share in INMOS to Thorn-EMI. STC (25% owned by ITT) tries to acquire ICL.

Source: data for 1968-80 from Dosi 1981, p. 94 updated.

2.3 Technopoles and education and training

The position of a society in wider divisions of labour, the diffusion of innovations and its development potential depend also on its skills and human resources. Skills are not, however, an independent variable but stand in a reciprocal relationship with other economic decisions. Whether new technologies are used for diversified high-quality production or rationalised mass production depends, for example, on the skill profile of the population, while a society associated with high skill levels will tend to have high wages, a relatively even distribution of income, relatively equal life chances and an effective social welfare system.

In order to provide skills three broad strategies exist. First there are market-oriented approaches in which individual self-interest is relied upon to get individuals to invest the time, effort, and money required for the acquisition of marketable qualifications to which firms can add job specific skills. A second approach is centred on the view that work and learning should occur in conjunction with one another and involves the social imposition and regulation of vocational training schemes agreed in tripartite negotiations. The German vocational training schemes are an example of this approach. Third vocational education can be provided by the state. In the French case, for example, most engineering training is provided in publicly funded vocational schools (or lycees professionnels), and with the exception of a small number of apprenticeships decisions about the provision of places are made by the Ministry of Education.

Skills and training comprise another area in which unregulated market mechanisms are, in fact, self-destroying and under-developing. High skills are a collective resource whose existence is a precondition for productive activities whether public or private. As Streeck (1987) has shown, however, the provision of skills is subject to a prisoners' dilemma problem where the optimal outcome for all requires co-operative, co-ordinated behaviour of all but where, for individuals, co-operation is too risky and the potential rewards of non-co-operation are too great.

The prisoners' dilemma is a classic example of a two-person non-constant sum game. The payoff matrix adapted to a consideration of a situation in which firms are deciding whether to train or not instead of the classic situation - in which two prisoners must decide whether

to confess or not to a crime where there is insufficient evidence for a conviction unless one of the prisoners turns state's evidence - is set out in Table 3. The first figure in each cell is the financial gain for firm 1 and the second is the payoff for firm 2. In this game there is a unique equilibrium where each firm chooses not to trainand receives a payoff of two units each. Neither of the other strategies is an equilibrium for if one firm trains or is expected to train it is in the interest of the other not to train and to poach its rival's workers, while if one firm does not train the optimal strategy for the other is not to train either lest it lose the workers it trains to its competitor. The critical feature of this game is that the equilibrium outcome is worse for both players than a joint strategy in which both agree to train. The optimal solution is to agree on and enforce a joint strategy as co-operation increases the welfare of all players. The need for enforcement is however critical for the two players play the game independently and even if they agree on a joint strategy it is still in their individual interests to break the agreement.

As a result, therefore, of the existence of a free contract job market

TABLE 3
The skills' dilemma

		Firm 2	
		Not-train	Train
Firm 1	Not-train	(2,2)	(10,1)
	Train	(1,10)	(5,5)

firms invest less in training than is in their own interest. The reason why is that skills are a collective resource. A firm's investment adds therefore to a pool of skills on which others, including its competitors, can draw. Various factors qualify this situation, but in general firms tend to provide firm-specific skills. Transferable and non-transferable skills are however interdependent, and so a firm that confines itself to the creation of non-transferable skills will under-develop them. Knowledge also, on which a more active involvement of workers depends, is kept from them in part for similar reasons. A market-oriented approach which is weak in creating dedicated skills will, concludes Streeck, fall far short if it is asked to create skills as cultural

resources which will appear to rational decision-makers as excessive qualifications. Yet the central role of generalised and polyvalent skills and the need for skills that can be used in as yet unknown ways transform skills into cultural resources of central importance.

The self-interest of firms on which market models rest cannot therefore be relied upon to achieve the desired results. Nor will the self interest of individuals lead them to choose to acquire the required skills not just because of the inappropriateness of financial rewards but because of market failure. The reason why is that individuals acquire fundamental skills when they are young and when they are least able to accept the long deferral of gratification that is the essence of an investment, since it presupposes certainty about what one will value in the years to come, and this certainty is itself a product of an individual's social and personal identity which in young people is in a process of formation. Young people whose personal identity has not yet been formed lack 'the crucial properties and capacities needed for rational decision-making of a neoclassical kind' (Streeck 1987).

The alternative approach that Streeck favours involves a reintegration of learning and work, a treatment of learning as socialisation and as an obligation, and the social regulation of firms. In the view of Streeck enterprises in the West as in the East should be places of learning as well as places of production. But if the acquisition and development of skills can only occur in conjunction with work within the firm, and if the firm does not have the rational motivation to fulfil this role of its own accord, regulation, of the kind embodied in the West German vocational training system, is required.

Skill shortages exist in all societies but are most acute in the US and UK where market models prevail. In West Germany and in Japan with their community and corporate institutions shortages are less severe, as they are in France where state intervention is the order of the day.

In a recent study Ray (1988) pointed out substantial differences in the training and roles of electrical (and mechanical) craft workers and technicians in France and Britain. Over three-quarters of French electricians hold the equivalent of a City and Guilds Part II certificate or better compared with 44 per cent in Britain. The most striking differences occur at skilled worker level. What is also important, however, is the fact that in Britain electrical technicians are employed in laboratories, drawing offices and as junior managers whereas their

French counterparts are also employed on the shop-floor in process control and maintenance functions.

In 1984 over four times as many gained craft qualifications in France as in Britain: 32,000 against 7,000. At technician level the French trained nearly half as many again: 14,000 against 9,000. 'France is now level with Germany in numbers of craftsmen trained each year in electrical work, (while ... France trains only half as many mechanical craftsmen as Germany) ... In 1975 Britain trained around half as many as France to craft and technician standards ... [In 1975-82 the rate of expansion was similar in the two countries] ... By 1987, despite the financial support provided to apprentice training by the YTS subsidy, numbers qualifying in Britain were 60 per cent below the peak of 1982, having declined even more sharply than employment in the industry' (Ray 1988: pp. 64-5). In 1987 the French lead had increased from a factor of two to a factor of three: the French trained three times as many qualified craftsmen as Britain to standards which are as high and often higher than equivalent British qualifications.

Skill requirements interact with the volume of employment and the profile of jobs: the evidence on skill structures seems to indicate significant differences in the quality of jobs, in the character of the work relationships and in the potential for development different European countries.

2.4 Technopoles and inter-firm relations (inter-firm relations, firm-financial institution relations)

Another characteristic of the new industrial order is the development of networks as a third form of governance alongside markets and hierarchies: for certain activities network structures - designed to secure new forms of integration/synergy within and between firms can overcome the rigidities of the vertically-integrated hierarchy on the one hand and market imperfections on the other. In a network mode of resource allocation transactions occur through networks 'of individuals or institutions engaged in reciprocal, preferential [and] mutually-supportive actions [... where the] parties are mutually dependent upon resources controlled by another, and [... where] there are gains to be had by the pooling of resources' (Powell, cited in Morgan 1992).

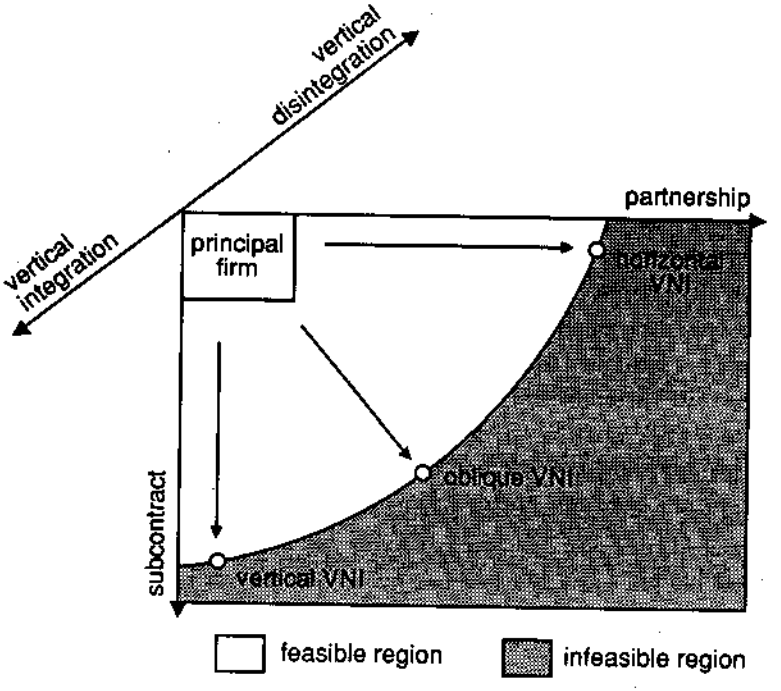
Within firms shorter product life cycles, a need to speed up the commercialization of R&D and accelerate its amortization or amortise

it over a sequence of products create strong incentives to create intra-firm synergies and integrate the value added chain within the firm from R&D through production and marketing to after-sales support. At an inter-firm level network modes of economic organisation are associated with strategic alliances, joint-ventures, producer-user and producer-supplier relationships. As Morgan shows direct and regular producer-user contacts improve the transfer of information and knowledge and allow the capture of learning-by-using effects. At the same time total quality control and integration of the value-added chain involves the establishment of complete supply chains (first-, second- and third-tier suppliers) committed to zero defect objectives. The advantages of this type of strategy are among the factors that lie behind the development of strategies of longer-term and more co-operative relationships of producers with their (core) suppliers variously called collaborative manufacturing, co-makership and upstream management.

Strategies of this kind are however not easy to develop in market environments in which there are always short-term gains to be made from opportunistic behaviour. Strong producer-user and producer-supplier linkages have been one of the defining features of the Japanese, German and Swedish economies. What the relative success of these economies shows therefore is the possibility of success in situations where these strategies are adopted.

The development network structures is associated with strategies of vertical-near integration or vertical near-disintegration. With their development power relations do not disappear. Indeed the networks vary in character and in the degree of asymmetry in the relationships between participants. As Leborgne and Lipietz (1990) have shown near-integration can assume several forms from vertical subcontract relations to horizontal partnerships and strategic alliances, with intermediate oblique variants of near-integration (see Figure 2). In each case the network of relations among firms can be either territorially dense, as some authors anticipate, or territorially disintegrated. While progressive network structures do make for successful firms and economies, there is no guarantee that progressive network structures will win out. The identification of successful network strategies does however help inform discussions of regional development strategies.

Figure 2:
Strategies of integration



2.5 Technopoles, industrial relations and work organisation

There are a number of ways in which systems of industrial relations shape the development of technopoles. To cite just one example consider the question of the extent of horizontal relationships within enterprises. Throughout the post war era there was usually a division between R&D, production and marketing. Often there was a geographical division between them. Always ther was a cultural and social division. (This divide date from the development of electric power when separate R&D departments were established in electrical engineering and chemicals companies. It spread from US and German electrical and chemical firms to the rest of world shaping the possibilities of product and process innovation. The Japanese on the other hand sought to reintegrate mental and manual work and to reintegrate R&D, production and marketing. In electronics Japanese firms' R&D departments regard the factory as a laboratory: products cannot be redesigned without the help of processes. This reintegration

of formerly separate jobs plays a major role in the diffusion of innovations as diffusion requires scientific and technical competence, creativity, learning by using and learning by doing. It is the fact that technopoles rest on the division of these tasks - to the extent of excluding all stages beyond the design of prototypes either through rules of membership or through their effect on land values - that lies, in the view of some critics, at the root of their limited impact on the wider regional economies in which they are situated. At the same time, however, there is some evidence of differences in the speed of diffusion of key processes in a number of different countries in the 1960s to the 1980s (Ray 1984). As far as the countries considered in this article are concerned one of the main findings was that the UK was often one of the first countries to introduce an innovation yet often the last to diffuse it through the potential population of adopters. Swedish, German and Japanese firms, in which there is a closer integration of mental and manual work, were on the other hand the quickest to diffuse innovations through entire industries.

3 Conclusion

In this article I have argued that the dynamics of technopoles and the speed and character of the diffusion of innovations which underpin competitive advantage depend upon investments in research and development, the character of strategic industrial polices aimed at the support and diffusion of advanced technologies, investment in education and skills, the development of network structures to secure new forms of partnership and of integration/synergy within and between firms and the character of systems of industrial relations. In all of these areas there are situations in which markets fail and where collaboration has advantages over competition. The extent and the way in which national and regional economies and societies seek to adapt to these challenges and the modes of regulation they choose differ, and it is these variations that help explain the comparative dynamics of technopoles and the success of innovation diffusion. These factors are not however mutually independent. To be effective strategies with respect to technology must be intimately related with industrial policies and training policies for there are significant interdependencies between them.

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1. This consern with diffusion leads to an important distincion between science parks which have very modest effects on local and regional industrial development and projects whose central goal is the diffusion of new technologies into local economic activities. Oulu University in Finland is an example of the latter. Situated in the centre of an area of forests, mining, and chemicals and metals, a decision was made to develop electrical engineering as a priority sector and a public applied electronics research institute was set up. An attemp was made to link these initiatives and to concentrate electronics on local industries. Graduates got jobs in local industries, and the instrumentation of these industries proved an important source of local employment, while the industries themselves were very successful.

2. See, for example, the very interesting discussion by Rousier (1992) of the way in which the development of engineering education, research-industry relations and international collaboration in Grenoble contributed to the creation of a local scientific and technical culture. The existence of this professional structure allowed Grenoble to respond for example to the national programme to develop a filiere électronique in the early 1980s and to develop a White Paper on electronics in Grenoble (Groupe de reflexion sur le Developpment de l' Electronique dans la Région Grenobloise 1982).

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Τεχνοπόλεις: Συγκριτική εξέταση της Ερευνας, της Καινοτομίας, και των Ειδικεύσεων

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Οι τεχνοπόλεις αποτελούν χωρικά συμπλέγματα δραστηριοτήτων υψηλής τεχνολογίας καινοτομικού χαρακτήρα και θεωρούνται ως μια από τις χωρικές μορφές της ανάπτυξης των τεχνολογιών αιχμής της πληροφορικής εποχής. Σε περιόδους κρίσης παρατηρούνται ασυμμετρίες ανάμεσα στις νέες τεχνολογικές εξελίξεις και στις θεσμικές και κοινωνικές δομές (ειδικότητες, διαχειριστικές πρακτικές, εργασιακές σχέσεις, κλπ.). Η έκταση της ασυμμετρίας διαφέρει από χώρα σε χώρα και από περιοχή σε περιοχή, με αποτέλεσμα κάποιες οικονομίες να είναι πολύ περισσότερο πετυχημένες από αλλες. Το γεγονός αυτό υποδεικνύει ότι θα πρέπει να εξεταστούν σύγκριτικά οι θεσμικές προυποθέσεις στα πλαίσια των οποίων συντελούνται η Ερευνα και Ανάπτυξη και οι καινοτομίες και η ικανότητα διαφορετικών συνθηκών στην προώθηση και διάδοση της τεχνολογίας. Ετσι ο δυναμισμός των τεχνοπόλεων και των περιοχών στις οποίες ανήκουν εξαρτάται από την ισχύ των καινοτομικών δραστηριοτήτων και την επιτυχή διάχυση τους στην περιβάλλουσα τοπική οικονομία.

Στο σημείο αυτό απαιτούνται δύο διευκρινίσεις. Ενα σύνολο καινοτομικών δραστηριοτήτων μπορεί να αποδειχθεί δυναμικό λόγω της έλξης πόρων: μπορεί δηλαδή κανείς να δημιουργήσει "καθεδρικούς ναούς στην έρημο" απλά συγκεντρώνοντας πόρους σε λίγες προωθημένες δραστηριότητες. Πρέπει εδώ να εξεταστεί αν οι πόροι που διοχετεύονται στις καινοτομικές δραστηριότητες μπορούν να μεταφραστούν σε μια ροή καινοτομιών. Είναι λοιπόν αναγκαίο να διαχωριστεί η εισροή των πόρων από την εκροή των καινοτομιών. Υπάρχει όμως και μια δεύτερη διάκριση ανάμεσα σε εκροές οι οποίες δημιουργούν τοπικά ευκαιρίες για μονοπωλιακά κέρδη και σε καινοτομίες οι οποίες έχοντας συστημικό χαρακτήρα δημιουργούν προστιθέμενη αξία σε ένα ευρύ φάσμα δραστηριοτήτων. Από αυτή την άποψη, η ταχύτητα και ο προσανατολισμός των καινοτομικών δραστηριοτήτων εξαρτώνται από το θεσμικό πλαίσιο και τις κοινωνικές σχέσεις. Η οργάνωση εργασίας, το μέγεθος, η δομή

και οι διασυνδέσεις των επιχειρήσεων διαφέρουν από περιοχή σε περιοχή καθώς επίσης και ο ρόλος του κράτους. Οι νέες τεχνολογίες δεν επιβάλλουν τους νέους τρόπους κοινωνικών σχέσεων. Η επιτυχία διαφορετικών τεχνολογικών και κοινωνικών επιλογών αντανακλάται άνισα στο χαρακτήρα, την ταχύτητα και την ποιότητα της ανάπτυξης, ενώ ότι συμβαίνει στις πιό δυναμικές περιοχές έχει επιπτώσεις στις περιοχες χαμηλών ρυθμών ανάπτυξης.

Εκείνο που θέλω να τονίσω είναι ότι σε ορισμένες περιοχές οι οποίες συνδέονται με την ανάπτυξη τεχνοπόλεων, η αγορά αποτυγχάνει καθώς απαιτούνται περισσότερο οργανωμένες και συλλογικές σχέσεις συνεργασίας. Εδώ περιλαμβάνονται η υποστήριξη της Ερευνας και Ανάπτυξης, η εφαρμογή βιομηχανικής πολιτικής, η δημιουργία δεξιοτήτων, οι διασυνδέσεις ανάμεσα στις επιχειρήσεις και δραστηριότητες και ο χαρακτήρας των μισθωτών σχέσεων εργασίας. Οι διεθνείς και διαπεριφερειακές διαφορές αυτών των συνιστωσών μπορούν να θεωρηθούν ως στοιχεία διαφορετικών πειραματισμών για την κατασκευή νέων θεσμικών δομών και νέων τρόπων ρύθμισης. Ενας τρόπος ρύθμισης είναι φυσικά πολυδιάστατος: περιλαμβάνει μεθόδους προσδιορισμού μισθών και εισοδημάτων, πιστωτικούς μηχανισμούς, δομές αγοράς, κλπ. Στο άρθρο εξετάζονται αναλυτικά πέντε στοιχεία: η θεσμοποίηση της Ερευνας και Ανάπτυξης, οι σχέσεις κράτους-βιομηχανίας, οι τρόποι επαγγελματικής εκπαίδευσης, οι διεπιχειρησιακές σχέσεις και οι μισθωτές σχέσεις εργασίας. Σε καμμία περίπτωση δεν υφίσταται ένα νέο ηγεμονικό σύνολο απαντήσεων. Αντίθετα υπάρχει μια σειρά πειραματισμών με απροσδιόριστα ακόμα αποτελέσματα.

Ο κεντρικός ρόλος των δαπανών για Ερευνα και Ανάπτυξη στην ανάπτυξη περιφερειακών συμπλεγμάτων καινοτομικών δραστηριοτήτων καθιστά το ύψος των δαπανών και τον προσανατολισμό της έρευνας σημαντικές παραμέτρους του μεγέθους, του χαρακτήρα και του αριθμού των τεχνοπόλεων στη Γαλλία, τη Γερμανία και το Ενωμένο Βασίλειο. Μερικές από αυτές τις διαφορές είναι ιδιαίτερα έντονες. Από τη μια πλευρά η οργάνωση της έρευνας είναι πολύ διαφορετική σε κάθε χώρα. Από την άλλη διαφέρουν οι δαπάνες. Στο Ενωμένο Βασίλειο η συνολική δαπάνη για E&A (£9,7 δισ. με τιμές αγοράς το 1987/88) ήταν περίπου στα 3/4 της αντίστοιχης δαπάνης στην Γαλλία (£12,8 δισ. το 1987) και το 1/2 της Γερμανίας (£19 δισ. το 1987). Διαφορές στο επίπεδο και τη σύνθεση των δαπανών μπορούν να εξηγήσουν, για παράδειγμα, το γιατί οι τεχνοπόλεις είναι λιγότερο διαδεδομένες στο Ενωμένο Βασίλειο από ότι στη Γαλλία, ενώ ο κεντρικός ρόλος των κρατικών ερευνητικών κέντρων στη Γαλλία εξηγεί το γιατί τα CNRS, CEA, CNET, CNES και

άλλα παρόμοια ιδρύματα προσδάλλονται στις κυριότερες Γαλλικές τεχνοπόλεις όπως στην Επιστημονική Πόλη νοτιο-δυτικά του Παρισιού, τη Γκρενόμπλ και την Τουλούζ.

Μια δεύτερη κεντρική συνιστώσα της ανάπτυξης τεχνοπόλεων είναι ο σκοπός και ο χαρακτήρας της βιομηχανικής πολιτικής η οποία ανταποκρίνεται στο γεγονός ότι η αγορά είναι αδύναμη απέναντι στην επίτευξη βέλτιστης κατανομής των πόρων σε μακροπρόθεσμη δυναμική προοπτική. Σύμφωνα με τον Zysman προσδιορίζονται τρεις τεχνικές και πολιτικές στρατηγικές με στόχο την εθνική ανάπτυξη: μέσω της κρατικής παρέμβασης, μέσω της αγοράς και μέσω της τριμερούς διαπραγμάτευσης. Διαφορές στον ρόλο του κράτους συνδέονται με διαφορές στους μηχανισμούς μέσω των οποίων το χρήμα και οι πιστώσεις κατανέμονται και διαμορφώνουν όχι μόνο τις στρατηγικές των επιχειρήσεων αλλά και την ικανότητα του κράτους να δράσει. Τρεις παραλλαγές του χρηματοδοτικού συστήματος μπορούν να προσδιοριστούν: η αγορά κεφαλαίου με τιμές που προσδιορίζονται στην αγορά, το πιστωτικό σύστημα με κρατικά διευθυνόμενες τιμές, και ένα πιστωτικό σύστημα όπου κυριαρχούν τα χρηματοδοτικά ιδρύματα. Τα διαφορετικά αυτά συστήματα έχουν σημαντικότατες επιπτώσεις πάνω στην ανάπτυξη των τεχνοπόλεων.

Η θέση μιας κοινωνίας στην ευρύτερη διαίρεση της εργασίας, η διάχυση των καινοτομιών και οι δυνατότητες ανάπτυξης τους εξαρτώνται επίσης από το ανθρώπινο δυναμικό και τις υπάρχουσες δεξιότητες. Οι δεξιότητες και η κατάρτιση αποτελούν μια περιοχή όπου οι μηχανισμοί της αγοράς είναι πρακτικά αυτοκαταστροφικοί και λειτουργούν αρνητικά λόγω της ύπαρξης ενός τύπου "διλήμματος του φυλακισμένου". Ελλείψεις δεξιοτήτων υπάρχουν σε όλες τις κοινωνίες αλλά είναι περισσότερο έντονες στις Ηνωμένες Πολιτείες και το Ηνωμένο Βασίλειο όπου επικρατούν τα μοντέλα αγοράς. Στη Δυτική Γερμανία και την Ιαπωνία με τις κοινοτικές και κορπορατίστικες παραδόσεις οι ελλείψεις είναι λιγότερο σοβαρές, όπως και στη Γαλλία όπου η κρατική παρέμβαση είναι έντονη.

Ενα άλλο χαρακτηριστικό της νέας βιομηχανικής τάξης είναι η ανάπτυξη δικτύων ως ενδιάμεση μορφή διοίκησης ανάμεσα στην αγορά και την ιεραρχία: για ορισμένες δραστηριότητες τα δίκτυα, σχεδιασμένα έτσι ώστε να εξασφαλίζουν νέες μορφές ολοκλήρωσης/συνέργειας ανάμεσα στις επιχειρήσεις μπορούν να υπερβούν τόσο τις ακαμψίες των καθετοποιημένων ιεραρχιών όσο και τις ατέλειες της αγοράς. Τα πλεονεκτήματα αυτών των στρατηγικών αποτελούν παράγοντες οι οποίοι βρίσκονται πίσω από την ανάπτυξη περισσότερο μακροπρόθεσμων

σχέσεων συνεργασίας ανάμεσα σε παραγωγούς και βασικούς προμηθευτές, στα πλαίσια μεθόδων γνωστών ως συμπαραγωγή και συνολική ως προς τις πηγές διαχείριση.

Υπάρχουν τέλος, ορισμένοι τρόποι με τους οποίους τα συστήματα των εργασιακών βιομηχανικών σχέσεων διαμορφώνουν την ανάπτυξη των τεχνοπόλεων και την ταχύτητα διάχυσης της τεχνολογίας. Υπάρχουν κάποιες ενδείξεις για τις διαφορές στην ταχύτητα διάδοσης βασικών διαδικασιών σε διαφορετικές χώρες από τη δεκαετία του 1960 έως τη δεκαετία του 1980. Το Ηνωμένο Βασίλειο για πράδειγμα, ενώ ήταν συχνά από τις πρώτες χώρες στην υιοθέτηση μιας τεχνολογίας, ήταν ανάμεσα στις τελευταίες όσον αφορά τη διάχυση τους στους πιθανούς αποδέκτες. Οι Σουηδικές, Γερμανικές και Ιαπωνικές επιχειρήσεις αντίθετα, όπου υπάρχει στενότερη ολοκλήρωση της διανοητικής και χειρονακτικής εργασίας, αποδεικνύονται ταχύτατες στη διάδοση της καινοτομίας σε ολόκληρο το βιομηχανικό σύστημα. Η ύπαρξη οριζόντιων σχέσεων ανάμεσα στην έρευνα, το σχεδιασμό και την παραγωγή μέσα στις επιχειρήσεις και η επανενσωμάτωση της διανοητικής και χειρονακτικής εργασίας που χαρακτηρίζουν τα Ιαπωνικά, Γερμανικά και Σουηδικά συστήματα βιομηχανικών σχέσεων εξηγούν τις διαφορές στη διάχυση της καινοτομίας, καθώς η διάχυση απαιτεί επιστημονική και τεχνική ικανότητα, δημιουργικότητα, εκμάθηση μέσα από τη χρήση και εμπειρία. Πραγματικά. ακριδώς επειδή οι τεχνοπόλεις στηρίζονται στη διαίρεση των παραπάνω συνιστωσών, σύμφωνα τουλάχιστον με ορισμένους κριτικούς αναλυτές, οι επιπτώσεις τους στις περιδάλλουσες περιφερειακές οικονομίες είναι αναγκαστικά περιορισμένες.