Editorial: global competition of high-tech centres

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Abstract: This article highlights the present state of development of the global competition between high-tech centres. Special attention is paid to science parks as a development policy option and the extent to which this policy has been adapted in the USA and major European and Asian countries. Another important framing theme of the article is to outline the development of science parks and clarify the science park terminology. In addition, the functions, performance and new directions of science parks are briefly discussed. Lastly, the structure of the special issue of IJTM at hand is outlined.

Keywords: high-tech centre; science park; technopolis; technopolitan planning; urban and regional development; global competition.

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1 Territorial communities in global transformation

Globalisation and information society development together with new developmentalism and related forms of new governance are among the most important sources of change in our time. Regarding this era, the OECD as the think tank of the developed countries has presented *Vision 2020*, the main message of which is to strengthen the mobility of capital, improve the conditions for global competition, continue the implementation of national adjustment policies and programmes, and to increase flexibility in the use of labour [1]. As the development has largely followed these lines, the social sphere has become increasingly dominated by a market-driven system backed up by institutions of global governance. The global age may well lead to increased prosperity and improved efficiency through the global division of labour, competition, and specialisation, but it has a certain tendency to increase individualism, polarisation, regional disparities, and democracy deficit, thus giving rise to new societal and global tensions [2–3].

As surprising as this may sound, genuine globalisation may be said to be in its infancy because it will take decades until its true social consequences are known. Among the short-term changes shaping the transformation of the economy, the following are worth noting here [4]:

- Following the developments in China, Eastern Europe and other countries, there are fewer and fewer regions that are either willing or able to insulate themselves from global economy.
- New technological opportunities of global networking enable and encourage major restructuring of economy and society. Traditional value-added chains will be replaced or supplemented by value-added networks, contacts between producers and consumers will become more direct, and the borders between sectors will disappear, just to mention few concrete outcomes.
- Enterprises operating internationally react to user/customer demand for the best available products worldwide, and organise themselves as globally inter-linked units with responsibilities divided over different regions.
- Key prerequisites for success are the capacity to develop and transform knowledge further, the development of enterprises into learning organisations, the efficient management of the knowledge of the organisation, and the ongoing upgrading of the competencies of employees.
- Even small and medium-sized enterprises must face the world-market situation and adapt to it. Inter-linking with cooperation partners for the utilisation of the networks will be indispensable to ensure competitiveness and innovativeness.
- Due to the overall transformation, people's life-situations are likely to change; they will become more mobile with new patterns of work and consumption of increasingly mass-customised or personalised services.

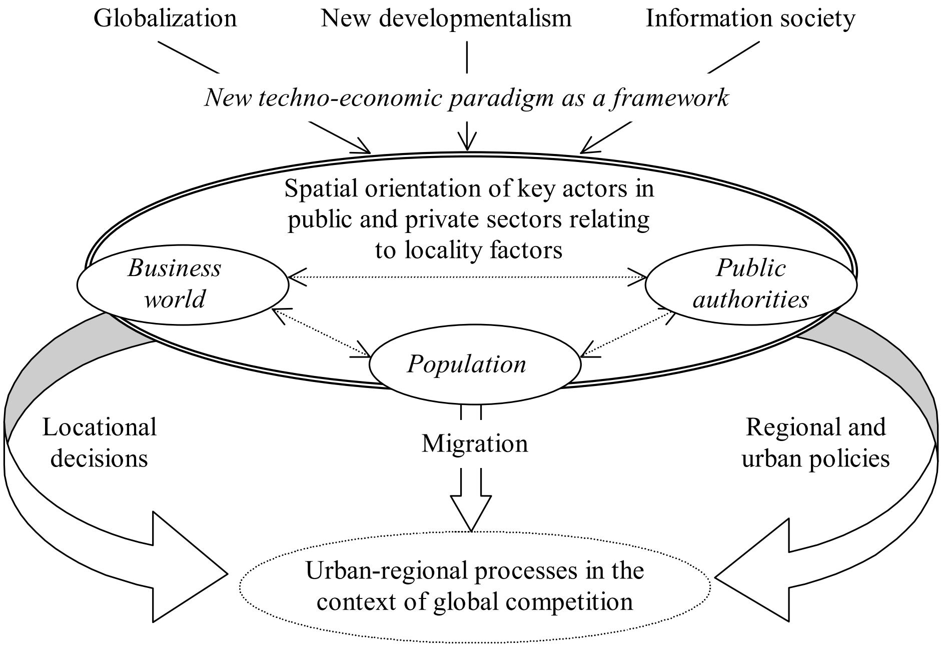
In this process, disparate cities and regions are subject to the effects of largely uniform technological and economic forces [5]. This development increases the international division of labour, and hence also regional differentiation and specialisation and apparently regional inequality. It will be increasingly critical for cities and regions to take advantage of globalisation and information society development on the basis of their existing conditions and characteristics and innovative adjustment strategies. It seems that localities will need to be linked to international and global networks in order to stay innovative and, hence, attractive in the global competition of cities and regions [6–7]. Yet, the catch in this market-oriented globalisation imperative is that if nation states and cities simply acquiesce to contextual changes, without seriously attempting to intervene in global policy-making and governance processes, competitiveness may precipitate the 'race to the bottom' and 'downward leveling' processes to the detriment of a large number of disadvantageous countries, regions, and localities [8]. As economic forces converge due to a shared interest in capital accumulation and other aspects of the corporate agenda, nations and cities will be pulled apart [9]. Obviously, balancing multi-level public policies and governance will be needed in order to derive benefit from companies as a positive social force without being diverted to excessively volatile and resource-depleting competition of territorial communities (On this policy challenge to cities, see [10]).

The overall impression of present-day development policy is that postindustrial ‘growth machines’ direct more and more support to private sector investments, innovation, and entrepreneurship at the expense of redistributive and welfare policies. This is, in fact, a logical consequence of globalisation. The trend is summed up by Logan [11] as follows: “Concerns with social exclusion, the incorporation of newcomers, collective services and education, quality of the urban environment, safety – concerns that were always at the core of the progressive agenda – are relegated to a second tier of public policy. To the extent that they are relevant to the primary growth agenda, they are accorded more weight; on the own, they are neglected.” Even if this aspect is not discussed explicitly in this article or elsewhere in this special issue, it certainly needs to be taken into account when discussing the global competition of high-tech centres in a wider policy context.

2 From global orientation to local ties

What set the course of global and regional developments regarding locality-specific factors can be traced to the attitudes and decisions of visionary entrepreneurs, corporate executives, influential brokers and symbol analysts, leading politicians, and top-level public managers. More than anything, the emerging market driven global system puts pressure on territorial communities to enhance their attractiveness in the eyes of existing firms and businesses that might locate their activities at a specific site. The question is whether any city can actually avoid striving for greater global attractiveness [12]. The basic constituents of this phenomenon are exemplified in Figure 1 [13].

Figure 1 Orientation base of location decisions in public and private sectors



The competitiveness and attractiveness of territorial communities are profoundly affected by the degree of their global orientation and in more practical terms, extraneous resources. This means that growth-oriented territorial communities are becoming ‘catalyst cities’ and ‘catalyst regions’, which pursue their objectives by utilising networks and alliances, transnational organisations, and direct enterprise contacts operating at different levels and on varying scales [14]. On the other hand, a strategy linked only tenuously to local strengths and conditions functions in exceptional cases only, for urban-regional development is decisively influenced by the internal growth and development factors of a territorial community.

The global-local dialectic is particularly obvious in high-tech industries and knowledge intensive activities. Even though fast information transfer, distance work, and network-based organisation are possible, knowledge intensive firms and jobs seem nevertheless to concentrate in certain geographical areas. This is sometimes referred to as the locality paradox. What is noteworthy in regard to present development is that sectors with high R&D and technological intensity have an even stronger tendency to agglomerate than others. Thus, the high-tech concentration in certain regions from Silicon Valley in California to Cambridge in UK to Oulu Region in Finland confirms the assumption that the development of ICTs has not totally annulled the importance of physical proximity and interaction. This is borne out by the fact that the R&D activities of a certain sector tend to converge on the area where the innovative activities of other sectors are concentrated rather than where the manufacturing actually takes place. With some reservations we may generalise that the R&D activities of all sectors tend to concentrate in high-tech centres with a highly stimulating and innovative milieu (cf. [15]). Knowledge and information intensive producer and industrial services, including not only R&D but also financial services, legal services, and marketing, have a tendency to agglomerate due to anticipated technology spillovers, availability of skilled workers, closeness to market, and a need for face-to-face contacts and collaboration in teams within an organisation and in customer relationships requiring tailor-made solutions [16]. This gives good reason to believe that it is the internal information flows of high-tech centres that are important both for the creation of innovations and for high economic performance.

As stated, the improvement in connections over distance provided by ICTs do not detract from the significance of strategic face-to-face contacts [17]. One of the main reasons evinced in many previous studies on this topic is that while in the present state of technological and socio-technical development, ICTs can transmit signals and digital information fairly well, its limits are evident in such areas or aspects of social life that relate to tacit knowledge, disambiguation, trust, cultural attractiveness, and place-specific human desires. Thus, even though cities and regions need to adapt global orientation, this should not be at the expense of building on local milieu and local ties and constant upgrading of local governing capacity. At the level of firms, this is reflected in new developments in which innovation and technopreneurial performance are becoming ever more dependent on the associational capacity of the firm in corporate governance, inter-firm cooperation in the supply chain, and managing stakeholder relations in the wider institutional milieu, as hypothesised by Cooke & Morgan [18].

3 Science parks as a development policy option

3.1 Global and national perspectives on the high-tech race

In general, *high-technology* concerns the latest developments in technology, which in practical terms relates to leading-edge technologies requiring high R&D input and a high level of expertise. Even if the sectoral approach can serve only as an approximation of the industries that are heavily dependent on high-tech and in the forefront of its development, it is nonetheless a convenient way to point out what high-tech refers to. [19]. Paradigmatic high-tech industries include:

- computers and office equipment
- communications equipment and semiconductors
- software
- pharmaceuticals
- electronics
- biotechnology; and
- aerospace.

High technology is generally perceived to have an important role in driving national and regional economies. As an indicator of this trend, suffice it to say that IT industries accounted for a third of US economic growth in the latter half of the 1990s [20]. Further evidence is that the global market for products manufactured by four research-intensive industries – aerospace, computers and office machinery, electronics and communications equipment, and pharmaceuticals – is growing more than twice as fast as that for other manufactured goods and is driving national economic growth around the world. Similarly, global economic activity in high-tech industries was especially strong from 1992 to 1995, when output grew at over 8% per year, which is more than twice the growth rate for all other manufacturing industries ([21] see also [22]).

In this respect it is natural that nations should seek to develop these R&D-intensive industries. To sum up, the rationale behind high-tech-oriented development policy is built on the following kinds of arguments [23,21]:

- High-tech firms are associated with innovation, and innovative firms tend to gain market share, create new product markets, and use resources productively.
- High-tech firms are associated with high value-added production and success on foreign markets.
- Industrial R&D by high-tech industries has spillover effects, thus benefiting other commercial sectors by generating new products and processes that can often lead to productivity gains, business expansions, and the creation of high-wage jobs etc.

From the policy perspective, the global competition of high-tech centres is a policy issue in which all the levels of governance are involved (on the multiscalar framework of economic globalisation, see [24]). At a highest level of governance it is about ensuring favourable preconditions for the globalisation of the economy and a more polycentric world order, as presented in the agendas of the UN, the World Bank, the IMF, the WTO, and the OECD. A flip side of this picture is the competition between macroregions, and especially between Europe, USA, and Asia. These policies are discussed within regional institutions, such as the EU, NAFTA, and ASEAN, and within influential countries, such as Germany, USA, and Japan, and their 'clubs' such as the G7. One declared intention of regional institutions is to plan free trade areas, but in most cases the establishment of true free trade conditions is still remote. In this respect the most important exception is the European Union: its decades of effort have succeeded in creating a single market for Europe.

Europe has sought to strengthen its global position by the long-term project of the formation of the European Union and more recently the adoption of a common currency called the Euro (by 12 Member States including such big countries as Germany, France, and Italy) and the enlargement of the EU to include ten Eastern European countries in May 2004. This process has caused many Eastern European countries to attract IT firms from Western countries by providing a low-cost environment for high-tech production. This process has been going on for years and may accelerate due to the imminent enlargement. Yet it seems that even before this process really took off more severe competition emerged from the Far East. China especially emerged during the 1990s as the globally most attractive country with low production costs, high growth rate, good workforce, and above all, burgeoning markets. This situation began to expose new tensions in the first half of the 2000s, when the economic recovery in the US failed to generate new jobs. It was generally considered that a large part of the jobs in the US and other developed countries would move even faster to low-cost countries in Asia. The world seems to be evolving towards three blocks with slightly new profiles: USA, an enlarged EU and East and South East Asia, centering around China, even if Japan is still the largest economy and technologically the most advanced country in Asia. The darker side of the picture is that Africa, Middle East and Latin America lag far behind and to some extent are outside this global race.

As regards *nation states* and national economies, they continue to matter in the global competition of high-tech centres, for they still have a decisive role in guaranteeing the stability of society, maintaining sustainable macroeconomic stability, contributing to human and social capital, and designing and utilising in a cost-effective way tax reduction schemes and other government interventions. From a global perspective USA is in a class of its own as a leading high-tech nation with the world's largest economy, the top level of technological expertise, a large number of world's largest high-tech companies, a competitive and entrepreneurial culture, and a leading role in international politics. The role of the USA in technology transfer is by far the most important in the world. It has also originated many of the legendary cases of high-tech centre developments.

However, it seems that particularly Asia as a rising continent has attracted international attention in high-tech development. Even if Japan stands alone as the most advanced industrialised country in Asia, at this historical phase the momentum seems to be with its neighbours, notably China. Of the four tigers of Asia, Taiwan and South Korea are well positioned in high-tech competition, as are also Singapore and Hong Kong SAR with a slightly narrower technology foundation. Of the larger countries, China, Malaysia, India and Indonesia all show mixed signs of technology development and competitiveness [23]. Among the large developing countries China and India especially have invested much effort in developing their high-tech industries and technological capability. In their strategies technopolitan planning has been given an important role, which is manifested in the construction of science or software parks and high-tech industrial zones.

In the European context special interest has been directed to smaller countries, for in the 1990s such countries as Ireland and Finland developed to join the most competitive countries in the world. Ireland has for some time been in a class of its own in terms of attracting foreign investments in Europe. During the rapid development in the 1990s it became the leading software producer in Europe. This is very important for Ireland, for it is one of the most foreign trade-dependent economies in the world [25]. The Nordic countries have exceptionally good records in competitiveness, innovativeness, functioning of education system, transparency, and sustainable development. In the Global Competitiveness Report 2003–2004, released in October 2003 by the World Economic Forum, Finland was ranked the world's most competitive economy, with top ranking for its all-around performance in macroeconomic environment, the quality of its institutions, and the state of its technology and supporting infrastructure. In the name of competitiveness Finland has streamlined its administrative machinery and the entire welfare state structure, even to the extent that an exceptionally high unemployment rate has become a regular feature of society, accompanied by downsizing of the welfare services. Nevertheless, its innovation policy and national innovation system built since the 1980s have become one of the most successful in the world. The paramount example of the fruits of the Finnish innovation environment is Nokia Corporation (see [26]).

Most countries in the world are small, and fundamentally at a disadvantage in breaking into most of the growth sectors that revolve around high-tech development. Maskell and others [5] present many reasons for small countries to remain mainly at low-tech level. For example, high-tech means high risk and high cost strategy. Besides, small countries have domestic and labour markets of limited sizes, and they can seldom provide the science-based input required by high-tech industries. The Nordic countries, for example, have to a large extent remained low-tech countries, and were able to increase their prosperity before the international success of Ericsson and Nokia in telecommunications gave them a high-tech image and helped them to take a step forward in the electronics industry [27–28].

3.2 *Highlights of high-tech centre trends*

The competition between high-tech centres is best viewed neither as a playground of international organisations and macroregional institutions nor as competition between nation states, but in 'pointillist' style as a mosaic-like setting in which more or less independent high-tech centres compete with each other. Stories from Silicon Valley to Cambridge to Sophia-Antipolis that reflect this approach are well known and documented. The Silicon Valley effect spawned a global wave of 'Siliconia' on different scales all over the world [29]. Interest in this development model increased in the US in the 1960s, reached Europe in the 1970s, and started to intensify and spread throughout the world in the following decade. In fact, it was in the 1980s that the science park movement really emerged as a global phenomenon. It became one of the most appealing local-regional development models expected to provide a shortcut to restructuring local economy and to getting a grip on desired growth sectors. The urban-regional level is of vital importance because *cities and regions* have become independent actors that compete with one another for the flows of investment, capital and expertise in order to create employment opportunities and to secure the welfare of the local community. This highlights the necessity to integrate the core value-added functions of the community into the global economy [30]. This view has also attracted special attention due to global rankings of high-tech centres (e.g. the ranking published in Wired Magazine in June 2000, see [31]).

The number of science parks rose dramatically in the 1990s and it seems that it is continuing to go upward in the early 2000s. It is difficult to give even an approximation of the number of science parks, for the figure depends on the criteria used. The most important thing is to define whether the figure includes innovation centres and incubators or not (see e.g. [32]). For example, in China there are some 120 science parks, 58 university-based science parks and about 300 incubators, which means that the figures may be very different depending on what is included. Also, as the size of parks can be very different, the figures as such may be even misleading. For example, in France there are about 40 large parks, whereas in Germany their number is four times higher but most parks (or technology centres) are much smaller. The International Association of Science Parks (IASP), for example, tends to be rather strict when labelling any project as a science park, for they give this status only to those projects that fulfill the criteria of the official definition of science park given by the IASP. Keeping this in mind, the approximation of the number of genuine science parks as defined by the IASP in the world in the early 2000s may be between 700 to 850. When a looser definition is applied, the total number is probably closer to some 1,240. The latter approximation can be divided in the following way (cf. [33]):

- North America: 500
- Europe: 400
- China: 120

- Japan: 120
- Asia-Pacific (other than Japan and China): 40
- Rest of the world: 60.

The cradle of research parks is the US, where they became a popular development strategy as early as in the 1960s, inspired by the success of Silicon Valley and also by Boston's Highway 128 and Research Triangle Park in North Carolina. Not only universities, but especially state and local governments invested in this policy in order to create high-tech jobs and increase the attractiveness of their locations. ([34], see also [35].) According to Professor William Miller the success recipe for a dynamic high-tech centre is a mix of education, industrial research, entrepreneurship, and availability of risk capital [12]. What is essential here is not necessarily any individual element, but the cultural context in which these elements materialise. The entrepreneurial culture of Silicon Valley is unique and as such more or less impossible to replicate anywhere where no such cultural features exist [36–38].

This development slowly found its way to Europe. In the UK the first wave came in the early 1970s and the second a little more than ten years later, so that after the first pilots of Cambridge and Heriot-Watt of the 1970s the number of established parks reached 38 by the early 1990s and has grown to approximately 100 in 2002 [39,38]. Most of the UK science parks are fairly small parks with a close connection to a university.

Another leading European country in technopolitan planning is France with its technopoles, which are in most cases geographically larger than UK science parks. Nowadays there are 44 technopoles in France and a large number of business innovation centres and incubators, the first and foremost technopole being Sophia-Antipolis near Nice in Southern France. In their early days emphasis was more on recruiting multinationals and national R&D institutions, especially in such large complexes as Sophia-Antipolis, but over time this has balanced out as more and more small IT firms became an important tenant group in technopoles.

In Germany the same trend assumed rather a different form, for they set up mostly business innovation centres and technology centres, which have a slightly lower profile than those of the US, British, or French science parks. They pay special attention to supporting new technology-based firms (NTBFs), but do not necessarily have such a strong connection to higher education institutions (HEIs), in contrast to other major high-tech countries. Munich is the leading high-tech region in Germany, but there are technology parks, innovation centres and business incubators around the country, concentrating especially on North Rhine-Westphalia and Baden-Württemberg and around Berlin. Depending on the criteria, the number of science park-type formations varies from 70 to 150.

Thinking of Europe as a whole, the diversity of science park projects is significant. In most cases the interest in this policy initiative and along with it the actual number of science parks started to increase after 1983, for before it only few British and French pilots had been established. These two countries also represent two basic models of science park in Europe, which may be termed 'incubator-led' and 'attraction-led'. In the UK, Germany, the Netherlands, Belgium, and Greece the model of incubator-like park dominates, i.e. they support NTBFs in production, product development, and finance. In France and Spain technopoles are larger, with the aim of changing the entire production system of the area by attracting large high-tech companies and multinational R&D departments [38].

Asia is a promised continent of high-tech centres with more than 200 science parks and many in the making. Developments there have been characterised by government-led megaprojects, which reflects the overall development policy models adopted by most Asian countries and their strong commitment to high-tech and information society development in general [40]. Thus, Asian high-tech centres are to a great extent rather recent creations of governments. This process started with Japan in the lead. Its efforts to build up Tsukuba Science City and later to create more regionally dispersed high-tech centres along the decentralised model of the Technopolis Plan are expressions of government-led technopolitan planning, even if in the case of the latter much was built upon local and regional institutions. Paradoxically, as much as Japanese developers were impressed by the developments in Silicon Valley and Cambridge in UK, their own initiatives and actions were manifestly different from both of these [41]. Japan, of course, also has more conventional science parks, of which some of the best known are Kanagawa Science Park and Kyoto Research Park. The number of Japanese science parks exceeds 120 (cf. [42]).

During the 1980s such big countries as China and India began to develop their high-tech areas, which did not succeed at that time. The Indian government has developed Science and Technology Entrepreneurs Parks (STEPs) around technical universities since the mid-1980s, the number of which is 12. These parks aimed at transferring high-tech R&D results from academic institutions to industrial enterprises by encouraging entrepreneurship and attracting venture capital. The early years of these parks were not that successful, though [42]. An additional scheme started in the wake of the new era of economic liberalisation in the early 1990s through the establishment of Software Technology Parks of India (STPIs) with export-oriented incentives and support. There are almost 40 such software centres and parks all over India. Some of the Indian parks proved to be success stories, such as Bangalore, known as India's Silicon Valley, and also Hyderabad, the biggest city of the state of Andhra Pradesh, and the Technopark Kerala at Trivandrum (official name Thiruvananthapuram), the capital to the southern state of Kerala. They have been important in 'testing' how developing countries are able to create science parks capable of attracting leading IT and software companies from Microsoft to IBM.

China's high-tech concentrations are mostly in coastal provinces. The story of high-tech industrial zones began in the 1980s in Shenzhen, which had an internationally oriented industrial base and Shanghai, which has long been China's commercial centre. Transferring their models to other parts of the country has not been easy, but new winds are clearly blowing, especially after the adoption of the open door policy [43–44,42]. Since the late 1990s one particular initiative of the Central Government of China made the world of high-tech business look at the northwest of Beijing: the Zhongguancun Science and Technology Park in the Haidian district of Beijing was established in 1999 to become the Silicon Valley of China. It comprises some 40 educational institutions, more than 200 R&D institutions and seven science parks, thus making it the most powerful research concentration in the country [45–46]. In the early 2000s the total number of high-tech industrial development zones (HIDZ) is in the region of 178 and the respective number of export-oriented economic-technological development areas (ETDA) exceeds 3,000, of which only 47 are nationally organised. To break these HIDZs down, which are more relevant from the viewpoint of high-tech development, there are 53 high-tech parks established by the central government and about 67 established by the local governments in China. In addition, there are 36 national university-based science parks and 22 local parks respectively. There is a plan to establish about 100 new university-based science parks throughout the country during the next five years or so. Since the 1990s the number of incubators has grown and the number is expected to continue to grow in the next few years. The total number of incubators has been estimated to be some 300. In the area of Beijing alone there were almost 50 incubators in 2002. These show in an illuminating way the scale on which the Chinese government has applied the technopolitan development model to support innovativeness, technopreneurship, and high-tech development, which are meant to contribute to economic growth.

In other East and South East Asian countries the numbers of science parks are lower, in many cases only a few per country. New government-initiated parks have been created in emerging and newly industrialised economies since the 1980s and more so during the 1990s. Many of them made it quickly onto the growth track. Among these are such famous cases as Taiwan's first and most important park, Hsinchu Science-Based Industrial Park, which was opened in 1980, and Singapore Science Park that was officially opened in 1984. In the 1990s one of the large-scale creations that attracted a lot of international attention was the Multimedia Super Corridor of Malaysia. Even if an economic downturn in the early 2000s affected this development, Asia as a whole has been remarkably determined and still has a lot of untapped potential in high-tech development.

3.3 Technopolitan planning

The basic idea behind the development of science parks and technopolises is to boost local and national economies by attracting high value added activities to a single site of production and innovation. Since the late 19th century there has been growing understanding of industrial districts and location decisions and more recently of flexible specialisation, new industrial spaces, cluster formation, and regional innovation systems. They were slowly translated into development policies and measures of universities, development agencies, and governments. Universities and local and regional governments became key players in the formation and implementation of this policy, inspired especially by the examples of many distinguished entrepreneurial universities in the USA and later in Europe. Universities aimed mainly at improving university-industry linkages and also generating income, whereas governments have mainly targeted job creation and regional development (cf. [47,38]).

The five major elements in creating successful high-tech concentration are:

1 land, infrastructure and site provision

2 capital formation and investments

3 innovation, entrepreneurship, and technological change

4 human resources

5 the best possible institutional context and support systems [48,12].

These aspects are prominent in the explicit goals and functions of most of the science parks. Yet, the same elements are also obvious in various combinations in the strategies and policies of high-tech cities and regions. For instance, the Metropolitan City of Seoul, South Korea, has designed its development policies since the mid-1990s when the decentralisation of the highly centralised structure of Korea began. Seoul has adopted a highly selective development model, like many other capital areas with high congestion. The aim is to attract especially innovative and high technology functions. The major criteria on which this development policy is based are environmental friendliness, high level of added value in the value chain, and high level of expertise. In practical terms the City of Seoul supports high-tech development, among others by providing premises for IT firms, providing funding for firms, promoting technology transfer, facilitating communication and knowledge transfer, and providing incentives, such as tax relief. Spatially many of the high-tech activities of the city are located around the metro line two (green line) in the central business district, other centres being Hong-neung venture valley, in which many prestigious universities and research institutes are concentrated, the high-tech area known as Teheran Valley south of the Han River that flows through the city, and as the latest formation the Digital Media City area near the World Cup Stadium.

Large-scale technopolitan planning is sensitive to economic fluctuations, and may easily lead to government failure. For example, both Technoport Osaka Project of the Metropolitan City of Osaka and Rinku Town Project of the Osaka Prefecture, flopped in spite of the huge economic potential of the area and full local and regional government support to high-tech development. The lesson to be learned is that as fashionable and important as it is to become involved in high-tech development, it bears fruit only when the timing is right and certain preconditions are met. More recently Osaka has become involved in more dynamic and small-scale solutions and institutional arrangements to promote innovativeness, technopreneurship, and internationalisation of businesses.

In general, *government intervention* is considered to be conducive to building sufficient physical and social infrastructure that serves an agglomeration of high-tech industries, technopreneurship, and innovativeness. Policies that enhance the quality of labour through higher education and targeted education and training are among the most crucial preconditions for any high-tech centre. In addition, public policies have in many cases contributed to specialisation and to the building of economic and research-industry linkages [49]. As a public development policy *technopolitan planning* contains three areas in which the role of public intervention is crucial:

1 Public undertaking of part of the R&D and transaction costs due to external R&D and technology transfer, through incentive programmes and intermediaries that offer support, especially to SMEs.

2 Urban regeneration programmes that aim at making the innovation or high-tech industrial site well-functioning and attractive to all those involved in the development of the area.

3 To stimulate new industry, system-areas and districts, through local integration, networks, and inter-firm alliances [38].

Technopolitan planning needs to meet the challenges of globalisation by providing locality-specific actions that are feasible and strategically well grounded. This strategic task in a competitive environment inevitably leads to *specialisation*, for no single site can create world-level expertise with a broad set of high-technologies or to attract all kinds of business activities [50]. The other imperative that leads in same direction is that while

ICT markets develop, specialised demands emerge, generating incentives and pressure for IT firms to move up the value chain [46]. In this regard, Cortright and Mayer have made interesting observations in their analysis of 14 high-tech metropolitan areas, including Atlanta, Austin, Boston, Denver, Minneapolis-St. Paul, Phoenix, Portland, Raleigh-Durham, Sacramento, Salt Lake City, San Diego, San Jose, Seattle and Washington D.C. They observed that high technology varies dramatically from place to place, which emphasises the role of specialisation in high-tech development. In fact, each area tended to specialise in relatively few products or technologies, with the exception of such large-scale concentrations as Boston and San Jose. Various indicators point in this direction. For example, high-tech employment is concentrated in only a few industry segments. This is why areas that are strong, let's say in software, usually show rather low concentration in hardware (e.g. Denver, Atlanta, Washington D.C.). Similarly, patents in high-tech areas are granted to only a handful of firms specialising in one or more related technologies. Similarly, venture capital flows not only to a few high tech metropolitan areas, but also to a specific set of technologies within those areas [20]. This mirrors an important historical aspect of science park development: many high-tech centres have been highly dependent on one or a few leading high-tech firms which originally started to generate a cluster around them (cf. [19]).

Cortright and Mayer [20] have provided an excellent analysis of high tech specialisation and some advice for policy makers. As their message is important from the point of view of global competition of high-tech centres, the following lengthy quotation of the policy implications is worth presenting here:

> "Looking in detail at the specialties of the leading high technology firms in 14 metropolitan areas provides a variegated picture. The strong and consistent role of specialisation in shaping the pace and character of metropolitan high tech development underscores the fundamentally indigenous and idiosyncratic nature of development. In thinking about strategies for developing a high tech economy, the leaders of any metropolitan area are well advised to look closely at their own existing knowledge base for the best opportunities to grow an industry cluster.
>
> The tendency toward high tech specialisation suggests that decision makers should avoid replicating generic development strategies. Because high technology is so diverse, and because it prospers in response to the distinctive knowledge base and characteristics of each individual region, there is no universal recipe for high technology success.
>
> The survey findings also underscore the difficulty of generating a new high technology cluster where none previously existed. Because new high tech clusters build on the knowledge base of current workers and firms, metropolitan areas with weak technological endowments are greatly handicapped in creating new ones. Successful high technology development is usually an indigenous process, building most critically on the distinctive knowledge and existing industrial base of a region. Moreover, prowess in one high tech field doesn't necessarily qualify an area to succeed in others. Economic development efforts should be tailored to build on or extend existing strengths or emerging local competence; trying to create a totally new high tech centre where none currently exists is likely to be a lengthy, and probably fruitless, endeavor." [20]

From the point of view of urban and regional economy one reservation should be made here. As a rule, diversification is an in-built stabiliser of an urban-regional economy, which implies that specialisation should be counterbalanced with attempts to widen the repertoire of industries and service sector in particular [30].

Successful technopolitan planning requires that the development plan itself reflects a strategic understanding of the global-local dialectic and that the local community as such forms a supporting frame for the science park. Many science parks have faced lack of sufficient economic support from public organisations whenever short-term objectives have been shown to be difficult to achieve. This is why sufficient understanding of the nature of the science park endeavor and commitment to a long-term development policy are indispensable.

4 A glance at science parks and technopolises

4.1 The emergence of science parks and technopolises

Science and technology parks are a post-World War II phenomenon [51]. The protoforms of high technology concentrations were seen as early as in the latter half of the nineteenth century in major industrialised countries such as Britain and the US. Between 1870 and 1914 new countries and cities began to rise to compete with the US, while Britain gradually began to lose its position, be it that it was the cradle of industrial revolution. In those decades cities like New York and Berlin might have claimed the title of high-tech industrial centres of the world [52].

The concept of industrial district was coined by Alfred Marshall in the 1890s and saw its first organised forms in the early years of the twentieth century. The construction of the first modern science park was begun only in the latter half of the 1940s by Stanford University in Palo Alto, California. Thus, the first university-owned industrial park in the world, Stanford Industrial Park (later Stanford Research Park), was founded in 1951, at the core of the agglomeration that, with its wider surrounding area, later came to be known as Silicon Valley, the world's leading high-tech centre.

One of the key figures in this process was Professor Frederick Terman, who wanted companies to settle next to the university. As mentioned, in the early 1950s he contributed decisively to the establishment of the first high-technology industrial park, 'where business, academic and government interests could come together in a synergistic vision of the future.' The first firm to settle in this park was Varian Associates. The number of firms increased rapidly to the extent that they eventually were to become the core of the early explosive growth of Silicon Valley. As they say: the rest is history [53–54].

The science park is for the most part an American phenomenon, designed to serve the needs of entrepreneurially-minded academics and the promotion and utilisation of university-industry linkages. The idea started to spread over the States after Stanford had become the standard for science-based industrial development, inspiring local initiatives in different parts of the country. This scheme found its way to Japan in the form of Tsukuba Science City, the planning of which started in the early 1960s, going into operation in the early 1970s. In Europe the same trend found its expressions in the early 1970s through Sophia-Antipolis of France and the science parks at Cambridge University in Cambridge and at Heriot-Watt University in Edinburgh, UK. In Russia the story of high-tech centres began with science cities that were closed, self-contained enclaves, as they were linked to the military and nuclear power aspects of the construction of the Soviet superpower. The construction of such concentrations began around Moscow as early as in the 1940s and 1950s [55]. The construction of Akademgorodok in Siberia, which is one of the paradigmatic forms of a science city parallel to Tsukuba of Japan and Daedeok of Korea, began as early as in the late 1950s. After these early developments in three continents the number of such concentrations mushroomed. The majority of the currently existing science and technology parks are fairly young, as they were created after the beginning of the 1990s or later. In the mid-2000s there are some 700 to 850 science and technology parks worldwide that fulfill IASP criteria for science park.

4.2 Typology

The types of high-tech concentrations vary from the vastness of a high-tech region to the high density of an urban setting, such as urban knowledge parks and science cities, to smaller science parks and finally to microenvironments such as small-scale business incubators. Even though this research field has developed rapidly within the last 20 years, this conceptual field is far from clear. Classifications of high-tech centres have been proposed by Worthington, Luger and Goldstein, Castells and Hall, Komninos, Park and many others [41]. One basic problem is that the naming of parks has not been based in any clear set of criteria, which leads to confusion between the names used and the factual features of high-tech formations. To give a general idea of the varieties of science park-related concepts, a brief list of basic terms is presented in Table 1. The classification is based mainly on the discussions of Castells and Hall [54], Park [41], and Komninos [32].

Table 1 Basic types of high-tech centres and networks

Types	*Names*	*Major actors*	*Functions/ Goals*	*Examples*
1 High-tech microenvironments	Incubator Accelerator	Growth-oriented firms, start-ups and spin-offs	Quick take off and growth of IT firms	International Business Incubator in San Jose Incubateur Grand Luminy, France
2 Research centre	Centre of excellence Research centre Innovation centre	Research institutes R&D units New businesses	High-level of expertise	Canadian Innovation Centre at Waterloo Centres of excellence in Finland
3 High-tech industrial park	Industrial park High-tech industrial park High-tech park	Government and industries	Promote industrial activities	High-tech industrial zones in China

Table 1 Basic types of high-tech centres and networks (continued)

Types	*Names*	*Major actors*	*Functions/ Goals*	*Examples*
4 Science park	Science park Research park Technology park Technopark Software park Technology precinct High-tech park Knowledge park (Park-like technopoles)	IT firms, Government, university	Industrial growth	Hsinchu, Kerala, Sophia-Antipolis, Cambridge, Mjärdevi (Sweden), Innopoli (Espoo, Finland) etc.
5 Technopolis	Technopolis Plan and similar development programmes (Polis-type technopoles)	Local government, private firms, research institutes	Regional development and industrial decentralisation	Kumamoto, Hamamatsu, and other technopolises in Japan Technopoles in France
6 Science city	Science city Science town	Government, research institutes	Higher level of scientific excellence in urban form	Tsukuba, Daedeok, Akademgorodok, Kista, York
7 Intelligent city	Intelligent city Smart community Learning city Learning village Knowledge city (Digital city)	City government and actors in local community	Advantages through knowledge systems and virtual innovation milieu	Smart communities in the US, European digital cities (Antwerp, The Hague etc.), Intelligent Island of Singapore, Cyberjaya in Malaysia
8 High-tech city	High-tech metropolitan area High-tech city Technocity	Private firms and urban innovation milieu	High value adding activities	Tokyo, Paris, London, Munich, Stockholm, San Jose etc.
9 Large high-tech complex	High-tech centre High-tech region Learning region Innovative region	High-tech firms and regional production and innovation networks	Production, innovation and learning for global success	Silicon Valley, Boston Route 128, Research Triangle area, Multimedia Super Corridor, Baden-Württemberg

Table 1 Basic types of high-tech centres and networks (continued)

Types	*Names*	*Major actors*	*Functions/ Goals*	*Examples*
10 Global or macroregional networks	Associations and networks of high-tech centres Innovation networks	Science and technology parks, high-tech cities and high-tech firms	Sharing information and creating partnerships and alliances	Int'l Association of Science Parks (IASP), World Technopolis Association (WTA), Four Motors for Europe, Telecities
11 Virtual high-tech centre	Virtual technology park Virtual innovation milieu E-Science park E-Technopark	Science and technology parks	Supporting the functions of the 'real' high-tech centre	E-Technopark of Kerala, India, Zhongguancun E-Park, China, website of York Science City, UK

In the interests of providing some conceptual clarifications, let us next discuss the basic concepts used to describe different kinds of high-tech centres. The discussion is divided into three main families of high-tech centre concepts:

1 science parks

2 technopolises

3 microenvironments

This division is far from clear-cut, but helps to group these concepts. Some authors have emphasised the difference in size of the geographical area within which the high-tech activities are organised: '*poles'* (or polises) are larger than '*parks'*, which in turn are larger than such microenvironments as incubators (cf. [56]). Even if this is not always the case, we may use this as a loose criterion to differentiate between these broad categories. In principle, *science parks* are clearly defined areas for high-tech production, innovation and university-industry linkages and also a park-like environment, whereas *technopolises* include a wider urban-regional setting with urban and social infrastructures. It must be remembered, however, that such parks as Hsinchu Science-Based Industrial Park, which are government-led large-scale projects with not only research and/or industrial zones but also residential zones, are close to technopolis-type creations and even science cities in spite of having the 'park' in their name. Yet in most cases science parks do not provide sufficient urban amenities as such and do not comprise a wider urban setting, which implies that they are not genuine technopolises. Another important criterion is whether a high-tech centre is based on spontaneous agglomeration development or planned outcome of government or university intervention. As a rule the larger the area, the more likely it includes aspects outside the control of public developers of a high-tech centre. The most notable exceptions to this rule are countries with centralised political power structures, such as many Asian countries, which have planned and established larger areas such as high-tech industrial zones and science cities.

4.2.1 Science park formations

High-tech concentrations have been named in various ways, including such as

- science park
- research park
- technology park
- high-tech park
- technology precinct
- technopole
- technopolis
- science city
- innovation centre and the like.

They all refer to an economic and technological development complex that aims to foster – directly or indirectly – the development and application of high technology to industry and to create new business from it. [57]. As the science park is a sort of paradigmatic form of these high-tech formations, let us start this conceptual expedition from it.

Science parks are special physical environments for the creation of economic value through the development, application and transfer of knowledge and high technology and the creation of new enterprises [51]. The most commonly applied conception was originally defined by the United Kingdom Science Park Association (UKSPA), whose formulation was for the main part adopted by the International Association of Science Parks (IASP) [58]. In general, UKSPA has had a tendency to define science parks on a more managerial and 'functional' basis, whereas IASP has recently adopted a slightly broader and more 'culturally' oriented approach to them. Actual differences, however, are rather small.

Let us start with the definition given by UKSPA:

> "A Science Park is a business support initiative whose main aim is to encourage and support the start-up and incubation of innovative, high-growth, technology-based businesses through the provision of: infrastructure and support services including collaborative links with economic development agencies; formal and operational links with centres of excellence such as universities, higher education institutes and research establishments; management support actively engaged in the transfer of technology and business skills to small and medium-sized enterprises." [59]

IASP International Board on 6 February 2002 formally adopted the following definition for the concept of a science park:

> "A Science Park is an organisation managed by specialised professionals, whose main aim is to increase the wealth of its community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions. To enable these goals to be met, a Science Park stimulates and manages the flow of knowledge and technology amongst universities, R&D institutions, companies and markets; it facilitates the creation and growth of innovation-based companies through incubation and

> spin-off processes; and provides other value-added services together with high quality space and facilities." [59]

Another concept that has generally been used to refer to these science park formations is research park. The Association of University Related Research Parks (AURRP) defines the term *research park* (or science park) as:

A property-based venture that has:

- existing or planned land and buildings designed primarily for private and public research and development facilities, high technology and science based companies, and support services
- a contractual and/or formal ownership or operational relationship with one or more universities or other institutions of higher education, and science research
- a role in promoting research and development by the university in partnership with industry, assisting in the growth of new ventures, and promoting economic development
- a role in aiding the transfer of technology and business skills between the university and industry tenants [59].

Even if the scales and features of science parks vary in real life from one park to another, these definitions are sufficient to show the very core of the concepts of *science park* and *research park*. The differences between these are virtually non-existent, as both of them, and the former in particular, refer to basic science and have traditionally emphasised university-industry linkages. It seems that the concept of science park is mostly used in the UK and elsewhere in Europe, while the term research park is preferred in the USA and occasionally in Japan. As examples of such formations let us mention Cambridge Science Park, UK, Stanford Research Park in California, USA, AREA Science Park in Trieste, Italy, and Kyoto Research Park, Japan. In some cases the university connection appears in the name of the park, such as Keele University Science Park in Staffordshire, UK, or Peking University Science Park in Beijing, China.

A third similar concept in this family is *technology park*, which takes the focus away from basic science toward applied science and technology, even if actual differences may not be obvious. In fact, it is used more or less synonymously with the terms science park and research park. Anyway, many parks emphasise this technological aspect in their names, such as Australia Technology Park in Sydney. A special form in this category is the software technology parks of India, which are based on the Indian Government's development scheme. Another special concept is *technology precinct* that is occasionally used in Australia. There are also *technology centres*, such as Technology Centre Hermia in Tampere, Finland, which are identical with technology parks.

A special form that relate to this family of concepts is industrial park and *high-tech industrial park* in particular. It refers to an industrial district in which high-tech as such is a consciously chosen profile of the park and selection criterion for tenants. Many older science parks have actually evolved from high-tech industrial parks, such as Stanford Research Park in California or Kista Science City, Sweden.

High-tech concentrations belonging to the science park family are presented in Table 2.

Table 2 Science park-type creations. (see [51,58,41,38])

High-tech industrial park

- High-tech industry facilities and manufacturing concentration.
- A special large-scale form of these are the high-tech industrial zones in China.

Research park

- Designed concentration of R&D labs and research and higher educational institutions in a park-like environment, which characteristically have little or no on-site production. In more concrete terms research parks are areas in which spatially contiguous land and/or buildings are leased or sold to firms who do basic or applied research or develop new products. They are usually affiliated with one or more universities as a foundation of their expertise and scientific research.
- Used usually interchangeably with the concepts of science park and technology park.

Science park

- A concentration designed to offer an attractive technology intensive environment to knowledge-intensive organisations and IT firms, providing infrastructure, institutionalised academic/research setting, and management services.
- Science park is often used as a generic term. It is frequently used interchangeably with the concepts of technology park, research park and high-tech park and also that of technopole. Its university connection is sometimes expressed by a special term 'university-related science park'.

Technology park

- Similar to science park, as it offers an attractive technology intensive environment in close proximity to university or research institutions. Usually denotes a tenant company involvement in applied science or high technology, with a special view to the development, transfer or commercialisation of high technologies (in contrast to parks that emphasise basic science research). In some conceptualisations technology parks are seen to be more production-oriented than science parks or research parks in which production plants may be totally absent.
- Synonymous with technopark or technology centre and also used occasionally interchangeably with the concept of technopole. Similar concepts are also in use such as software park and technology precinct. In an urban context such formations are sometimes referred to as urban knowledge park or something similar.

On some occasions science parks have been conceived as a species of a *business park* that is suited to serve the facility-location needs of technology-oriented companies, having close proximity and connections to a university [34]. They have, however, different meanings and connotations. Yet some business parks have a high-tech image and they may also be located in the larger concentration of technology companies, thus forming a part of a full-scale high-tech centre.

4.2.2 Technopolis formations

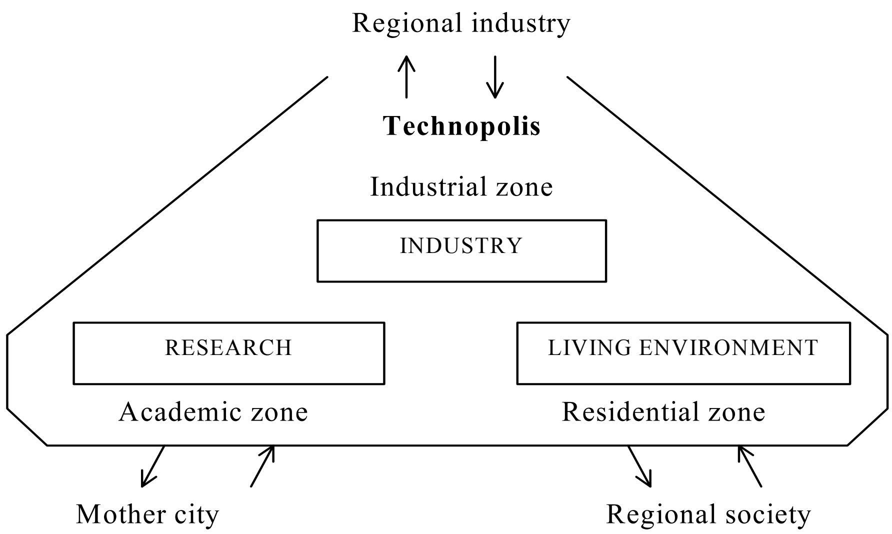
There are high-tech centre conceptions that point clearly to a wider spatial aspect of high-tech concentrations of urban or regional settings. To start with, the concept of *technopole* refers to a loosely defined concentration of technological expertise. In some conceptions they have been described as territorial communities where a distinct technological focus can be identified, such as Cambridge, UK; Montpellier, France; Austin, Texas, USA, etc.

[60]. The concept of technopole was born and is most commonly used in France. Castells and Hall [54] have used this term as a generic term to cover all high-tech industrial and research complexes.

Scientific and technological concentrations within a wider urban setting with urban functions and community life have been described by concepts like *science city* and *technopolis*. More recently such concepts as *intelligent city* have emerged to describe the basic features of new knowledge-based city formations. In Komninos' [32] account intelligent city characteristically refers to those functions that relate to knowledge, research, training, and technological development, whereas digital city is a more general concept in the sense that it refers to all the functions of a city that have a digital dimension and are connected to the real space and physical entities of the city. There is no unanimity in this matter, though. Nevertheless, places such as Cyberjaya, Malaysia's first state-of-the-art intelligent city, for example, is a technopolis-type creation focusing not only high-tech development and business but also living conditions within a wider urban area. It also reflects the features of an intelligent city with its emphasis on an intelligent urban system that supports high-tech development in the area. The more general concept of a *high-tech city* and similar concepts are usually applied to promotional purposes to refer to any city with high technological profile.

Note that the 'polis' dimension can be given different connotations depending on how narrowly or broadly this urban community dimension is defined (polis = city, urban community). The narrow definition was in the core of the Japanese Technopolis Plan as the 'polis' referred to the cooperation between industry, academic and local government (as defined by MITI's advisory panel in 1980). A simplified conception of this model is presented in Figure 2. Yet, one of the initial ideas was to encourage a rebirth of regional cities as high-tech cities, which suggests a wider conception of technopolis behind Technopolis Plan [41]. Anyway, a broader understanding of technopolis is to see the high-tech activities in a broader context of urban-regional development, including educational systems, transportation, and housing, forming an integral part of the urban system.

Figure 2 Simplified picture of the interactive functions of technopolis [41]



The broadest conceptions can be named large high-tech complexes or *high-tech regions*, which have various forms, as illustrated by such creations as Silicon Valley, Boston Route 128, Multimedia Super Corridor (Malaysia) and the like. Luis Sanz, the Director General of the IASP, gives the following formulation to *knowledge region*:

> "A knowledge region is a territorial unit with abundant human and social capital, containing structures, organisations and people actively engaged in generating [social and economic] development through science, technology and innovation, and whose interaction achieves a high concentration of technology-based firms and highly skilled knowledge workers and entrepreneurs." [59]

A sort of second generation of the concepts of regional communities includes *learning region* and *intelligent region*, which extends the idea from high-tech production systems to innovation systems and knowledge processes.

Technopolis and high-tech region formations are summarised in Table 3.

Table 3 Technopolis formations (see e.g. [38,51,54])

Technopole

- Refers to any concentration of high technological expertise, such as Sophia-Antipolis or Montpellier in France. It may refer to various types and scales of high-tech concentrations, from science parks to high-tech industrial zones.
- Sometimes used as a generic term in a similar way to science park or high-tech centre.

Science city

- Planned special urban areas with universities, research labs, and urban facilities and services, such as Tsukuba Science City in Japan. Science cities are originally government-led new town projects.
- 'Science city' (or 'science town') is a concept reserved for special science city formations, mostly new town projects or extensions of science parks with a designed urban form. Most of the other city conceptions have a different meaning, e.g. cities of science, technocities, informational cities, high-tech cities, intelligent cities, digital cities etc. Similarly, as a science city has some differentiating features from conventional science parks, they are not synonymous.

Intelligent city

- Is an urban formation that as an urban system is 'intelligent', i.e. it forms an environment of intelligence, learning and innovation at real and virtual levels capable of supporting the communication and interaction of a community of people for technological development, successful business, and proactive governance.
- Close to the idea of a smart community.

Technopolis

- A concentration of technological activities and expertise within an urban setting or designed urban form, closely associated with the Technopolis Plan of Japan.
- Sometimes used as a generic concept to describe any high-tech concentration. Technopolis is close to the originally French concept of technopole.

Table 3 Technopolis formations (see e.g. [38,51,54]) (continued)

High-tech region

- Broader environments and wider industrial complexes in which high-tech industry and research labs are concentrated, such as Boston Route 128, Silicon Valley, or the Research Triangle Park in North Carolina, USA, or the Multimedia Super Corridor, Malaysia, or Mobile Valley around Stockholm, Sweden.
- Similar to science region, knowledge region, high technology region or high-tech centre, but slightly different as a concept from intelligent region, innovative region or learning region, even if these are sometimes used interchangeably.

Learning region

- Regions with a high learning capacity achieved through a functioning regional innovation system, networks, and a culture of learning. A learning region is able to scan, monitor and evaluate its environment, and share and process knowledge through collective learning procedures, thus giving region-specific advantages in global competition. Baden-Württemberg is one of the most famous cases that has been characterised as a learning region.
- Close to such concepts as intelligent region and innovative region.

4.2.3 Incubators and small-scale centres

Beside science park and technopolis-type formations there are also small-scale centres and microenvironments that usually have a close connection to high-tech centres, either as small-scale concentrations or as microenvironments that operate in the science park with a focus on supporting businesses in their innovation processes or in their take off or growth phases, or as a concentration of research institutes with focused R&D activities.

One such concept is *innovation centre* or business innovation centre. It describes a small development that provides short-term occupancy premises and facilities for start-ups and small businesses to develop ideas and to conduct strategic research or prototype development (cf. [19]). Innovation centre is usually smaller and has a narrower scope than a science park, but nevertheless aims to provide a stimulating environment within a wider institutional frame with a cluster of firms and researchers where innovations can flourish (cf. [58]). Besides, it has been said that the original UK model of science parks is closer to US's innovation centres than to US style science parks [19]. Indeed, some innovation centres are more or less like business incubators, but they may also have more research-oriented profiles. Examples of this type of creation are the Cambridge Innovation Centre in Cambridge, Massachusetts, USA, and Canadian Innovation Centre, which is located north of the University of Waterloo at Waterloo in Ontario, Canada.

There are also *centres of excellence*, which gather actors whose know-how and competence have created, or are expected to create, an exceptionally high level of expertise and innovation in a certain sector. Such centres are typically funded by public sector organisations within centre of excellence programmes. They pool expertise, usually within or in collaboration with universities and research institutes. An example of a government policy-based centre as a part of the innovation system is the Centre of Expertise Programme of Finland for 1999–2006, implemented jointly by several ministries under the coordination of the Ministry of the Interior. Many centres are also university-based creations, such as the Centre of Excellence in Bioinformatics of the University at Buffalo, Buffalo, NY, USA.

Another small, or medium-sized concentration, that may include high-tech firms is a *business park* or business centre. It concentrates business activities in a certain building complex or a specific business location. The tenants may do business in manufacturing, sales, or services. Some business parks may have a high-tech image or they may be located near universities and high-tech companies, such as Bristol Business Park. Another formation close to business park is an *office park*, usually a small-scale office building complex, which is not generally conceived of as a subcategory of the family of science park-related concepts. Examples of such parks are Cambridge Square Office Park in the North Fulton corridor in metropolitan Atlanta, Georgia, USA; Stella Business Park in Leppävaara, City of Espoo, Finland, and Osaka Business Park in the City of Osaka, Japan.

Incubator is a microenvironment that usually operates in a science and technology park or beside a university (in many cases incubators inhabit just one building in a campus area or in a science park in which their activities are concentrated). It is designed to encourage start-ups and spin-offs to bring ideas and technological expertise to commercial realisation. What characterises incubators is that they usually offer extensive management support services and favourable conditions for the creation and early-stage growth of newly established small IT firms. As examples, mention can be made of the International Business Incubator in downtown San José, California, USA; the University of Central Florida Technology Incubator, Orlando, Florida, USA; Beijing Zhongguancun International Incubator, China, or the Centre for Internet Business Incubation affiliated to the Mokwon University, Daejeon, South Korea.

Lastly, most recent formations of microenvironments include *business accelerator*, which is a system designed mainly to support new ventures or companies developing their cutting edge technologies in order to accelerate their development processes, which then are expected to boost their growth. The accelerator may offer technology assessment, strategy making, business development and prototype development services. As examples let us mention the Business Accelerator of Communitech, Waterloo, Canada; the Business Accelerator of Kista Innovation & Growth (KIG) programme of Kista Science City, Sweden, and eAccelerator, which is a subprogramme of the eTampere information society programme, Tampere, Finland.

4.3 Functions and services of science parks

From the management point of view there are two basic realms of high-tech centre management. *High-tech cities and larger high-tech complexes* are developed on the basis of local and regional development policies. They are usually such complex formations that they are not 'managed' in the strict sense of the word but rather steered and governed by governments at different institutional levels. In contrast, *science parks* as territorially limited areas with buildings and with clearly defined management structure form more manageable environments. The same holds for microenvironments. In this section the emphasis is on the management of science parks.

A basic function of a science park is to provide infrastructure for the high-tech activities of research institutions and high-tech firms. In this sense they are characteristically property-based projects that have, however, extended their activities to include a wide range of management and business services. The reasons why such projects have been established in different countries, regions and cities vary, but one of the typical aims is to promote the businesses of knowledge-based small and medium-sized enterprises.

As summarised by Sanz [61], science and technology parks must provide the following elements and services to their clients:

- high-quality and adequate infrastructures (space, landscaping, communications and transportation accesses, good location, good facilities and buildings, etc.)
- good common services (office facilities, meeting rooms, parking, cafeteria, restaurant, hotel accommodation, security, etc.)
- good value-added services (telecommunication infrastructures, quality access to internet, videoconference, consulting services, commercial support for the companies, etc.)
- efficient links to university and research institutes, to researchers, laboratory and equipment facilities, etc.
- incubation units to encourage and facilitate the creation of new local companies
- international links and contacts to facilitate the access of their companies to international networks
- technology/knowledge monitoring and observatory, helping clients to be updated, to know what their competitors are doing, to know where are the sources of new and relevant technologies and knowledge, etc.

As to the practice of a science park, services can be divided into two broad groups as follows [57]:

1. 'Hard' business services: infrastructure
   – Real estate and property management
   – Telecommunication
   – Transportation
   – Human resources
   – Pleasant living environment
2. 'Soft' business services: management assistance
   – Technology transfer
   – Business incubation
   – Legal support
   – Protection of intellectual property
   – Financial incentives
   – Marketing support

A general trend in these functions has been from infrastructure to 'soft' services, and from production to innovations and commercialisation. Other more or less visible new directions are such as from incubation to accelerators, from innovation islands to innovation networks, and from real/physical places to virtual spaces (see [15,37]).

What science parks seek to achieve by these services can be grouped into four main categories [58]:

1. they contribute to regional development

2 facilitate innovation and industrial renewal

3 stimulate the commercial exploitation of research results

4 support new business formation and development.

These vary depending on the initiator and developer of a science park, because universities emphasise the commercialisation of research whereas governments tend to have broader goals which usually relate to the promotion of regional or national economies.

4.4 Assessing the results

Already by the 1980s it had become clear that science parks or wider high-tech complexes do not automatically create positive effects, especially not in the short term [62]. For an individual area, the high-tech industries or R&D units do not necessarily offer a great number of jobs. The risks relating to development are increased by the fact that at least according to US experiences the global success of high-technology firms is often linked to a single product and global growth in its demand. To succeed in this in turn requires a sufficient research input and innovative environment.

In regional development actual 'success' means in practice the creation of multiplier effects and positive externalities strengthening the regional economy, in addition to which high technology should help to reform the existing industries and services. The situation in Oulu is an example of the significance of multiplier effects. Nokia and other high-tech firms in Oulu buy almost half of their interim products from the companies operating in the region. The most important regional sector using interim products is the electronics industry and the telecommunications industry, whose purchases are directed at the machine and equipment industry, the metal industry, and the service sector. It seems that the multiplier effects that are most significant for regional development are created through the sub-contracting networks utilised by large IT firms and, on the other hand, by a demand for industrial services. It has been estimated that one job in high-tech industries creates about 0.7 jobs in the other sectors in the Oulu Region. [13]. The more developed and dynamic area surrounding the science park, the more it can generate jobs from high-tech industries of the area, be they on-park or off-park firms.

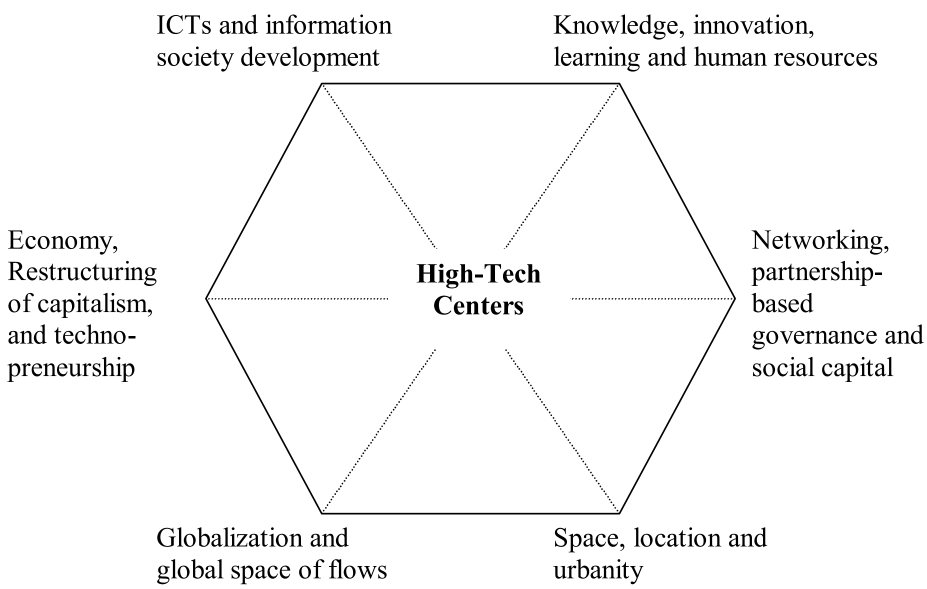
It is generally held that science parks offer a conducive environment to product development, cooperation with R&D organisations, support from technology transfer agencies, brand name, and quality premises [38]. Ferguson [58] studied what the actual impacts of science parks are as seen by the tenant firms themselves in selected Swedish science parks. Science parks aim to support new technology-based firms by offering a favourable business location in close proximity to research institutions. The actual benefits of such a park to firms, however, are rather modest. Firms in parks reported no significantly greater access or contact with researchers. The quality and impact of this connection, however, varies from one park to another. The greatest and most consistent difference detected was an image advantage associated with a science park location that firms both expected and felt they also received. This image and reputational capital helps, among other things, to gain access to customers and to create credibility. (On the evaluation of science parks based on the Cabral-Dahab Science Park Management Paradigm, see [63]).

There are, however, contextual and situational differences that favour different policies and practices and produce different outcomes. For instance, the role and development paths of the most celebrated science parks in the USA or Europe are very different from the cases of less favoured regions in those countries, not to mention those of Bangalore or Kerala in India or those of Chinese international incubators in Beijing and other metropolises. China, for example, gained new momentum since the 1990s after its open door policy and emerging integration into global markets. This created an opportunity to attract highly skilled and entrepreneurial overseas Chinese back to major metropolitan areas, providing a rationale for setting up international incubators.

4.5 New directions

The core content of high-tech centre studies revolves around spatial concentration of business generated from high technology and research. The main aspects to be taken into account when analyzing high-tech centres are illustrated in Figure 3.

Figure 3 Key dimensions of high-tech centres in context



It seems that all the dimensions presented in Figure 3 are likely to pose new challenges to high-tech centres in the foreseeable future. The premises of technopolitan planning as one model of high-tech centre development is certainly going to reach a new stage as science parks develop further and adjust to the changing conditions of global knowledge economy.

Globalisation and economic restructuring are certainly among the most important contextual factors that have markedly conditioned the operations and competition between high-tech centres and most likely will continue to do so. This is why even such global leaders as Silicon Valley will face a threat from emerging large economies and newly industrialised economies (NIEs), which may lag behind the technology and innovation capacity and managerial competence of high-tech leaders, but which are expected to grow fast, win considerable market shares in foreseeable future, and take a huge lead in production and innovation capacity over next ten to 20 years.

Similarly, *information society development* through extended use of ICTs in economy and other sectors of society as well as 'soft' dimensions of economy – knowledge, innovation, and learning – have already affected the role of high-tech centres, not only by greater emphasis on innovation but also by emerging efforts to built regional innovation systems and efficient institutional arrangements to support technology transfer. This dynamism of innovative and intelligent multi-actor setting is well expressed in many recent studies on how globalisation, knowledge-based economy, innovation and networks relate to the idea of a learning region [64–66,15].

New principles of organisation reflect the overall transition from hierarchies to *networks*, which implies more flexible organisation forms and structures. In addition, cluster-based policy has broadened the view of science parks and technopolises: rather than being autarchic islands of innovation, they form part of wider networks of production and of value chains, which calls for a cluster-focused development policy [67]. All these mean that location will have new relevance in the emerging new logic of the competition and cooperation of high-tech centres.

Networks have for years been seen as one of the most important elements of success models of high-tech centre development. The network approach has proved to be important from the competitive environment of Silicon Valley to welfare societies such as Finland or Sweden. As analysed by Saxenian [68], Silicon Valley has a regional, network-based industrial system that promotes learning and mutual adjustment among specialist producers of a complex of related technologies. Dense social networks and open labour markets encourage entrepreneurship and experimentation. In this respect its most important challenger, Boston Route 128, was not able to show similar institutional capacity and flexibility, because autarchic corporations that internalised a wide range of productive activities dominated it. It seems that the network-based industrial system of Silicon Valley has been well suited to conditions of technical and market uncertainty. Yet it seems that new challenges are waiting around the next corner due to the pressure caused by stiff global competition.

The social organisation of development activities has proved to be critical in developing high-tech centres. One of the core aspects of this can be traced to the social and cultural aspects of high-tech development. Components of *social capital* that will enable a community to enter on a dynamic spiral of growth include elements of the following types [69]:

- large number of small independent family-owned businesses, culture of independence, and entrepreneurial propensity to find a new business
- strong social cohesion and shared value system
- shared culture in which norms of mutual trust, reciprocity, commitment to collective welfare, and sanctions to control opportunistic behaviour are exercised
- technologically oriented vocational and professional training and education system
- intensive information flows and exchanges

- autonomy of strategic decision making in the local institutional infrastructure of local government, banks, educational institutions, large firms and associations, being able to provide quick response to the needs to firms.

A high level of social capital helps a community to adapt to changing conditions. This, in turn, relates to a city's governing capacity and the degree of local social capital, i.e. shared norms, high level of trust, and efficient networks and institutional arrangements [30]. In global comparisons the Nordic countries fared very well in building institutional environment with a pluralist structure, dense networks, and high level of trust. This has decreased to some degree the overall transaction costs of development activities and helped in creating well functioning policy networks and innovation systems (see [28]).

High-tech cities and large urban regions have shown considerable resilience as high-tech *locations* over long periods of time. They provide the concentration of brains, money, research and education, and quality-of-life attractions that are essential both for firms and for skilled workforce. R&D as well as producer services are unevenly located in urban regions. They have shown little tendency to disperse, in spite of the potential of the new ICTs and organisational forms that reflect boundary-eroding tendencies of globalisation and networking. Rather, what may be dispersed is more routine production and some engineering that may find its way to technical branch plants [16]. However, a new dimension that may slightly alter this situation is the emergence of *intangible islands of innovation*, innovation networks, and virtual science parks, which create new connections and flows between high-tech centres. One of the early expressions of the new trend was the South Wales Technopole Project proposed by the Welsh Development Agency in 1992. It reflected the search for a new generation of technopole by creating a 'virtual' innovation network, bringing the advantages of geographical proximity without the need for co-location [6]. Another similar case is the virtual network of European technology parks that has been piloted in the OnLi Project within the 5th Framework Programme of the EU [38]. The work of the Joint Research Centre, a research-based policy support organisation of the European Commission, reflects these new ideas [38]. As an example built to serve an individual technology park let us mention eTechnopark, which is a virtual extension of one of the most proactive Indian software parks, Kerala Technopark. It is a web-based platform envisaged as the unifying interface between actors within the Technopark and between the park and the outside world. The elements of this platform include:

- Technopark Infotech Alert
- Technopark eCampus
- an outsourcing engine to promote the business of Technopark companies
- world class IT platforms/applications for Technopark companies at a reduced cost
- delivery of other such new generation services to the knowledge community at Technopark.

This kind of virtual extension is designed to make the park more attractive and intelligent and more capable of utilising the new knowledge management tools.

Science and technology parks may have served well in the past decades, but there is increasing pressure to get rid of a fixed idea of a single physical site on which technological expertise and innovation activities are concentrated. There is a tendency from the technopolis model towards post-technopolitan command centres with new network-based design and more efficient coordination and guidance of the different agencies providing:

- technology and market information
- technology intermediation
- advanced technology services
- innovation financing.

These services are more and more growth oriented, seeking new ways to create innovations, to commercialise them, and to have easy access to global markets. As concluded by Komninos [70], the nodal, property, and marketing-led technopoles are transforming into multi-centre and multi-level research-production interfaces.

5 Contributions and structure of this special issue

This special issue of IJTM focuses on various aspects of global competition of high-tech centres. In the first section, the development paths of high-tech centres are plotted on a global scale by Professor Emeritus William F. Miller. This is followed by a description of the development paths of two prominent European science parks, Cambridge and Sophia-Antipolis, presented by Reader Elizabeth Garnsey and Senior Researcher Christian Longhi. Lastly, Assistant Professor Willem van Winden, Senior Researcher André van der Meer and Professor Leo van den Berg analyse the ICT cluster trajectories during the 1990s, providing case descriptions of the European cities of Amsterdam, Cork, Dublin, Groningen, Helsinki, Jönköping, Oulu, and Stockholm.

The second part discusses urban knowledge parks and science cities as special high-tech centre formations. First, George Bugliarello, President Emeritus and Professor of Polytechnic University, discusses urban knowledge parks with a special reference to Metrotech. The other article in this section is Professor Ari-Veikko Anttiroiko's overview of science cities of the world.

The third section addresses the role and the impact of science parks. It starts with Dr. Regis Cabral's article, in which the Cabral-Dahab Science Park Management Paradigm is applied to the case of Kista Science City, Sweden. In the next article Professor Rolf Sternberg analyses how technology centres in Germany have affected regional economy. The last contribution in this section is Senior Researcher Richard Ferguson's interesting account of why firms in science parks should not be expected to show better performance than those outside parks.

In the next part, broader aspects of high-tech centre development are highlighted by focusing on regional intelligence and innovation systems. The section opens with Professor Nicos Komninos, who writes about regional intelligence. It is followed by a paper by Professor Philip Cooke, who describes the role of research in regional innovation systems. The next article presents a comparative analysis of the local innovation system governance in the cases of Oxfordshire, Stuttgart and Toulouse, authored by Professor James Simmie, Associate Professor Corinne Siino, Associate Professor Jean-Mark Zuliani, Professor Emeritus Duy Jalabert and Professor Simone Strambach. The last article in this section describes knowledge transfer and industry innovation in relation to nanotechnology by the South-West Sydney Organisations. This description is given by two Australian experts, Senior Research Fellow Cristina Martinez and Regional Development Facilitator Kim Leevers.

In the last part the focus is on the East Asian high-tech centres. First Professor Shigeru Suzuki gives a detailed description of the technopolises of Japan, followed by Professor Sang-Chul Park's case description of the Daedeok Science Town, South Korea. In the last two articles attention is directed to Chinese experiences. First Associate Professor Yongling Yao describes high-tech concentrations in China. After this, more detailed description of high-tech industrial development zones in China are given by Director Lingji Li, Assistant Professor Ping Hu and Lecturer Lei Zhang.

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