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(Bari, 26th and 27th March 1992)

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Proceedings of the International Workshop on Science Park Evaluation

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FOREWORD

The MONITOR/SPEAR Programme of the European Commission is designed to developing R&D Evaluation Methodology. This International Workshop in Bari was held to discuss Evaluation Methodology for Science Parks in the context of the SPEAR Network Group. This topic has become more pressing in view of the recent stepping up of EC R&D Infrastructure Programmes towards the less favoured regions of the Community.

The Commission is extremely grateful to Professor Gianfranco Dioguardi, Chairman of TECNOPOLIS Csata Novus Ortus in Bari and wishes to warmly thank Dr. Umberto Bozzo for hosting this Workshop. This expression of gratitude extends, of course, to all those in Bari TECNOPOLIS who made the necessary arrangements for the work to run so smoothly, and to Miss Maristella Marroccoli in particular. We must also thank the participants themselves for their contributions to the Workshop.

The discussions were essentially divided between Findings (on the current Science Parks' performance) and Evaluation Methodologies. The reader may like to know that a baseline discussion on the concepts of science parks (and the like) had been initiated in the former SPEAR International Workshop (Braga, 1991), proceedings of which have been published by Universidade do Minho, Braga, Portugal.

Findings related to Evaluation

As to the **Findings** on the Science Park performance, we would like to single out the following points:

- The high expectations that Science Parks would stimulating large numbers of new company start-ups seems now to be unfounded.

  Similarly, the expectations that academics would become entrepreneurs, and the benefits from extensive day-to-day synergies between academics and companies have proven to be over-optimistic. However, it would appear that measurement of success should not be based strictly on these criteria. Indeed, some papers suggested that such synergies are often non-existant. This requires further investigation. A disapointing result is that Science Parks seem to have achieved little in terms of technology transfer.

- Drawing on the US experience, it would seem that the performance of Science Parks improves over time, i.e. the older Science Parks are the most efficient although the evidence is somewhat mixed. It is important for a Science Park to be closely connected with a University, since some evidence suggests that this may lead to higher performance rates. The major constraint appears to be "sub-critical" environment, i.e. inadequate population size, too low regional economic growth and problems of individual leadership.

- In contrast to some of the less optimistic views of the performance of Science Parks, the lessons from the particular case in Germany, deserve further consideration. Science Parks may be viewed as a cradle for Regional Development (i.e., as a means of attracting new businesses together with R&D-based companies). Yet the fact that a good number of companies in a number of Science Parks reported no in-house R&D activity and no real contact with the local University suggests a need for further thought about the rationale for Science Parks.

- Of particular importance are the findings which suggest that both on-park or off-park firms tend to be equally innovative, i.e. that Science Parks generate no extra incentive for innovation that cannot be found elsewhere. This is certainly a matter for further investigation.

- As far as the scientific dimension of Science Parks is concerned, the "excellence" factor is critical. The factors promoting excellence (which remain ill-defined) may well be the key for higher success rates.

Some key points relating to Evaluation Methodology

As far as **methodological lessons** are concerned, we would like to single out the emphasis on "quasi-experimental methods", i.e. the evaluation of Science Parks with an extensive use of control groups, thus enabling that net (rather than gross) effects are drawn out.

Some other important methodological issues are related to assessing the local environment in which the Science Park operates (what are the key indicators ?), the time scale for the emergence of spin-off companies and their size (what do we know of them in the longer term?). The methodology ought to be especialy focussed on identifying causes and effects at the various levels of analysis, i.e. input, performance and output level. It should also breakdown effects into first, second and third order magnitude or timescale because effects are certainly of a multiple character and tend to produce differentiated impacts. As demonstrated by this Workshop impact assessment remains a very difficult problem for regional policy analysts.

The key success criterion remains whether or not technology-intensive firms have steadily developed, (either assuming the form of true R&D spin-offs, local R&D Units of companies or local branches of Multinationals).

This suggests that some of the crucial areas of future methodological work will be:

to assess the multiplier effects of Science Park (e.g., what do on-park companies really contribute in terms of money and employment from the regional viewpoint, and particular emphasis should be given to the true R&D spin-offs).

to assess the economies resulting from the agglomeration effect i.e., the effect of bringing together Industry and Science. Underlying this, is the problem of measuring the so-called synergies that are expected to develop between companies and academic community in the day-to-day life of a Science Park. It is probably true that professional evaluators fail to fully understand the problems of measuring this type of interchange. This pertains both to typical economic measurement (e.g., economies of scale in the bringing together distinct activities) and to measurement of factors as economies involved in procuring information (what one might call the "economics of information"). At any rate, the findings on the negligible "proximity effect", quoted in the discussions provide important food for thought.

To develop regional "models" which outline the potential **for development of a single region via the Science Park mechanism** (e.g., a region which has a good number of diversified industries, as well as a sub-critical mass of research capability, might require the setting-up of a Science Park more in the fashion of the quoted German case, i.e. aimed at attracting businesses and not restricted to particular fields of activity. As opposed to this, a region which has significant scientific expertise, should design a Park with the aim of attracting relevant industries in a more specialised fashion. This would, in principle, help to define the mission of the Science Park and thus to provide stronger criteria for evaluation, particularly ex-ante).

Apart from these issues, this Workshop also identified a handful of **core indicators**. These ought to provide the backbone for the evaluation, in particular:

Land area,
Building area,
Facilities by type of use (e.g., incubator, Training),
Tenant companies by type of activity and type of spin-off (e.g., local, private or semi-public, multinational),
Nr. of jobs and skills by type of activity
Firms return on investment,
Patents applications and licensed out
Overall turnover (and R&D undertakings in particular) by type of financing source
Regional (and national) main Economic Indicators.

We would like to conclude this introductory note by referring to the discussion on the need for an iterative and interactive evaluation process. These are evaluations designed to interact closely with the management of programmes, thus providing new strategic goals as well as to generating inputs to improve management effectiveness. Although this type of evaluation has not yet been formalised, it does seem to be a rather interesting rationale for evaluation exercises and one which could provide greater value for money.

Methodological Issues in the Evaluation of U.S. Technology Parks

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As a general matter, economic development programs are implemented in the United States with little prior study, and are rarely subjected to rigorous evaluation after they have been put in place. The "test" that determines their desirability, both *ex ante* and *ex post*, tends to be political rather than economic. Symbolism plays a role in the attractiveness of many programs. For example, there is a bias toward "bricks and mortar" programs that politicians can cite as physical evidence of their concern, over service-type programs that are more invisible. Elected officials who want to communicate their commitment to high wage job creation, therefore, are likely to support the construction of a high tech research facility or technology park, more than job training and education programs for workers. Similarly, elected officials place importance on an image of activism. There is a bias in economic development policy-making toward doing something rather than nothing, even if that something does not produce net benefits (in a benefit-cost sense). This behavior is revealed, for example, in a distinct "bandwagon" or contagion effect. We see states and local governments adopting programs that have been introduced elsewhere, not because those programs have been shown to be effective, but rather to avoid the appearance of being inert or backward. For elected officials interested in the symbolism of programs, evaluation is irrelevant. For policy-makers motivated by a fear of appearing inert, evaluations are eschewed because they are too time consuming, and often inconclusive. In fact, there is evidence that elected officials intentionally choose not to have programs evaluated, so that political opponents do not have reason to criticize their actions.

This is not to say that there is little interest in the United States in rational planning, which includes careful *ex ante* and *ex post* evaluation. Many of the planners and policy analysts who advise elected officials, and most academicians, place high value on economic efficiency and policy effectiveness as criteria that must be satisfied in the design and implementation of programs. Their problem is to conduct studies that do not sit on the shelf, but find their way into the policy-making process.

To be fair, the difficulty planners and analysts have in conducting useful evaluations is only partly a consequence of culture clash between them and elected officials. There are also methodological problems which make the evaluation of some public programs inherently difficult. Those problems increase the time and cost of evaluations, which further erode their attractiveness to elected officials.

In this paper, I discuss methodological problems that surround the evaluation of technology parks. In doing so, I beg the issue of whether those evaluations would be useful in the policy-making process if they were conducted properly. Suffice it to say, however, that the resolution of the methodological problems is necessary, if not sufficient, for evaluations to be useful to policy makers. First, I discuss the nature of the problems and propose means to overcome them. Then, I draw on my own work (with Harvey Goldstein) to illustrate what a methodologically correct evaluation of technology parks would look like.

The choice of technology parks as a focus of study was motivated by the observation that they are among the most popular economic development strategies currently in use, not only in the United States, but in Western Europe and the Pacific Rim, as well. In the United States, for example, there has been an explosion of technology park development. At last count, there were more than 120 parks in operation, with many more in the planning stage. Those parks, moreover, represent a small proportion of all parks that have been started (many have failed). They are located in at least forty of the fifty states, in both dense metropolitan and more rural settings. Figure 1 shows the geographic distribution of U.S. technology parks. Figure 2 shows the age distribution of those parks, indicating that the great majority of parks in operation are relatively young.

Methodological Problems in the Evaluation of Technology Parks

Technology parks present particular problems for researchers who wish to conduct evaluations. For example:

- Unlike some programs that have a single objective, technology parks typically have multiple objectives. Therefore, the definition of "success" will differ, depending on who you ask. Moreover, even when a single objective is selected, "success" toward that objective is difficult to operationalize. In short, "success" is a normative concept.
- Analysis of the determinants of "success" is inherently limited, and perhaps biased, because a full treatment of "failures" is not possible. If we define a "failed" park as one that no longer exists, we have eliminated the possibility of studying it.
- If "success" is defined in terms of the creation of net new economic activity we have a problem of counterfactuality. That is, we only observe outcomes where parks are located in the presence of the park. Special procedures must be applied to ascertain outcomes in that location if the park did not exist.
- Data to conduct a full evaluation are not routinely available. Special procedures must be used to collect and create the required data.

These problems are discussed more fully below.

Defining "Success" and "Failure"

There is no consensus about the definition of success among public officials, university administrators, economic development planners, and others who are involved in technology park development. Various actors cite different goals for park development, depending on their particular perspective. Park managers and economic development officials generally cite economic development as most important; university administrators are generally most concerned about university and technology development; and private park developers tend to cite income or profit generation as the key goal.

We can deal with these differences in two ways. First, we could employ multi-objective (or multi-attribute) planning and attempt to weigh, then combine, each of the goals to come up with one composite benchmark. In practice this is difficult to do because weights are hard to assign and progress toward the goals tends to be measured in different units. For example, economic development may be measured in terms of job creation; technology development in terms of new processes and products created; and profit generation in terms of dollars. A composite outcome measure therefore is hard to construct.

A second approach is to adopt the perspective of one set of actors and perform the evaluation for them, recognizing that the conclusions drawn may not be relevant for others. That avoids the problem of combining different units of measurement, but not the problem of operationalizing the definition chosen.

Because we consciously directed our evaluation toward elected officials and park managers, we used their most frequently cited goal -- economic development -- as the relevant outcome measure. We still had to decide how to account for somewhat different types of economic development outcomes, including job creation, income growth, greater income equality, expanded opportunities for special groups within the labor force, and regional economic restructuring. These are not necessarily mutually consistent.

Both "success" and "failure" can be measured in different ways over the life cycle of a technology park. In the start-up, or incubation stage of park development, for example, we might judge success as the ability of park management to recruit at least one R&D organization without relaxing requirements for location. Success in this first stage, then, would really be a potential" measure because the parks could fail in a later stage, either by going out of business or by changing their focus away from technology.

We can measure success in the consolidation and maturation stages of park development, at least in terms of economic development, by counting the number of jobs represented by the R&D organizations that have located in the park, as well as the following *induced* changes in the region: employment growth, business start-ups, regional income and income equality, employment opportunities for women and minorities, occupational mix and the local wage structure (related to "regional restructuring"), research capacity of the local university(ies), and the business climate and political culture.

The Problem of "Counterfactuality"

As just noted, success in the middle and late stages of park development should be measured in terms of "net" or "induced" outcomes, or in common parlance, by asking: what would have happened in the region if the park did not exist? That is a counterfactual question because the only situation that is observed is one that includes the park. To get around that problem one can employ an interrupted time series or quasi-experimental research design. With the former, outcomes are plotted on a time line and the slopes of the segments before and after park development are compared. If the intervention (park development) had an effect, the slopes would differ. However, this technique does not control for other influences that may account for changing slopes.

Quasi-experimentation refers to a class of research designs that apply some aspects of classical experiments -- such as the use of control groups and pre- and post-test observations -- to causal research in actual field settings. It differs from classical experimentation because the random selection of cases into experimental and control groups is usually not a feasible (or ethical) option in field research, nor is the physical isolation of cases from all other putative causal influences. Quasi-experimental designs potentially can increase internal validity of research findings toward the level of validity that can be obtained in classical experimentation.

In the context of technology parks a quasi-experimental research strategy would treat counties with parks as the experimental group and counties without parks, but similar in other respects, as the control group. Both would be compared on the basis of some outcome variable. If park development had a systematic effect, the outcome variable in park counties would have changed more than in the other counties.

Data

I stated above that success in the consolidation and maturations stages of park development, in terms of economic development outcomes, ideally would be measured in terms of employment growth, business start-ups, regional income and income equality, employment opportunities for women and minorities, occupational mix and the local wage structure (related to "regional restructuring"), research capacity of the local university(ies), and the business climate and political culture. Data to measure the gross level of many of these outcomes can be gleaned from secondary government sources. But, data to estimate the net impact of parks are not readily available and must be deduced from published data or collected directly from businesses inside and outside the parks and from universities. For example, it is not enough to observe the number of high tech start-ups in a region over time. To estimate the impact of the technology park on business formation we can ask businesses to indicate the effect of the park and its tenants on their start-up or spin-off decision.

Similarly, published data reveal only the gross direct employment and payroll outcomes -- which park promoters typically cite as evidence of success the employment and payroll of park businesses. (Research Triangle Park, for example, boasts of 32,000 employees and $1.5 billion in payroll.) This is only part of the story, however. As noted above, some of those jobs and payroll dollars may well have been created within the region, even if a park had not been developed. Quasi-experimentation should account for that. In addition, the real effect of a technology park on the region's economy is likely to extend beyond the park through input-output linkages to other businesses in the region. That can be measured using detailed case studies in which trading patterns within the region between park and non-park organizations can be observed.

An Evaluation of U.S. Technology Parks

The foregoing discussion indicates several strategic research decisions that had to be made in order to conduct our evaluation. The first was whether to limit the analysis to statistical analysis of a large sample of parks, using a quasi-experimental design, or to supplement that approach with detailed case studies.

The quasi-experimental design method has the advantage of having a large number of observations of areas both with and without parks since the cost per unit of observation is low. It is the large number of observations that allows us to control effectively for rival factors (besides the existence of a technology park) that may affect an area's economic growth performance. The large number of observations also allows us to generalize to the full population of parks (i.e., high external validity).

The disadvantages of the quasi-experimental design include the difficulty of identifying a control group that is similar to areas with technology parks in all important ways. In practice, we cannot control for all other rival factors in a formal sense. Instead, it is necessary to rely upon logic and experience in particular cases to rule out some factors. A second disadvantage is that in order to have standardized measures for all the cases, some valuable information about some parks becomes inadmissable in a quasi-experimental design, including much of the contextual and historical factors that may have contributed to a particular park's success or failure.

The advantages of the case study method are the abilities to incorporate current and historical contextual factors -- political, social and personal -- directly into the analysis and interpretation of the results, and to collect highly detailed primary data from a variety of actors and textual sources. Among the disadvantages of the case study method is a high cost per case. When resources are limited, the researcher often is required to limit the number of cases. With a small sample size one has difficulty generalizing the case study results to the full population (research methodologists refer to this problem as "low external validity").

Rather than relying on either approach exclusively, we decided to use both. We employed a quasi-experimental research design, using data from published sources and a mail survey to all known park managers (from which we received 77 responses). We also conducted three detailed case studies, obtaining information from a number of "key actors" in each, either by mail or face-to-face survey: (1) the park manager or director; (2) the population of businesses and organizations located in each park; (3) a sample of high-technology businesses located outside the park but within the designated region; (4) key administrators in universities affiliated with the park; and (5) selected state and local government officials and business leaders.

Our hybrid approach allowed us to maximize the internal and external validity of the results, given the resources available. In the remainder of this paper I summarize the insights this strategy provided.

Results from the Large Sample Analysis

After experimenting with different definitions of economic development success or failure we chose to use, as the measure of success, the difference in total employment growth rates -- both after and before a park had been established -- between counties with a technology park and a control group of counties without a park, having the same metropolitan status, population size, and location as the counties containing the technology parks. By matching control group counties to each county with a park in that way we attempted to control for selection differences between areas with and without parks. Tables 1 and 2 show the results of this data construction for forty-five parks.

Table 1 indicates that the *after* total employment growth rates for park counties range from more than 10 percent to approximately -6.0 percent. These numbers mean nothing unless they are compared to some benchmark, so the control group counties' growth rates are also shown. The respective difference in growth rates ranges from +9.25 to -9.75 percentage points. Thirty-two of the forty-five parks are in counties that grew faster than their control group counties in the years after the parks were established. Using a more stringent success criterion, which requires park counties to grow 20 percent faster than control group counties, we find that twenty-six of the forty-five parks have been successful. Table 2 presents the data in a different format. The table distinguishes parks that employ more than one hundred employees from those employing fewer than one hundred to account for the possibility that very small parks are not as likely to have had a significant impact on their region, despite the high success index they may have been assigned. The table lists sixteen parks that are judged to have been successful under our stringent criterion, another ten parks that have been successful under our more lenient criterion, and nineteen parks that have ben unsuccessful -- at least in terms of induced employment growth.

What accounts for these rankings? Specifically, are there local economic and/or park characteristics that systematically account for a park's success or lack of success by our measures? First, it is critical to stress again that the definition of "success" used here is a limited one. One limitation in our approach is that we look only at the employment growth rate for the first five years after park creation. Many of the economic development impacts of parks will take longer than five years to materialize. In addition, parks that are not ranked high in our lists may still be judged to be "successful" by other measures. Conversely, because we are not able to control for all conceivable rival factors, we undoubtedly are listing as "successes" some parks that are in counties that would be growing relative to their respective control groups even if a technology park were not present.

Table 3 presents cross-tabulations of the success indicators and four key characteristics: the parks' vintage, the geographic region of the country in which the park is located, the size of the metropolitan area in which the park is located, and the type of university with which the park is formally or informally associated. Vintage is important for three primary reasons -- because it takes time for a park to establish linkages with other businesses in the region, because new R&D organizations are highly attracted to regions that already have a concentration of R&D (i.e., localization economies matter to R&D organizations), and because there is a premium for being an "early bird" since the supply of technologically-oriented businesses is limited. Geographic region is included as a proxy for the local industrial base and political culture. The Northeast and North Central/Midwest regions, in general, have older manufacturing bases and higher rates of unionization, for example, than the other two regions. Size is included to capture the presence of agglomeration and urbanization economies, and economies of scale, in general. And, the type of university is included to enable us to test whether the ability for neighboring private sector scientists/engineers and university researchers to collaborate has affected growth.

The table suggests the following:

- Vintage. We split the parks into three vintages. Because no parks were established between 1971 and 1973, we made the break between old and middle-aged parks at that point. Thus, "old" parks have been in existence at least twenty years, "middle-aged" parks have been extant for at least eight years, and "young" parks have been in existence for no more than eight years. Old and middle-aged parks indeed appear to have been more successful than the youngest group of parks.

The difference in performance between old and middle-aged parks is not large, and may be an artifact of the arbitrary dividing line we have drawn.

- Region. We can make two observations of note from the left-hand side of the table: parks in the northeast region of the U.S. generally are older than in other regions, and almost half of all parks are in the South. Entries on the right-hand side of the table suggest that parks in the Northeast and North Central regions have been more successful than those in the South and West.

- Metropolitan area population. Parks in medium-sized regions, with populations between 500,000 and 1,000,000. appear to have performed better than other parks, and, parks in small areas, with populations less than 100,000, have performed better than many might have expected. These results, of course, are sensitive to how we arbitrarily draw up the size classes.

  The results for small areas can be explained, in part, by the fact that parks located in those regions can serve the same function as a central business district: they can be a source of agglomeration economies that small places otherwise would lack. That parks in areas with populations between 500,000 and 1,000,000 have performed relatively better might be explained by those areas being sufficiently large to offer various urbanization and agglomeration economies that are important to attracting R&D activities. Those economies include a diversified pool of skilled labor, cultural amenities, good airline service, and necessary business support services. Yet, those areas are not so large as to have generated disamenities, congestion, environmental degradation, a high cost-of-living, and other diseconomies of metropolitan scale.

- Affiliation with research universities. Parks affiliated with type I research universities appear to have been more successful than parks without that affiliation. There is no clear difference between parks affiliated with type II research universities and parks without a research university affiliation. That may be because the counties shown to have no affiliated research university may still have doctoral-granting universities, specialized engineering and medical institutions, and other types of higher education facilities which also can benefit businesses in the technology parks.

One of the difficulties in interpreting the results in Table 3 is due to the fact that the effect of each causal factor on success is not isolated from all other factors. A standard way to control for other factors is to employ multiple regression analysis. We have performed this type of analysis in which we explain the variation in the park success measure (i.e., the dependent variable) by the characteristics listed in Table 3, as well as other explanatory variables. Alternative measures for seven types of factors were formulated and tested, as well, including: (1) location, (2) vintage, (3) characteristics of park businesses, (4) university linkages, (5) park-provided services, (6) park-imposed restrictions, and (7) governmental assistance.[1]

Three of the variables above proved to be statistically significant explanatory factors in most of the alternative models that were estimated: the age, or vintage of the park; formal affiliation with a public of private university; and the provision of garbage collection services. That is, these are the factors best able to explain the variation in the measure of technology park success. We present the results from two of the models below (ordinary least squares and logit models) and then present additional results from a survival/hazards model.

Table 4 contains results from a regression of the relative employment growth rate differences ("DIFF" in Table 1) on region (represented by dummy variables), the square of vintage, metropolitan population, the use of deed restrictions (represented by a dummy variable), the provision by park management of garbage collection services (dummy variable), the use of government assistance by park businesses (dummy variable), and park ownership by a private or public university (dummy variable).

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[1] Three alternative measures of *locational characteristics* were developed — a regional dummy (or indicator variable) to capture industrial base, political, and socio-cultural differences; a dummy to indicate whether the park's county was a core county in a metropolitan area, a metropolitan non-core county, or a non-metropolitan county; and the park region's population. The last two measures are highly correlated and serve as proxies for the same underlying phenomena, namely the presence of agglomeration and urbanization economies. Consequently, they (and others that are similarly correlated) were not used in the same regression model.

For *vintage* we used the number of years parks had existed before 1985. Because 1951 was our first observation, this variable ranged from 1 to 34.

As *characteristics of park businesses*, we used data on the types of favored businesses within parks, and the percent of floor space within parks that is for small businesses, in incubators.

We tried three measures of the *university-park linkage*: a dummy indicating whether the parks are owned and operated by a university, a dummy indicating whether the parks are proximate to a research university, and a dummy indicating whether the parks are near a type I research university.

The *park-provided services* we included as dummies included garbage collection, fire protection, and road maintenance. The *restrictions* we tested include deed restrictions, in general, and a limitation on manufacturing activity.

Finally, we included dummy variables (0 or 1) in different regressions to indicate whether *government subsidies* to park businesses or management.

We squared the vintage variable for two reasons. First, the results in Table 3 suggest that vintage (time) enters the model non-linearly. Second, we wanted to count time more heavily than other variables in the analysis because it can contribute to success in several ways, as we discussed above. We used garbage collection as the "bellwether" infrastructure service because it is one of the few services for which there are private alternatives; hence provision of garbage collection services by park management represents a convenience and probable cost savings to the park business. Finally, we chose the organizational status of the park (owned by university) as the measure of "the university connection" after trial and error. We suspect that it outperforms other measures of university affiliation in our models because it is less ambiguous.

The results indicate vintage, garbage collection, and university variables each are significant explanatory variables (at the 0.10 level of significance) and relate to the dependent variable in the expected direction. The overall explanatory power of the model, however, is low. That is not so surprising given the nature of the data and the small sample size.

Table 5 shows results from a regression model using a dichotomous measure of park success as the dependent variable, and logit estimation.

In these results garbage collection and university ownership are statistically significant variables but the vintage variable ceases to be a significant explanatory factor of park success.

Because of the inconsistent results for the vintage variable between the ordinary least squares and logit models, we estimated a third "survival/hazards" model. This class of models is used with events (such as the creation of technology parks) that can terminate in death (or failure) over time. The model allows one to estimate "survival rates" (or, in this context, success rates, as indicated in Table 2) for different vintages. The key insight from this analysis is that hazard rates are, indeed, higher and more significant for younger parks than for older parks.

Lessons about Park Failures from the Large Sample

In the discussion of the econometric results above, I focused on the determinants of "success," measured as the direct plus induced regional employment growth that can be attributed to technology parks. The results also shed some light on the determinants of "failure," at least to the extent that we define "failure" as a small or null value for the dependent variable. For example, we can interpret the ordinary least square regression and hazards model results to mean that the younger the park, the higher the degree of failure. Similarly, the results can be read to suggest that parks that do not collect garbage are more likely to fail than parks that do provide that service.

The insights these results provide about park failures are limited for at least two reasons. First, the data we use in the regressions are only from parks that have not ceased to operate. We also would like to know how the parks that have "died" differ from those that continue to live. Second, the particular measure of success we have used is most appropriate for parks that have passed into the maturation stage for the very fact that induced employment effects can take years to materialize. Consequently, younger parks in the sample that have not yet entered the maturation stage may prematurely be judged as failures. Ideally, we would like to identify predictors that indicate which young parks are likely to proceed into the maturation stage, and which parks will not.

A complete empirical analysis of failure is not possible because data are difficult, in many cases, impossible, to collect from parks that have ceased to exist. However, we can use anecdotal information about failed parks and data from existing parks to understand better how parks that fail differ from parks that are successful.

Park managers and other technology park professionals with whom we spoke, including some individuals who have worked in parks that did not attract businesses, identified two factors that are associated with park failure: a lack of commitment and patience by key individuals, and distributional politics.

Data from existing parks reveal another important set of reasons for failure: inadequate population size and growth potential in the region, and the absence of a research university. The small size of regions limits the possibilities of agglomeration and urbanization economies. Slower growth means that the region has relatively less future development potential, including expanding pools of labor and supplies. Not having proximity to a research university restricts R&D organizations' access to intellectual capital, regardless of the region's size.

Table 6 includes data from three types of parks: with no employees, with less than 100 employees, and with 100 or more employees. We present data on average metropolitan area size and growth rate, percent of parks in metropolitan areas, and percent of parks affiliated with research universities, by year of technology park birth, for each employee size class. Following our discussion of success and failure above, we can designate parks established prior to 1985 and with zero employment as of 1988 to be failures in the incubation stage. Similarly, parks established prior to 1982 and with fewer than 100 employees as of 1988 can be designated as failures in the consolidation stage, and parks established prior to 1985 having fewer than 100 employees as of 1988 can be classified as "at risk failures" in that second stage of development.

We can use the table to ask: How do the parks that have "failed" differ from those in the table that have not? Parks that have failed are more likely to be in smaller regions, in counties that have had lower employment growth rates, and are less likely to be associated with a research university.

Insights from a Sample Case Study

Since it was not possible to select a representative sample of cases, we decided to study three relatively mature parks that are generally believed to be "successful." Given that, we sought diversity in location, regional economic structure, and university affiliation. With mature parks enough time will have elapsed for any outcomes resulting from the technology parks' establishment and development to be observed. By using "successful" parks as cases, we can attempt to ascertain the critical success factors that, if discovered, would be instructive for future public policy and private investment decisions. That is not to say that unsuccessful parks are not valuable to study. But it is more difficult to obtain reliable information from key informants on unsuccessful parks, for political and interpersonal reasons.

After discussing the selection criteria with colleagues familiar with technology parks, and after communicating with park managers about their interest and willingness to cooperate in a case study, we finally selected the Research Triangle Park in North Carolina, Stanford Research Park in California, and the University of Utah Research Park in Salt Lake City, Utah.

Key Methodological Issues. In each case study we attempted to measure the impact of park development on firm location, employment growth, growth in level of per capita personal income, level of income inequality, local labor market conditions of women and minorities, and the overall innovative capacity of the region. I focus below on the first two for one technology park -- Research Triangle Park in North Carolina -- because they illustrate the use of input-output analysis to estimate the indirect growth effects.

Research Triangle Park. Created in 1959, the Research Triangle Park (RTP) in North Carolina is the largest, and considered to be one of the most successful, technology parks in the world. RTP occupies 6700 acres in the middle of a triangle formed by the University of North Carolina in Chapel Hill, Duke University in Durham, and North Carolina State University in Raleigh. There are approximately 50 R&D-oriented organizations in RTP with a combined workforce of about 32,000. From its beginning, RTP has deliberately sought the R&D branch plants of major, technology-oriented corporations. The list forms a veritable who's who of the Fortune 500 -- IBM, Data General, Dupont, Northrop -- as well as foreign-based firms such as BASF, Burroughs-Wellcome, Glaxo, Ciba-Geigy, Northern Telecom, Rhone-Poulenc, and Sumitomo. These and other organizations occupy spacious, low-rise, often architecturally distinct buildings in a low-density, wooded setting. Indeed, the appellation "park" is no misnomer in the case of RTP.

In addition to being one of the earliest, largest, and most "park-like" planned concentrations of R&D activity in the world, RTP serves as a model because it is the symbol of one of the most dramatic cases of regional economic restructuring that has yet been documented. For that reason, representatives of regions that have little or no technology-oriented activity, or tradition, look to RTP and see some reason for optimism. The story of RTP is also one in which a particular set of actors have made a big difference.

Firm location and employment growth. The existence of RTP appears to have been a significant factor for the location of organizations both inside and outside of the park to locate in the region. For the former, we estimate that 21 of the R&D organizations in the park probably would not have located in the Raleigh–Durham area if RTP did not exist (see Figure 3). These percentage figures translate into an estimated direct employment growth for the region of about 18,900.[2]

For the sample of businesses in selected industry sectors that located in the region but outside RTP after the latter was founded, we estimate that approximately 16 percent would not have located in the region if the park had not existed. This translates into an induced employment impact from RTP of about 1240 jobs in the region's high–tech sector.[3] Approximately one–half of the 16 percent probably would

[2] These estimates are based on the responses from the CEOs of park organizations to the question of whether the organization would have located in the region if the technology park had not existed. Possible responses were: (1) very likely, (2) likely, (3) maybe, (4) unlikely, and (5) very unlikely. The estimate of the percent of organizations, and the employment in these organizations, that would not have located in the region is calculated by assigning the following probabilities to the response: very unlikely = 0.9, unlikely = 0.7, maybe = 0.5, and likely and very likely = 0.0.

The estimate of the number of organizations that would not have located in the region but for the park is calculated as the sum of the probabilities over all respondents. We then inflate this number for the full population of organizations to include non–respondents. The employment estimate is made by multiplying the probability times the employment in each organization. We inflated the result in the same way to include non–respondents.

[3] The estimate for the percentage of firms in the sample that would not have located in the region except for the park is based on the same procedure used for park organizations. The estimation of indirect employment stimulated by the park is made similarly as for employment inside the park. The only difference is due to the fact that a sample was used rather than the full population. The size of the out–of–park population in employment terms is calculated by subtracting all employment in the park from the growth of employment in the region's high–tech sector between 1960 and 1987. Percentages and probabilities derived from the sample were then applied to this population.

not exist anywhere if the park had not been created (see Figure 4).

The relatively high percentage of firms whose decisions to locate in the region were based upon the existence of the park, seems to be related to the absence of other strong locational "pulls" besides the universities, and the relative autonomy of park businesses from other businesses in the region. That is, in the absence of the park (and the universities) there would be insufficient reasons for a large corporation to choose the Raleigh-Durham area for the location of an R&D branch plant. This contrasts with Stanford where a well-developed set of networks among firms exists in the region and provides a strong locational pull for new companies. Also, at Stanford and Utah, many of the entrepreneurs were already living and working in the region, and thus were most likely to start their businesses in their respective regions regardless of the existence of a technology park.

The estimates of employment stimulated by the park, described above, do not include firm and employment growth in the region brought about by the household income multiplier from the payroll for those 20,140 jobs in the region induced by the park (18,900 in the park and 1,240 outside the park). Neither does it include the employment impact from park organizations purchasing inputs from local businesses.[4] We estimate that the number of jobs generated in the region due to the household income multiplier is about 25,500. The number of jobs generated by the local purchases of all businesses in the region that would not be in the region except for the park is estimated to be about 7,400. The total number of jobs in the region for which the Research Triangle Park is responsible, i.e., would not be in the region if the park had not been created, is estimated to be about 52,000 in 1988.[5] This represents

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[4] Some portion of the high-technology businesses and employment included in our estimate of that induced by the park by localization economics may have located in the region as suppliers of inputs to park organizations. In these cases this employment impact is double-counted. We believe, however, that it is small.

[5] These estimates were made by applying data from U.S. Department of Commerce, Bureau of Economic Analysis, regional input-output tables (*RIMS II*), for North Carolina to the information obtained from the park organizations and sample of out-of-park high-technology businesses. The steps in the estimation of jobs generated by the regional income multiplier are as follows:
E_1 = number of jobs inside the park "caused" by the park (18,900)

12.1 percent of total regional employment in 1988, and 24.1 percent of the total increase in non-government employment since 1959 when the park was founded.

Conclusions

The purpose of this paper was to identify and discuss methodological issues that arise in an evaluation of technology parks, and then, to illustrate how they have been dealt with in one such evaluation. Even more than other programs, technology parks present a challenge for researchers. Evaluators must define carefully what they are measuring due to the normative nature of the outcome (success) variable. Then, they must operational their outcome measure by developing workable definitions for key variables. In particular, they must develop ways to measure the net induced effect of the technology park, rather than the direct gross effect alone. That requires the construction of a quasi-experimental research design, using before and after measures, and a large sample partitioned into control and experimental observations. It also may require the use of case studies with considerable primary data collection, to estimate the indirect effects on growth through induced start-ups and migration, and through the multiplier effect related to input-output linkages.

This approach applied to U.S. technology parks led to a series of definitive findings that can be summarized as follows: Even though the three case study parks appear to have been important for their respective regions, technology parks, by themselves, are not necessarily a wise investment for other regions. The "success" rate among all parks that are announced is relatively low. And, to the extent that

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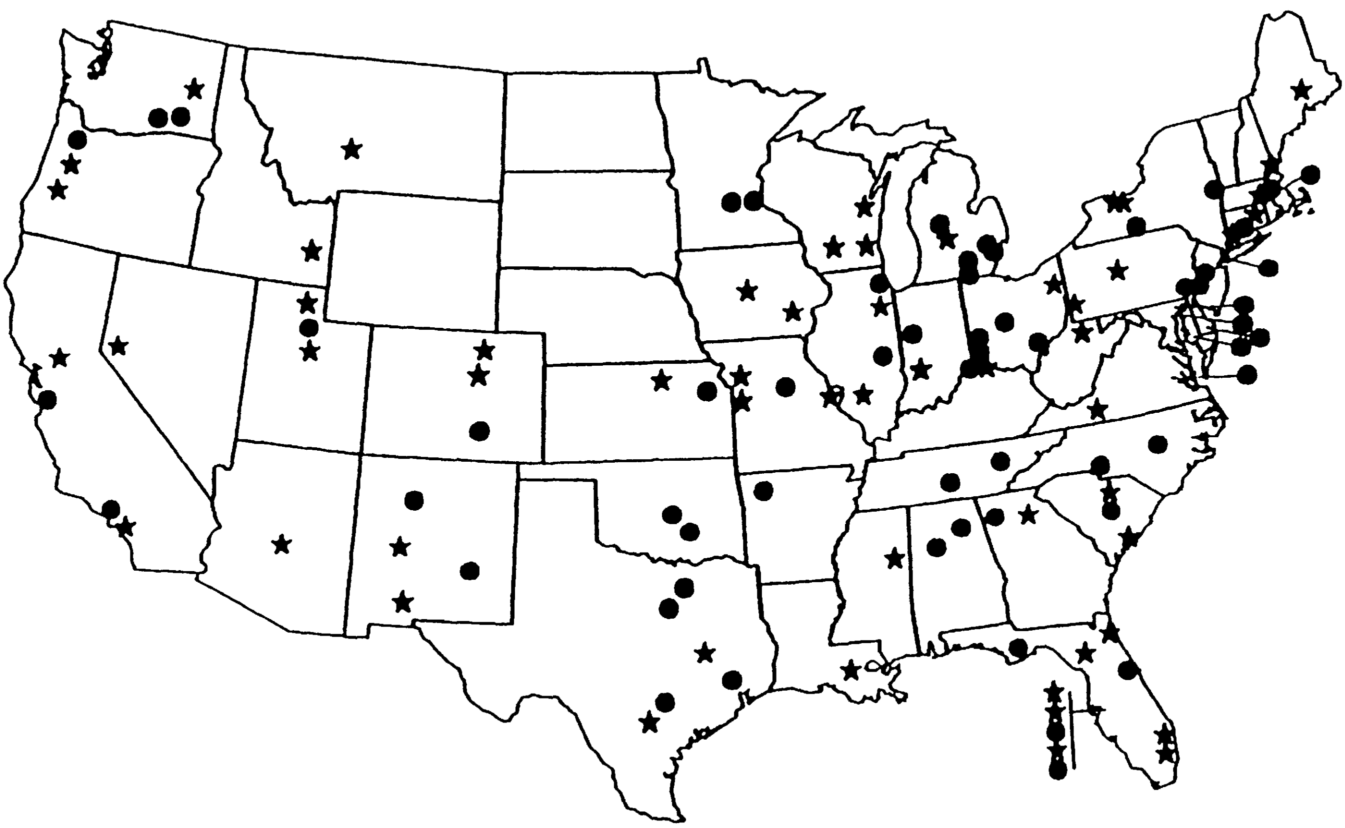
E_2 = number of jobs in the high-tech sector outside the park stimulated by the park (1240)
L = average annual salary of employees from E1 and E2 =$40,000
C_1 = increment to regional payroll from E1 and E2, = $(E_1 + E_2)$ x L = $805.6 million
P = estimate of local purchases (in $ millions) by park organizations and out-of-park high tech businesses "caused" by the park = $620.9 million (from responses to questionnaires)
p = percent of local purchases paid to labor = 0.30 (from regional input-output tables)
C_2 = increment to regional payroll from local business purchases = $186 million
C = C_1 + C_2 (total increment to regional payroll) = $991.6 million
F = employment multiplier of households (from regional input-output table) x 0.9 leakage factor to rest-of-state) = 24.3 jobs/$ millions of earnings
E_3 = total number of jobs created through regional income multiplier = C x F = 24,095.
The estimation of the number of jobs generated by local business purchases is:
E_4 = C_2/H where H is the average annual payroll/employee in sectors providing inputs to park organizations ($25,000 in North Carolina) = 7440.

vintage matters, it is too late for regions contemplating parks to "get in on the ground floor." Technology parks will be most successful in helping to stimulate economic development in regions that already are richly endowed with the resources that attract highly educated scientists and engineers. That is not to say that regions with less rich endowments can not have a high technology future, but more basic and long-term investments in improving public and higher education, environmental quality, and residential opportunities will be needed first. If a decision to create a technology park is made, government leaders should be prepared to invest liberally, and all other stakeholders should be prepared to wait a number of years before the investment is returned.

Figure 1
Geographic Distribution of Research Parks



Initiation of Park

● 1982 or before
★ 1983 or after

Figure 2

Age Distribution of Research Parks

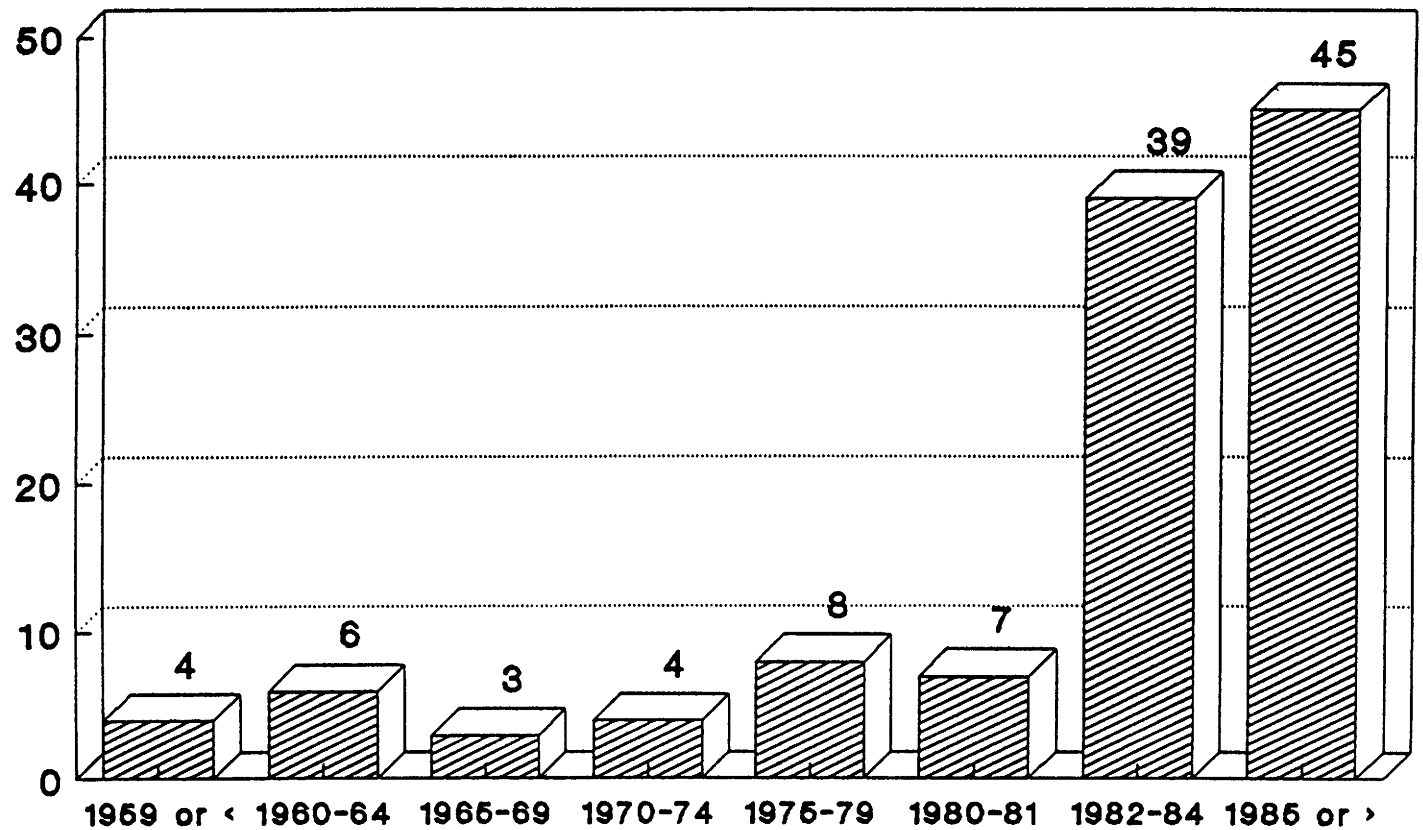


TABLE 1
Research Park "Success" Indicators

Name of Park	City	State	Yr. Est.	Research Park County			Control Counties			DIFF
				Before	After	DIFF1	Before	After	DIFF2	
Ada Research Park	Ada	OK	1960	-1.92%	1.33%	3.25%	0.25%	3.51%	3.27%	-0.02%
Ann Arbor Technology Park	Ann Arbor	MI	1983	-1.03%	3.67%	4.70%	-2.97%	3.23%	6.19%	-1.49%
Arizona St.Univ. Res. Park	Tempe	AZ	1984	3.40%	6.22%	2.82%	2.76%	5.75%	2.99%	-0.17%
Carolina Research Park	Columbia	SC	1983	0.90%	3.31%	2.41%	0.98%	3.54%	2.57%	-0.16%
Central Florida Res. Park	Orlando	FL	1979	5.88%	7.92%	2.03%	5.28%	6.59%	1.31%	0.72%
Charleston Research Park	Charleston	SC	1984	2.24%	3.49%	1.25%	1.02%	3.47%	2.45%	-1.20%
Chicago Technology Park	Chicago	IL	1984	-1.41%	1.86%	3.26%	4.58%	6.19%	1.61%	1.65%
Clemson Research Park	Clemson	SC	1984	-0.85%	1.59%	2.44%	1.61%	3.67%	2.06%	0.38%
Connecticut Technology Park	Storrs	CT	1982	2.00%	6.17%	4.18%	3.23%	4.23%	1.00%	3.18%
Cornell Research Park	Ithaca	NY	1951	-2.62%	1.45%	4.07%	-2.39%	-7.80%	-5.41%	9.48%
Cummings Research Park	Huntsville	AL	1962	2.71%	7.40%	4.69%	-0.83%	3.46%	4.29%	0.40%
Engineering Research Center	Fayetteville	AR	1980	3.91%	3.43%	-0.48%	3.09%	2.60%	-0.50%	0.02%
Great Valley Corporate Center	Malvern	PA	1974	2.73%	3.95%	1.21%	-0.20%	0.92%	1.13%	0.08%
Innovation Center and Research Park	Athens	OH	1978	1.06%	0.67%	-0.39%	1.67%	-0.66%	-2.33%	1.94%
Interstate Business Park	Tampa	FL	1983	4.68%	6.60%	1.92%	4.06%	7.03%	2.97%	-1.05%
Johns Hopkins Bayview Resrch Campus	Baltimore	MD	1984	1.81%	4.08%	2.27%	1.44%	4.35%	2.91%	-0.64%
Langley Research & Dev.Park	Newport News	VA	1966	3.84%	-6.00%	-9.84%	4.79%	3.75%	-1.04%	-8.80%
Maryland Science & Tech.Park	Adelphi	MD	1982	2.88%	6.10%	3.23%	2.52%	4.31%	1.79%	1.44%
Massachusetts Biotech. Res. Park	Worcester	MA	1984	-0.93%	4.06%	4.99%	1.25%	2.76%	1.51%	3.48%
Miami Valley Research Park	Kettering	OH	1981	1.59%	3.06%	1.46%	1.04%	2.38%	1.35%	0.11%
Morgantown Indus.&Res. Park	Morgantown	WV	1973	3.69%	4.44%	0.75%	2.20%	2.71%	0.51%	0.24%
Ohio State Univ.Res.Park	Columbus	OH	1984	0.02%	5.02%	5.00%	-1.66%	2.56%	4.22%	0.78%
Oregon Graduate Center Science Park	Beaverton	OR	1982	7.94%	5.03%	-2.91%	2.13%	3.54%	1.42%	-4.33%
Princeton Forrestal Center	Princeton	NJ	1975	2.64%	1.82%	-0.82%	2.21%	4.90%	2.69%	-3.51%
Purdue Industrial Research Park	W.Lafayette	IN	1961	0.15%	5.96%	5.81%	-0.06%	4.66%	4.72%	1.09%
Rensselaer Technology Park	Troy	NY	1982	1.17%	3.83%	2.66%	1.68%	2.72%	1.04%	1.62%
Research Triangle Park	R.T.P.	NC	1958	-0.29%	4 37%	4.66%	1.98%	2.19%	0.21%	4.45%
Richland Industrial Park	Richland	WA	1962	0.98%	1.73%	0.75%	0.73%	4.85%	4.12%	-3.37%
Roswell Test Facility	Roswell	NM	1983	2.81%	-1.09%	-3.89%	0.40%	0.46%	0.05%	-3.94%
Shady Grove Life Sciences Center	Rockville	MD	1976	4.30%	3.85%	-0.44%	1.40%	1.55%	0.15%	-0.59%
Stanford Research Park	Palo Alto	CA	1951	8.09%	8.37%	0.28%	6.05%	2.80%	-3.25%	3.53%
Sunset Research Park	Corvallis	OR	1983	-0.03%	3 06%	3.09%	-3.06%	2.33%	5.39%	-2.30%
Swearingen Research Park	Norman	OK	1950	-2.33%	7.37%	9.70%	0.21%	3.63%	3.42%	6.28%
Synergy Research Park	Richardson	TX	1982	6.24%	3.89%	-2.35%	7.12%	0.54%	-6.58%	4.23%
Tennessee Technology Corridor	3 counties	TN	1982	3.59%	2.35%	-1.24%	2 48%	4.61%	2.13%	-3.37%
The Research Forest	The Woodlands	TX	1984	11.16%	0.24%	-10.9%	3.04%	0.73%	-2.31%	13.22%
Univ. Center R&D Park	Tampa	FL	1982	5.81%	6 60%	0.79%	6 41%	4.64%	-1.76%	2.55%
Univ. City Science Center	Philadelphia	PA	1963	0.32%	1.78%	1.46%	-0.12%	3.87%	3.98%	-2.52%
Univ. of Calif. – Irvine Park	Irvine	CA	1983	4.17%	6 36%	2.19%	2.11%	4 17%	2.06%	0.13%
Univ. of Utah Research Park	S.L.C.	UT	1970	2.96%	6.15%	3.19%	5.93%	5.45%	-0.48%	3.67%
Univ. Park (MI)	Mt Pleasant	MI	1982	3.38%	3.62%	0.25%	0.61%	3.47%	2.86%	-2.61%
University Rsearch Park (NC)	Charlotte	NC	1968	14.1%	3.96%	-10.1%	8.97%	2.41%	-6.55%	16.65%
Univ. Research Park (WI)	Madison	WI	1984	0.54%	3.92%	3.38%	-0.67%	2.43%	3.10%	0.28%
Washington St.Univ.Res. & Tech.Park	Pullman	WA	1981	0.34%	2.07%	1.73%	3.81%	1.94%	-1.87%	3.60%
Westgate/Westpark	McLean	VA	1982	1.46%	10.12%	8.65%	5.63%	6.13%	0.49%	8.16%

TABLE 1

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				Before	After	DIFF1	Before	After	DIFF2	
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Arizona St.Univ. Res. Park	Tempe	AZ	1984	3.40%	6.22%	2.82%	2.76%	5.75%	2.99%	-0.17%
Carolina Research Park	Columbia	SC	1983	0.90%	3.31%	2.41%	0.98%	3.54%	2.57%	-0.16%
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Clemson Research Park	Clemson	SC	1984	-0.85%	1.59%	2.44%	1.61%	3.67%	2.06%	0.38%
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Cornell Research Park	Ithaca	NY	1951	-2.62%	1.45%	4.07%	-2.39%	-7.80%	-5.41%	9.48%
Cummings Research Park	Huntsville	AL	1962	2.71%	7.40%	4.69%	-0.83%	3.46%	4.29%	0.40%
Engineering Research Center	Fayetteville	AR	1980	3.91%	3.43%	-0.48%	3.09%	2.60%	-0.50%	0.02%
Great Valley Corporate Center	Malvern	PA	1974	2.73%	3.95%	1.21%	-0.20%	0.92%	1.13%	0.08%
Innovation Center and Research Park	Athens	OH	1978	1.06%	0.67%	-0.39%	1.67%	-0.66%	-2.33%	1.94%
Interstate Business Park	Tampa	FL	1983	4.68%	6.60%	1.92%	4.06%	7.03%	2.97%	-1.05%
Johns Hopkins Bayview Resrch Campus	Baltimore	MD	1984	1.81%	4.08%	2.27%	1.44%	4.35%	2.91%	-0.64%
Langley Research & Dev.Park	Newport News	VA	1966	3.84%	-6.00%	-9.84%	4.79%	3.75%	-1.04%	-8.80%
Maryland Science & Tech.Park	Adelphi	MD	1982	2.88%	6.10%	3.23%	2.52%	4.31%	1.79%	1.44%
Massachusetts Biotech. Res. Park	Worcester	MA	1984	-0.93%	4.06%	4.99%	1.25%	2.76%	1.51%	3.48%
Miami Valley Research Park	Kettering	OH	1981	1.59%	3.06%	1.46%	1.04%	2.38%	1.35%	0.11%
Morgantown Indus.&Res. Park	Morgantown	WV	1973	3.69%	4.44%	0.75%	2.20%	2.71%	0.51%	0.24%

(3)

TABLE 2: *Ranking of Parks by Success Indicators*

Parks "Successful" Using MSR120	
Cornell Research Park	9.48%
Westgate/Westpark	8.16%
Swearingen Research Park	6.27%
Research Triangle Park	4.45%
Synergy Research Park	4.23%
University of Utah Research Park	3.66%
Washington St. Univ. Research & Techn. Park	3.60% ●
Stanford Research Park	3.53%
Massachusetts Biotechnology Research Park	3.48%
Connecticut Technology Park	3.17%
University Center R&D Park	2.55% ●
Inovation Center and Research Park	1.94% ●
Chicago Technology Park	1.66%
Rensselar Technology Park	1.62%
Maryland Science & Technology Park	1.44%
Purdue Industrial Research Park	1.09%
Parks "Successful" Using MSR100	
Ohio State Univ. Research Park	0.77%
Central Florida Research Park	0.72%
Cummings Research Park	0.40%
Clemson Research Park	0.39% ●
University Research Park (WI)	0.28%
Morgantown Industrial & Research Park	0.23%
University of California - Irvine Park	0.12% ●
Miami Valley Research Park	0.12%
Great Valley Corporate Center	0.09%
Engineering Research Center	0.02% ●
"Unsuccessful" Parks	
Ada Research Park	-0.02%
Carolina Research Park	-0.15%
Arizona State University Research Park	-0.17%
Shady Grove Life Sciences Center	-0.59%
Johns Hopkins Bayview Research Campus	-0.65%
Interstate Business Park	-1.05%
Charleston Research Park	-1.20%
Ann Arbor Technology Park	-1.49%
Sunset Research Park	-2.30%
University City Science Center	-2.53%
University Park (MI)	-2.61%
Richland Industrial Park	-3.37%
Tennessee Technology Corridor	-3.37%
Princeton Forrestal Center	-3.51%
University Rsearch Park (NC)	-3.54%
Roswell Test Facility	-3.94%
Oregon Graduate Center Science Park	-4.33%
The Research Forest	-8.60%
Langley Research & Development Park	-8.79%

● Denotes that park has fewer than 100 employees.

TABLE 3

Park "Success" and Selected Characteristics

	Characteristics	Number of parks	Year established*	Average difference	Percent successful	
					MSR 100	MSR120
Vintage	Old	12	1950–70	0.009	58.3%	50.0%
	Middle-aged	18	1973–82	0.007	72.2%	55.6%
	Young	15	1983–84	–0.009	40.0%	13.3%
Region	Northeast	7	1975.0	0.017	71.4%	57.1%
	North–Central/Midwest	8	1982.5	0.002	75.0%	37.5%
	South	22	1982.0	0.000	50.0%	36.4%
	Pacific	8	1981.5	-0.004	50.0%	37.5%
Size (1980 population range)	>2.5 million	7	1982.0	-0.001	57.1%	42.9%
	1 mil. - 2.5 mil.	11	1982.0	-0.001	54.5%	36.4%
	500,000 - 999,999	9	1979.0	0.015	77.8%	66.7%
	100,000 - 499,999	10	1981.5	-0.008	50.0%	10.0%
	<100,000	8	1979.5	0.008	50.0%	50.0%
*Type of University***	RU–I	15		0.006	60.0%	40.0%
	RU–II	8		0.004	62.5%	50.0%
	no affiliation	22		0.000	54.5%	36.4%

* The entries in panels 2 and 3 are median years.

** RU–I and RU–II are Type I and Type II research universities.

TABLE 4

OLS Regression Results

Variable	Coefficient	Std.Error	Sign. Level
constant	-0.0309	(0.017)	0.067
nrtheast regn dum	0.0135	(0.019)	0.490
nrthcntrl/midwst dum	0.0171	(0.018)	0.358
south regn dum	0.0128	(0.016)	0.422
vintage squared	2.87 E-5	(1.43 E-5)	0.050
MSA population	2.43 E-9	(3.95 E-9)	0.549
deed restriction dum	4.88 E-3	(0.014)	0.730
garbage collect dum	0.0221	(0.013)	0.096
government subs dum	-0.0115	(0.012)	0.350
university own dum	0.0227	(0.012)	0.072

Dependent variable: DIFF in Table 1
Number of observations: 45
$R^2 = 0.28$; Adj. $R^2 = 0.10$
F-stat (9, 35) = 1.5008
Significance of F-Test = 0.185
Significance level = 0.146

TABLE 5

Results from Logit Model

Variable	Coefficient	Std.Error	Sign. Level
nrtheast regn dum	-0.138	(1.520)	0.927
nrthcntrl/midwst dum	2.477	(1.537)	0.107
south regn dum	0.581	(0.001)	0.615
vintage squared	3.750 E-4	(1.20 E-3)	0.755
MSA population	3.550 E-7	(3.22 E-7)	0.270
deed restriction dum	-1.625	(1.137)	0.153
garbage collect dum	3.000	(1.266)	0.018
government subs dum	-1.736	(1.067)	0.104
university own dum	3.068	(1.352)	0.023

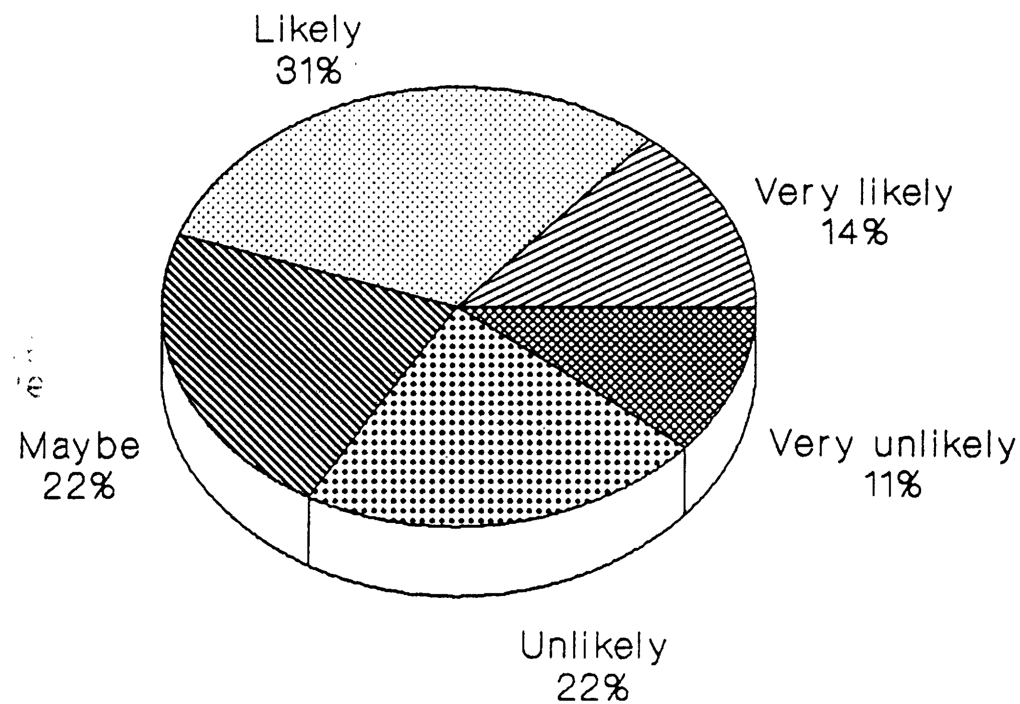
Dependent variable: 0/1 based on value of DIFF in Table 5
Number of observations: 45
Log-likelihood statistic = -19.813
Restricted (Slopes=0) Log-likelihood statistic = -30.645
Chi-squared (8) = 21.664
Significance level = 0.006
Percent successes predicted = 76.1

TABLE 6

Park Characteristics, by Size and Vintage

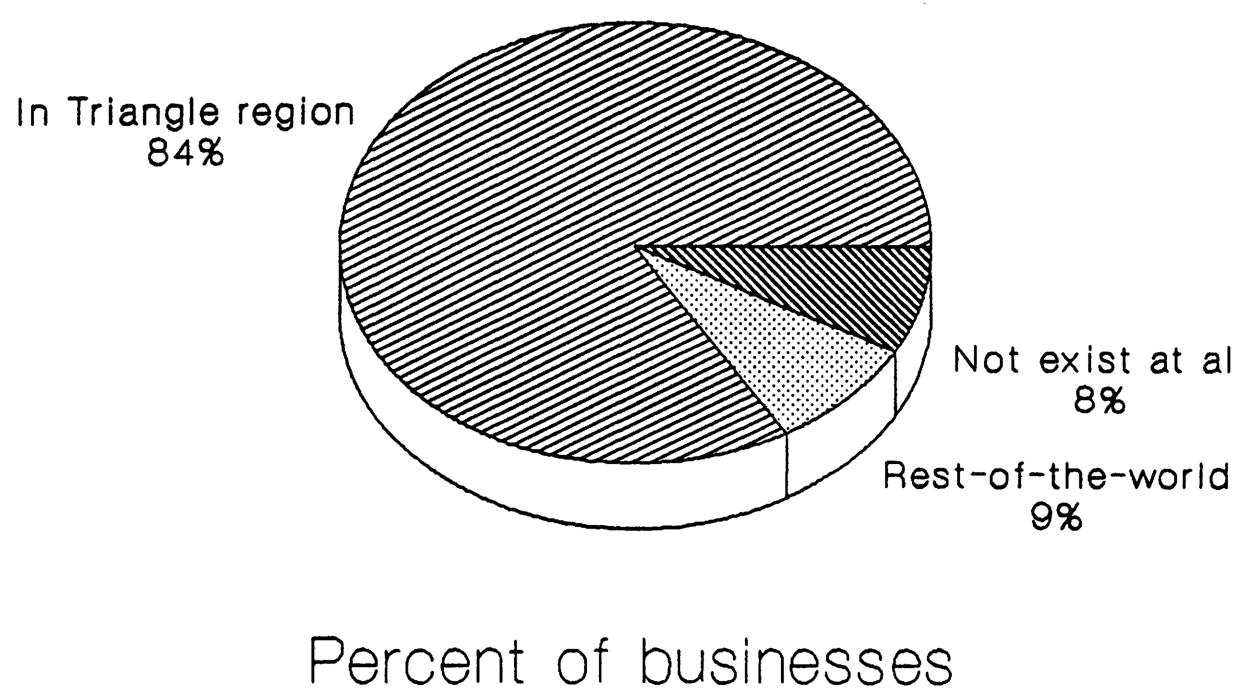
0 Employees (n=17)			
	Est. < *1982* (n=5)	Est. '82–84 (n=4)	*Est. '85–88* (n=8)
	failure in stage 1		
AVG. MSA POPULATION	520,666	717,438	583,345
% IN METRO AREAS	80%	75%	88%
AVG. AREA GROWTH RATE	2.74%	4.80%	4.83%
% TYPE I, II RESRCH UNIV	40%	25%	50%
1–99 Employees (n=28)			
	Est. < *1982* (n=4)	*Est. '82–84* (n=10)	*Est. '85–88* (n=14)
	failure in stage 2	*at risk in stage 2*	
AVG. MSA POPULATION	421,191	1,216,956	1,574,793
% IN METRO AREAS	75%	80%	71%
AVG. AREA GROWTH RATE	4.69%	5.18%	4.08%
% TYPE I, II RESRCH UNIV	50%	50%	43%
100 Employees or more (n=75)			
	Est. < *1982* (n=29)	*Est. '82–84* (n=26)	*Est. '85–88* (n=20)
AVG. MSA POPULATION	1,079,945	1,616,724	990,540
% IN METRO AREAS	83%	88%	90%
AVG. AREA GROWTH RATE	5.49%	5.55%	5.7%
% TYPE I, II RESRCH UNIV	62%	71%	70%

FIGURE 3: *"If RTP Did Not Exist, Would You Have Located in the Region?"*



(R&D organizations in the park, N = 40)

FIGURE 4: *"If RTP Did Not Exist, Where Would You Be?"*



Out-of-park high tech businesses, N=148

Mission Impossible: Evaluation of the Impact of Technology Parks

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Mission impossible: evaluation of the impact of technology parks

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"The statistical method communicates an ideal measure of an objective fact, but not a picture of its empirical reality. Agreed, it describes an impeccable aspect of reality, but at the same time it can falsify the actual truth to the point of misrepresentation. The latter is especially true for theories based on statistics. True realities are characterized by their individuality; bluntly put, one can say that the real picture depends, as it were, solely on exceptions to the rule, whence absolute truth acquires its primary characteristic of being *irregular....*"

Cited from Von Traum und Selbsterkenntnis - Einsichten und Weisheiten by C G Jung (trans DMQ)

Introductory remarks

In the following some observations will be made on what are accepted examples of successful technology parks, by way of attempting to identify *in what ways* they are successful and what impacts they have had. Some conjectures as to *why* they are successful are then ventured. In the next part of the presentation some of these criteria will be applied to the technology parks at Chalmers University of Technology in Göteborg, Sweden (ex post), and at the Swiss Federal Institute of Technology in Zürich, Switzerland (ex ante). Finally, an attempt to generalize the results will be made.

Some successful technology parks

What is a technology park, and what is a successful technology park? For present purposes, let us adopt a very broad definition of technology park, including science park, research park, engineering park, etc, but perhaps not business park. In the same spirit, let a park be anything from a piece of land with grass and trees to an asphalt jungle. However, let us concentrate on technology parks which have some links with universities having faculties of engineering and science. This idea of a technology park is not too different from the definition of a science park used by the United Kingdom Science Park Association:

"The term Science Park is used to describe a property based initiative which:

- has formal and operational links with a university or other higher educational institution or major center of research
- is designed to encourage the formation and growth of knowledge based businesses and other organisations normally resident on site
- has a management function which is actively engaged in the transfer of technology and business skills to the organisations on site."

It is probably impossible to define what might be meant by a *successful* technology park in terms of its impact on its surroundings. It is far easier to give some examples, chosen from among the several hundred technology parks in the world today. The following discussion will be based on four examples.

Example 1 is Silicon Valley near Stanford University in California. It began with the invention of the transistor (at the leading edge of high technology) by Walter Brattain, William Shockley and John Bardeen. It was promoted notably by professor Frederick Terman of electrical engineering at Stanford University beginning in the 1950's. Today Silicon Valley is concentrated on semiconductor technology, although there are other technologies represented there as well.

Example 2 is Route 128 outside of Boston, Massachusetts. One of the early firms to locate there was Digital Equipment, founded by Kenneth Olson, based on the idea that Digital Equipment could do what IBM did, with MIT's help, but better. Again, this was at the cutting edge of high technology. MIT professor Jay Forrester, inventor of the magnetic core memory and Kenneth Olson's doctoral advisor, professor John von Neumann, professor Vannevar Bush, and others combined forces to build the first modern computers. Today on Route 128 there are firms involved in computer hardware, in instrument development, in computer software and in biotechnology, that is, a relatively wide spectrum of technologies.

Example 3 is Research Triangle Park in North Carolina (Raleigh, Durham, Chapel Hill). This park was used to attract modern businesses to the state of North Carolina, thus providing employment for those who lost their jobs in the dying North Carolina textile, tobacco and furniture industries. A wide variety of companies, most of them with headquarters outside the state of North Carolina, now have premises in the vast acreage of the park. There have been very few if any spin-off companies formed as a result of the activities of Research Triangle Park.

Example 4 is the Cambridge Science Park in Cambridge, England. The first technology based firms on the Cambridge spin-off company scene are now over a hundred years old! The Cavendish Laboratory has given birth to many a successful company, and provided established companies with many more ideas (technology transfer). Formally, the Cambridge Science Park was founded by Trinity College in 1971. The senior bursar of Trinity College, John Bradfield, a zoologist in the Cavendish Laboratory, is generally acknowledged as having been the driving force behind the park. Trinity College has had a scientific profile from the time of Newton, more Nobel Prize winners having lived and worked there than in many whole countries, such as France. Again, the park is located adjacent to the leading edge in science and technology at the Cavendish Laboratory.

What do these four technology parks have in common? Aside from the fact that they are all successful, practically nothing:

- three are associated with outstanding universities (1, 2, 4)
- three are associated with leading edge technologies (1, 2, 4)
- one is fifty years older than the other three (4)
- two or three started spontaneously (1, 2, 4)
- one is the result of a government initiative (3)
- two now have organized legal forms (3, 4)
- one has few university spin-off companies (3)
- one is mainly concentrated on a single technology (1)
- two have benefitted strongly from venture capital (1, 2)
- one is dedicated to attracting "foreign" companies (3)
- three have "do it yourself" attitudes (1, 2, 4).

The impacts of these technology parks are also remarkably varied:

- two have been the cradles of whole new industries (1, 2)
- two or three have enhanced the reputations of their universities (1, 2, 4)
- two have been associated with regional economic recovery (1, 3)
- all four have changed regional employment mix by industry branch
- three have planted and grown new companies (1, 2, 4)
- three have significantly increased university-industry contact (1, 2, 4).

What lessons are to be learned from all this? In each of the above cases the development of the technology park and its subsequent strong impact on its region was based on a particular strength or set of related strengths which gave that particular technology park a distinct and strong advantage over almost all if not all competition. In Cambridge it was the expertise of the Cavendish Laboratory exploited in the Cambridge Scientific Instrument Company and in W G Pye & Co, in Santa Clara county it was Fairchild Semiconductor making immediate use of Nobel Prize winning science, and on Route 128 it was Digital Equipment cashing in on the combined computer expertise of MIT and IBM, as well as venture capital. In Research Triangle Park it was marketing a concept of an advantageous and attractive place to establish businesses, with a supply of well-educated people in an area offering a relatively high quality of life. An evaluation of the impact of a technology park, at least on this level, should include a description of the identified relative strengths (even those identified in retrospect), how they were developed, and what the results were. Such evaluations must be different for each case, which would be acceptable to C G Jung. Further, done appropriately, they could take the form of constructive criticism.

What are the most important impacts of these technology parks? The most important indicator of success is almost always perceived to be growth in employment in connection with the technology park. This can be more or less important to people in different roles, of course, and it is not always an original goal of the technology park. More important is the *distribution* of employment *attributed to* the technology park, especially if the new employment mix is in some way more advantageous than the original one.

Other things which give a technology park an aura of success include the accumulation of "high tech" (whatever that is) businesses and capabilities. This can be associated with increased semi-formal and formal technology transfer between business and universities (in *both* directions!), as exemplified by the MIT Industrial Liaison Program or its equivalents at Stanford University, for instance. The intensity of technology transfer might be measured in terms of the numbers of patents applied for, obtained and licensed, or in the numbers of spin-off companies founded or new units established in existing companies with the help of the technology park. Better yet, it could be measured in employment in spin-off companies and in new commercial units. It could be measured in terms of the volume of industry supported research and development in the university, or the numbers of students (undergraduate as well as graduate) choosing to work in companies associated with the technology park.

The important thing about this sort of technology transfer impact is that it is bi-directional when it works correctly. Certainly, without Route 128 the MIT Department of Electrical Engineering would not be half its present size. Neither MIT nor Stanford University would enjoy their present outstanding reputations without their technology parks.

An important impact of technology parks is on the political/sociological level. A technology park often serves as a symbol of faith in modern technology or entrepreneurship, a rallying point for persons and organizations devoted to technology transfer and industrial renewal, or a focal point for political and economic initiatives, etc. The potential of technology parks in forming and shaping cultural values concerning innovation and entrepreneurship, etc, should not be forgotten. These impacts can be every bit as important as the creation of jobs or increases in industrially sponsored university research, but they are very difficult to assess. Moreover, a technology park will be without this political/sociological impact if it has no real, measurable impact on the community at large.

It is by definition impossible for each and every technology park to be associated with one of the world's top universities and to produce the world's most successful companies in the world's most glamorous technologies. Where does that leave 90% of the contenders, then? There are other comparative advantages to be exploited, of course, as the example of Research Triangle Park proves. Many universities and research laboratories have centers of excellence in one or more fields, with potential that can be exploited. Many locations have commercial or geographic advantages that can help make a technology park successful. It is not necessary to be the best in the world in order to be the best in one's own region.

Perhaps the most important real function of a technology park is to *catalyze* bidirectional technology transfer between the participants in the park. In chemical reactions catalysts are not used up; at most they are only blocked and modified slowly by the reactions. Catalysts are normally added to a chemical mixture in small amounts, under the assumption that all that is really needed is a little extra push in order to make the reaction proceed in a particular direction at a particular rate, etc. The impact of the catalyst is measured in terms of increased yield, output, efficiency, etc, but not in terms of the amount of catalyst required. The less catalyst the better! This applies also to the technology park as catalyst in technology transfer.

The technology park should apply its resources where the possibility for success and growth are the most promising, that is, where something is just "sub-critical" or where "economies of scale" can be achieved relatively quickly with a small amount of catalytic activity. This amounts to about the same thing as identifying strengths and making use of them.

A technology park has no business *competing* with already established companies, organizations or the like in its activities. The main *raison d'être* of a technology park is to catalyze processes that do not yet exist, are not yet sufficiently strong, or are not going in the desired direction. Processes that are moving along nicely should not be disturbed. The strengths upon which a technology park is based should also be strengths relative to other actors in the area of interest. The impact of the technology park is in terms of making *new* and *different* things happen.

At Route 128 and in Santa Clara county there is no technology park building with tens or hundreds of technology park administrators carrying out important tasks for the board of directors whose members spend most of their time gathering donations to pay for it all. Here the required processes worked by themselves, with a little occasional help, such as inventing venture capital in Massachusetts, or making some land available near Stanford University. Most of the reactions were of super-critical size and economies of scale were realized quickly, probably due mostly to the outstanding abilities of the participants. The enormous impacts of these technology parks are the results of building on relative strengths.

The technology park at Chalmers University of Technology

The technology park associated with Chalmers University of Technology has roots going back to 1972 when Torkel Wallmark, then professor of solid state electronics, gave the first practical course in invention. This course was soon complemented with a "theoretical" seminar course in the same subject area. It was quickly realized that we needed to know more about technical innovation and technology transfer, and a research program evolved in parallel with our practical needs.

We knew that Chalmers employees applied for patents, although since patents are the property of individual university employees they did not need to report them to the university. Also, we knew that Chalmers employees founded spin-off companies, for instance Brüel & Kjær A/S, Ingemanssons Ingenjörsbyrå AB and Netzler & Dahlgren Co AB. We decided to document these activities, and patent application surveys were made and a catalog of spin-off companies has been updated annually for more than ten years.

Our next step was to build on these strengths by offering a course in patenting, which is attended by graduate students, Chalmers employees and inventors from small and large companies in Göteborg. Together with the University of Göteborg a course in establishing a new company was established an run for many years. The main goal for students in this course is to produce a business plan.

Evaluation of the effect of our efforts on these fronts is difficult. There are no comparable patent statistics from other Swedish universities. Chalmers employees, including graduate students, now apply for an average of about thirteen patents a year, of which about two thirds are commercialized in some way. Compared to the total number of Chalmers employees, about 2100, this is not too much lower than the patenting rate at MIT, about 100 patents per year and 11 300 employees (including graduate students). Also at MIT the commercialization rate is about two thirds. On the other hand, at ETHZ also about 15 patents are applied for per year, but the university staff is about 5300 persons, so the patent application rate at ETHZ is considerably lower than at the other two universities. We feel that the efforts of the Innovation Center, through the patent course and advisory activity, have contributed to the higher patent application rate at Chalmers University of Technology.

At Chalmers about 12 spin-off companies are formed annually. Here a narrow definition of spin-off company is used. For instance, according to this narrow definition only about eight spin-off companies are formed at MIT annually. At ETHZ about four or five spin-off companies are formed per year. The exceptionally high number of spin-off companies at Chalmers is probably due in part to the dedicated efforts of the Innovation Center in support of entrepreneurship among students and faculty. The general increase in spin-off company formation that can be noted at many Swedish universities occurred five or so years earlier at Chalmers than at any other Swedish university, which is also an indication of the impact of Chalmers efforts.

The impact of the Chalmers spin-off companies has only recently begun to be significant in the Göteborg region. While total employment in Chalmers spin-offs in Göteborg is not great, about 1621 persons, their contribution to employment in some important modern industry sectors such as electronics, computer technology, scientific and medical instruments and biotechnology is significant. More established industry in Göteborg tends to be in traditional industry sectors. Thus the Chalmers spin-off companies contribute strongly to *industrial renewal* in the region.

During the eighties the number of inquiries by private companies and government organizations concerning various scientific and technological questions where Chalmers employees might be able to be of assistance increased steadily. Also the amount of research and development supported by these organizations, almost always on a project basis, increased. This was felt to be a desirable development, which should be encouraged. Already in the late seventies a Product Development Center had been established, focussing mainly on small and medium sized companies. It was felt that this Product Development Center could be strengthened.

Against this background it was "inevitable" that Chalmers Teknikpark would be established, in 1985. It is a privately financed and built modern building with about 10 000 m^2 of floor space. At present Volvo, Bofors, Saab-Scania, SKF and the telephone company rent space, as well as Chalmers Industriteknik (CIT), the successor to the Product Development Center, the course and contact secretariat, the Institute for electromagnetic field theory, about 10 spin-off companies, a restaurant, the Chalmers faculty club, a travel bureau and a reception service. To a great extent it builds on previous successes.

It is hard to evaluate the effect of Chalmers Teknikpark on the university. However, the amount of industrially and equivalently sponsored research and development at Chalmers has increased to about 11% of the total research budget, a proportion which probably would not have been reached without CIT. Corresponding figures for MIT and ETHZ are 12% and 10%, respectively. (These figures do not correspond exactly to the universities' own figures because the latter are based on research expenditure figures that are not exactly comparable in the different universities.) Thus in this aspect of technology transfer, Chalmers University of Technology and Chalmers Teknikpark have done a fairly good job.

The people running Chalmers Teknikpark feel that they have been successful enough to begin an expansion of the original buildings. They feel that it will be possible to rent out the space to companies that they would like for Chalmers University of Technology to have as neighbors. They would like to make more space available to Chalmers spin-off companies. However, they must compete with other opportunities for Chalmers spin-off companies. For instance, a separate Innovation Building or spin-off incubator was established in the middle eighties. As it has only 600 m^2 of floor space, only six companies can be housed there. However, several spin-off companies have grown and left the Innovation Building for larger premises.

Still, there is pressure to find more appropriate space for spin-off companies, and a center for spin-offs in an old factory building complex about three kilometers from Chalmers has been established. This center is accumulating spin-offs at the rate of two or three per year. Chalmers Innovation Center supports an immaterial infrastructure for this center, which should be considered, at least in this context, as part of the Chalmers technology park. Never has there been any significant difficulty in filling any available space in any of the buildings included in the Chalmers technology park. This must be as good an indicator as any of success.

Technopark Zürich

The Technopark Zürich is still under construction (March 1992). It is part of a large building in the center of Zürich. The production area of the building, about 28 000 m^2 , does not belong to the Technopark Zürich proper, which amounts to about 22 000 m^2 of rentable space. The Technopark Zürich proper is divided into an innovation area, about 15 000 m^2 , and a transfer area, about 7 000 m^2.

The production area of the building is intended for already established companies that produce physical products or services, not necessarily high tech. For instance, in May 1992 an electrotechnical firm will move into this area. Another tenant will be an R & D oriented company cooperating with an ETHZ group adjacent to it. The presence of these firms will help to provide a commercial atmosphere and a connection to the world of industrial production and commercial trading at the park.

The innovation area will be used by a number of groups from the ETHZ (Eidgenössische Technische Hochschule Zürich = Swiss Federal Institute of Technology) and the University of Zurich, as well as small firms and new firms and entrepreneurs. There will be no production in this part of Technopark Zürich. Some research groups from the ETHZ which are involved in industrial cooperation and which typically receive around 50% of their funding from private sources will be located in the park. Example areas are mechatronics, computer supported textile machine construction, materials science, sensor technology and computer integrated manufacturing. Some of the activities of the Institute for Biomedical Technology and Medical Informatics from the University of Zurich will probably also be moved there. The BWI (Foundation for Research and Consulting of the Institute for Management and Industrial Engineering of the Swiss Federal Institute of Technology in Zurich), which is concerned with industrial management, will move to the park, as will the AFIF (Arbeitsgemeinschaft für industrielle Forschung der GFF an der ETH Zürich), which is a privately supported organization for technology transfer at ETHZ presently located on the ETHZ campus in Hönggerberg. These groups were chosen for their potential to spin-off commercially interesting product ideas and their ability to interact with commercial firms.

As mentioned above, about 10% of ETHZ research expenditures are financed by industrial partners. This is due to many efforts throughout the university, of course, but the AFIF must be singled out in this respect. It was founded already in 1936 in close connection with the Institut für Technische Physik. Today there are about 22 full time equivalent AFIF employees whose job it is to carry out projects initiated by industrial companies in cooperation with scientists and engineers at ETHZ and similar institutions. The "mother organization" of AFIF is GFF (Gesellschaft zur Förderung der Industrieorientierten Forschung an den schweizerischen Hochschulen und weiteren Institutionen), whose role it is to support the executive arm AFIF, for example through its large network of contacts and through its patent management service. There are about 75 members of GFF at the present time, mostly private firms and some public organizations. By bringing AFIF into Technopark Zürich the Technopark will be able to build on proven strength and expertise in university/industry cooperation.

The remaining 15% of the space, which is between the production and innovation areas, is designated the transfer area and will be used to provide an infrastructure supportive of innovation and entrepreneurship. There are to be a reception, telephone, telefax and postal services, office machine services, a cafeteria, conference and consultation rooms, an information service provided by the ETHZ main library, computer services, etc. Also, the administration and operation of Technopark Zürich will be located in the transfer area. Consulting and advisory services for small companies and entrepreneurs will be available.

The Technopark Zürich is administrated and run by two organizations. All real estate aspects of the project are handled by Technopark Immobilien AG (TIAG), while technology transfer and innovation are handled by the Stiftung Technopark Zürich, which is a Foundation. Thus, success means different things to TIAG and to the Foundation (Stiftung Technopark Zürich), which is exactly the reason why there are two organizations.

The Foundation is conceived as standing on three legs of technology transfer in Technopark Zürich. They are a) university-industry cooperation in R & D projects, b) development of new technology oriented enterprises, and c) continued education courses and seminars. These activities, and synergies between them, are expected to make Technolpark Zürich an especially attractive location. In addition, a special advisory group will be available, the experienced members of which can take positions on the boards of directors of the new enterprises at little or no cost.

There will probably not be too large problems with renting out the available space in the Technopark Zürich within a reasonable time, even though rentals are at market rates. The main reason for this prediction is that this particular space is rather attractive, due to the presence of university research teams and an otherwise high profile, still at reasonable rents. On the other hand, while success in rentals is a prerequisite for the success of this technology park, as of other technology parks, it is not a particularly good indicator of technology transfer impact.

It will be difficult to determine whether the Foundation is successful or not as a promoter of technology transfer and catalyzer of innovation. It clearly has a difficult job. The stated goals of the Foundation are:

- optimization of technology transfer through cooperation between producers of science and users of science under the same roof, thereby shortening the time to market
- provision of a visible, competent, transregional consultation center for questions concerning technology transfer and the utilization of research in the interest of all of Switzerland
- improvement of the success rate of new companies through careful and competent consultation as well as provision of easier access to venture capital through increased confidence in the new firms
- encouragement of multidisciplinary approaches to applied research and development projects.

It is probably possible to improve the rate and intensity of technology transfer between the two Zürich universities and associated organizations and industry and commerce, although just how this will be measured and documented is not clear. How can the time to market for new technology in Technopark Zürich be compared fairly with time to market outside the Technopark? Only with great difficulty, and only after five or ten years have passed, so that several examples can be analyzed. This is a difficult point.

Obviously, it is possible to provide a visible, competent, transregional consultation center almost from the very beginning, but this is hardly an impact of the park. Rather, it is a structural aspect. In a longer perspective, it is hoped that Technopark Zürich will have an important positive impact on the innovation and entrepreneurship culture of the region and on the spirit of cooperation between innovative groups and companies.

We already know that university spin-off success rates are astonishingly high compared to small company success rates in general. Probably this is due to high levels of education on the parts of the spin-off company founders as well as relatively well-defined business ideas, usually based on technical advances. This is exactly the profile sought for by Technopark Zürich, so the new companies to be found there will undoubtedly have high success rates. Scanty evidence on ETHZ spin-off companies indicates that total employment in those companies is increasing at about 15% per year. Here the chances for the Foundation to succeed are quite good.

Every large industrial company must be able to organize multidisciplinary approaches to applied R & D projects competently. On the other hand, universities have great problems at this level of organization. Here Technopark Zürich has an important function to perform. It should also be relatively easy to document such projects and the actual role played in them by the park. Their impact on industrial companies can potentially be large.

What comparative advantages and strengths does Technopark Zürich build on? One of the most important is close connections to one of the premier technically oriented universities in Europe, the ETHZ, as well as to the University of Zurich. These institutions are expected to provide significant scientific and technical input to Technopark Zürich, especially through the research groups located there. It can be hoped that the two universities will in turn benefit from Technopark Zürich.

In the region of Zürich with surroundings there are many industrial firms of various sizes in different modern industrial sectors such as telecommunications, electronics and scientific instruments. These firms represent a large potential of interaction with Technopark Zürich. It might be of interest to establish industrial liaison activities with them, such as those at MIT, Stanford University and Chalmers, for instance, to better tap this potential.

The spin-off companies from the ETHZ, as well as other small, technically oriented companies, represent a potential on which industrial growth and renewal might be built. Also, the documented patent activity at ETHZ can be developed further and utilized to advantage.

Concluding remarks

Apparently a very important impact of a science or technology park is in local employment. However, only a *very* few technology parks can make a claim to have significantly contributed to general employment in a region. Rather, usually it is in the *type* of employment that is generated that the value lies. More "metal bashing" is usually not a useful contribution, but *industrial renewal* in the form of *diversified* modern technology and industry is of the essence. This is borne out by statistics from the states of Massachusetts and North Carolina as well as the Göteborg region in Sweden, for instance. This does not mean that a technology park should concentrate on specific technologies, however. Rather, it should seek to support any and all projects with a perceived technological advantage, allowing competent company managements and market mechanisms to determine the direction of development.

An important impact of a technology park is on the associated university or other source of new technology. Highly successful technology parks tend to augment the reputations of the associated universities and increase the dynamic nature of the activities persued there. Technology transfer *to* a university is just as important as technology transfer *from* it. Often this takes the form of industrial support of university research, which appears to be an effective method of technology transfer *in both directions*. Fears that industrial companies might significantly interfere with "freedom of research" are generally not well founded in practical experience, but some care must be taken in formulating university/industry cooperation contracts.

An important role for a technology park to fulfill is that of coordinator for multidisciplinary projects. Universities tend not to do this well by themselves. On the other hand, there are good examples of where this has been successful at Chalmers University of Technology. Such project coordination is an explicit goal of Technopark Zürich.

At the Chalmers Innovation Center documentation and evaluation of technology transfer activities are treated as research subjects. The evaluations have not been carried out to satisfy some funding agency or government office, but rather to better understand what is going on and therefore to better be able to support and augment the process. Good documentation and evaluation includes constructive feedback to all the people involved. In this sense the Chalmers Innovation Center has been in the communication business for many years. Some other technology parks carry out similar work, but they are relatively few in number.

Finally, it must be obvious that the developments of the technology park at Chalmers University of Technology and Technopark Zürich are different. It appears not to have been possible to start up a technology park by slow stages in Zürich, and the total rentable floor space of all the technology park components in Göteborg probably does not amount to 22 000 m^2 even today. The roads taken reflect local boundary conditions and cultural differences which are very difficult to assess. It follows that evaluation of these technology parks must be made against the local background and according to local values. There is no formula for success.

Evaluating the French Science & Technology Parks' Experience

Thierry Bruhat, Conseil en organisation.

Introduction

I should like to share with you the principal results of an evaluation of the French technopole phenomenon that was first conducted in 1989 and is currently being updated.

In 1989, I personally requested that the French DATAR Regional Development Agency undertake a study of the twenty-odd Science/Technology Parks or "Technopoles" in France. Until that time, DATAR had concentrated its efforts on promoting the Sophia Antipolis Park, near Nice. This park has been officially declared of national interest and is supported by central government funds.

During the 1980's however, other cities such as Montpellier, Nancy and Rennes also set up technopoles. These technopoles all share one characteristic: they were all born of local initiatives, without assistance from the central government. Indeed, the State, then as now, lacked a national policy on technopoles. The State tended to view such efforts with suspicion or bemusement. Given such a context, my request did indeed turn more than a few heads. It was all the more surprising since I suggested that rather than paying heed to the arguments of those promoting technopoles, what was needed was an analysis of what was hidden behind the promotion campaigns, in order to gain "one" view of the nature of the phenomenon.

My work was based on the following hypotheses:

- the twenty technopoles* covered by this study were selected in an effort to assemble examples of the different programs developed in differing contexts and according to diverse strategies. These programs presented, or at least claimed to present, original features.

- Paris and the Greater Paris Ile-de-France region were excluded from this study although 60% of French state-funded research is concentrated in this region. This was a deliberate choice on my part, for what particularly interested me about the technopole movement was its autonomous nature and the fact that it was born of local initiatives. In Paris and the surrounding region, by contrast, development is wholly dependent on central government policies. Despite a high concentration of industry and research facilities, technology transfers and high-tech start-up companies remain a rarity in this region. It was therefore not a good example of technology park cross-pollination.

- Finally, I undertook this study with no preconceived notions as to what constituted a model "technopole" or what such entities should be called. You may be aware that there is a certain debate as to the gender of the word technopole in French. If one considers a technopole to be a "pole" for technologies, then the word in French must be masculine, while if one considers it to be a technological "metropolis" it is feminine. I decided it would be best to adopt local usage for each specific case.

(*) Sophia Antipolis, ZIRST de Meylan, Nancy-Brabois, Rennes Atalante, Technopole de Toulouse, Lyon Technopolys, Montpellier-LR- Technopole, Illkirch-Strasbourg, Villeneuve d'Ascq, Le Creusot- Monceau, Saint-Etienne, Orleans Innovespace, Metz 2000, Marseille Château-Gombert, Nantes Atlanpole, Angers technopole, Bordeaux Technopolis, Compiègne, Le technopole de haute Alsace, Futuroscope de Poitiers.

As concerns methodology, this work was carried out in three stages :

1 - The first stage consisted of studying the establishment of each technopole in its own unique context. To do this, I chose to present the different strategies of institutions and individuals as I was later able to define them. I was particularly interested in examining the strategies adopted by local authorities, sometimes successfully, to encourage meetings and cooperation between companies, researchers and universities - with or without the support of the State institutions locally present.
I felt that the start-up period was of particular interest in that these programs aimed to set into motion forces that were previously non-existent.

2 - Secondly, in 1989, I wanted to take a snap-shot of the results obtained so far by the technopoles at a local level. This involved trying to isolate the results of efforts carried out by the technopole, separate from all other data concerning trends in the local economy. More specifically, it required identifying the nature of activities of the technological park or parks, the number of new company start-ups, promotion and coordination policies and the rate of technological transfer (where such data were measurable), etc.

3 - Thirdly, I hoped to analyze these results and the strategies of individuals or institutions within an economic and industrial context at a local, regional and national level. Since these programs aim to have an impact on local technological and industrial activity, it is particularly interesting to compare their approach to questions of infrastructure to that of other institutions, departments, regions, the State, particularly as concerns the area of technological innovation.

In summary, this study consisted of three main methodological axes : the start-up dimension, the local impact dimension and the infrastructure dimension with special attention paid to the strategies of participants or institutions.

This choice was not arbitrary. It reflects two influences:

- The first influence I must confess to is that of F. Braudel and more generally what is known in France as "l'Ecole des Annales" or the Annales Journal School. These historians have developed an approach to studying the history of the creation of western capitalism based on an analysis of phenomena according to their duration, long-term impact and setting within an economic and political context. They also studied the interrelation between economic micro-structures and macro-structures, and between the private and public sectors. The works to which I refer lie on the frontier between History and Economics. I did not hope thereby to develop a method for analyzing the contemporary phenomenon of technopoles, but simply to bear in mind the complexity of thecreation of our economies and economic spaces, to better address the more limited question of the creation of new local technopole policies as concerns matters of technology, science and space.

- The second influence reflects the interest I hold, as a university researcher, for the analysis of participant strategies. For ten years now I have been giving deep thought to theories of action and communication within an economic and political framework in an attempt to shed some light on the notion of institutional strategies. It was therefore only normal that I maintain this angle of attack.

Field research consisted of interviews with leading technopole officials (organizers, researchers, corporate heads, local authority technicians etc.) I avoided the promotional speeches of political leaders or public relations/communications staff. Such speeches are well known, having been widely published in the press or in technopole promotional brochures.

This study, completed as I mentioned in 1989, led to a report published by the "Documentation Francaise" under the title "Vingt Technopoles : un premier bilan" ("Twenty Technopoles: a preliminary assessment"). This contained two main sections, the first, briefly presenting each of the twenty technopoles; the second, developing the start-up, economic impact and spatial questions previously mentioned.

1 - The French Experience

The second part of the report contained several chapters which set out to answer the questions which we are asking ourselves today concerning the French experience with technopoles.

1.1 - Approaches for technopole set-up

a) We found that there were two approaches. The "pole" approach and the "metropolis" approach.

The "pole" approach is used in technopole programs based on the scientific or technological park. Two early examples in France are Sophia Antipolis and the ZIRST de Meylan near Grenoble. These two operations are of similar type though their size and underlying logic are quite different. In both cases, it is a matter of filling a park designed to accommodate high-tech firms, research laboratories and higher-education establishments. They differ in that Sophia is a project of declared national interest and covers several hundred hectares, while the ZIRST de Meylan occupies just 60 hectares and receives no central government funding.

This technopole model is based on developing a park of technological activities in which it is hoped that the close proximity of companies, research centers and universities will promote the dynamics of endogenous growth, in which cross- pollination will play an important part.

b) The second "metropolis" model is that of the city as technopole.

Certain cities, for example Montpellier and Lyon, have declared themselves to be technopole cities since their agglomerations offer the basic ingredients required for technopole projects, namely research facilities, firms, and universities.

These Technopole cities link their promotion to that of their technopolitan resources. At a later stage, they foster poles of activity by promoting, near existing research facilities or universities, the creation of technological parks likely to attract firms with expertise in the facility's field. For example, a biomedical park would be situated close to a medical university ; a mechanical engineering park, next to mechanics research center, etc.

c) Programs exist which lie somewhere between these two "models". Some are not content to merely develop the technopole park, but rather seek to incorporate it into the town by treating the activity area as a "quartier" or town borough. At Nancy Brabois and Rennes Atalante, it is no longer a question of simply preparing a technological park, but of applying a more global approach to an entire zone comprised of housing, industry and parks. Other programs try to cluster several technopole sites or boroughs throughout a metropolitan area.

Taking these two models as starting points, numerous variations are possible. Some concentrate on site planning, hoping then to fill their park with prestigious company names, and pay relatively little attention to interaction and cross-pollination. Other programs, however, emphasize promotion and communication, striving to attract foreign investors by vaunting the city's modernity, research laboratories and high-tech companies.

Whatever the model, one characteristic that is unique to French technopoles is that the city, or more generally the metropolitan region, has become the spatial dimension of reference for most programs. Be it the city borough-as-pole or the multi-pole approach, some technopoles are trying to impregnate the entire metropolis with the technopole concept. By declaring an entire metropolis as a Technopole, continued innovations become an element of city policy, since they showcase the city's vitality and modernity.

Although the various programs vary greatly and have not all met with equal success, new structures, new approaches to park infrastructure planning as well as technology transfers at the local level have become apparent in France.

1.2 Principal institutional characteristics

a) As concerns the strategies of public institutions, all programs, Sophia Antipolis excepted, were born of local initiatives in which the local authorities were the driving force. France is marked by the complete absence of technopole programs resulting from the initiative of either large private companies or banks.

Often, local authorities form a mixed syndicate, since this allows them to work in association with support organizations (Chambers of Commerce, etc.) or employer groups interested either in participating in the promotion of the economic area or in the preparation of a zone for pilot projects.

Where other forms of intercommunity association exist, for example districts or urban communities, these structures manage the technopole program.

As the larger French towns grew, research establishments or universities as well as larger companies were usually placed, particularly in the 1960's, outside the city centers in the surrounding communities offering sufficient land reserves. This explains why today attempts to harness technical resources require intercommunity programs.

In most cases semi-public companies (Sociétés d'Economie Mixte - S.E.M.) are set up. These are limited liability companies in which the local authorities hold at least 51% of capital. The S.E.M.s plan and prepare infrastructure for the parks or technopole boroughs and, more rarely, are also responsible for program promotion.

Sometimes, instead of S.E.M.s, associations are formed. When this is the case they tend to principally be involved in coordination within the parks or within the metropolis.

2 - Analysis of "technopolitan" poles : what does one find in these parks ?

One notably finds :

- A small coordination staff - 3 to 5 people - who try to create a certain goodwill between park occupants, while sharing park promotion with the S.E.M. Budgets are usually modest: 2 to 5 million FF.

- Start-up company nurseries. These are commercial buildings which are made available to start-up companies at rents significantly below market prices.

- Small- and medium-sized high-tech companies but with few industrial firms. Services are well represented.

- A few large companies or rather establishments for those large companies, often little more than commercial representatives - in this case the mere presence of their name is considered to be an asset. It is enough for Hewlett-Packard, Bull, or France Telecom to be present in a park for it to be classified as high-tech.

In France, the best way of selecting companies for a park remains a subject of debate. Some argue that only high-tech firms should be admitted, while others favor an even greater restriction on companies, limiting participants to a theme field (computer science, electronics, biomedicine etc.). Still others assert that parks, to the contrary, should be opened to a wider array of activities.

Our experience has shown that overly restrictive choices tend to make it harder to find park tenants in sufficient numbers.

- One may also find government research facilities and universities which were already present before the technopolitan park or parks were planned.

- Finally, central government industrial and research offices slowly but surely set up representation or move activities to the parks.

3. Synergies : have technopoles fulfilled their promise ?

1) In the beginning, technopole projects were supposed to bring researchers, universities and companies together in order to favor cooperation, transfers of technology, start-up companies, etc. Unfortunately, it must be acknowledged that results have been disappointing. The teams from the Universities of Grenoble and Nice that studied the ZIRST and Sophia parks respectively discovered little synergy within the parks. This tends to prove that physical proximity alone is not sufficient to ensure cooperation. This remark applies to all the different programs: institutions remain compartmentalized.

2) Companies operating in labor pools outside the parks tend to view these programs as little more than urban planning, real estate promotion or simple local authority publicity campaigns. They feel little or no inclination to participate.

3) Projects which attempt to create networks between the technopolitan resources already present in an urban area fail to take the leading role away from the local representatives of the central or regional authorities - the centers for technological transfers, cells for the practical application of state-conducted research, the French ANVAR agency for applied science, etc.

4) Promoters of technopole schemes often assume that simply preparing park infrastructure will lead automatically to development. Experience has shown this to be incorrect, and that it is better to first reflect upon the conditions determining local economic development, and only then to consider specific park projects.

5) High-tech firms tend to develop in their own isolated world, with no links with the other companies which constitute the major strands of the industrial fabric of the urban area where the technopole is situated. The technological parks therefore tend not to spread their influence to the area's other industries.
It may seem that these conclusions are harsh. It should be born in mind however that the high expectations for technopoles were largely the result of their own self-imposed ambitions. Nevertheless, in France the technopole phenomenon is not without merit in that it opens new horizons in the areas of economics, technology and urban planning.

4. Promising developments

In a certain way, it can be said that the enthusiasm in France for technopole projects, according to the models that have just been presented, is running out of steam. Indeed, where promotion efforts have failed to attract companies or lead to the creation of new ones and where they have done nothing to modernize the industrial fabric, they rapidly lose their credibility and tend to weaken automatically.

Nevertheless, these efforts are a rich source of experience and if they receive proper attention from those who would promote local development as well as from government, they could prove to be of great importance for the future. The following questions provide food for thought :

a) If technological parks lead to little local economic development, should one and can one act at the local level to encourage local technological development? What policies, methods and skills will be required ?

A corollary exists : is the market capable of generating its own technological evolution, or does it require the State or, at the local level, the local authorities, to intervene to favour conditions for transfers of expertise and technology until such time as the market is ready to take over this task ?

The French technopole experience has included local technological development initiatives. Although these efforts have been limited to park planning and infrastructure or promotion campaigns, it would seem that the local technological and industrial environment finds it difficult to independently establish the contacts necessary for its own enrichment.

b) If physical proximity is not a prerequisite for cross- pollination, then how can cooperation between universities, research centers and industry be fostered in a given geographical area ?

Indeed, it has become apparent that even within the parks institutions remain compartmentalized. This contrasts with the needs of companies, be they big or small, for new technologies, technological know-how and information. How can supply be tailored to meet demand in a limited geographical area? Should not these areas try to base their structure on improving supply ?

c) Experience has shown that the zoning encouraged by technological parks within the economic and urban framework of metropolitan areas tends to create "cathedrals in the wilderness". Is this politically acceptable? If not, how can high-tech development zones be better integrated into the local economic geography? Would not one solution be to deliberately impregnate the existing economic and social fabric with a culture of technology ?

d) The economic activities attracted by technopoles in France are generally service oriented. These activities require establishment close to urban centers. What are the likely consequences of this redefinition of urban functions and how will cities be affected by the economy's attempts to retake the cities ?

As for zoning, futuristic urban planning projects such as Nantes-Atlanpole are attempting to reinvent the French city based on a new conception of space. Is this a sign of rediscovered inventiveness in urban planning policy?

e) As is widely known, France remains a highly centralized country. Both universities and public research centers remain under the control of central government, this despite decentralization laws. The same can be said of the decision- making centers of large companies, companies whose headquarters remain for the most part located in the Paris region.

Technopoles represent initial, somewhat hesitant attempts to create local structures likely to encourage the transfer of technologies and to contribute to industrial adaptation. Should the development of such policies be encouraged? These policies incorporate elements of R&D, economic and urban planning, etc., in an effort to give rise to, at the local level, projects and comprehensive strategies better adapted to the local context than those imposed by the authority of central government. In France central government intervention remains highly vertical with little regard for horizontal economic rationalization.

f) Finally, these programs often neglect the needs of companies. Unlike the firms attracted to the parks, most companies require the elaboration of a basic environment that would increase their competitive advantages. The list of needs is long : a highly- trained workforce, high-quality support services, easy access to technological resources, a suitable financial culture, etc. These needs are not at present met by technopoles. Perhaps technopoles should be viewed simply as embryonic, city-specific, local R&D policies to which other dimensions should be added.

At this study's completion, I was disappointed, apart from a few exceptions, at what I had actually found in the field. Nevertheless, I was extremely interested in those rare attempts to reinvent the city and economic geographies in such a way as to favour environments marked by cooperation between researchers, academics and private enterprise. That is why I wished to take part in the evaluation conducted in 1991-1992 by Datar and the France Technopole association, aimed at assessing the initial effects of technopoles on regional development. The study addressed three issues: the interrelationship between technopoles and regions,the issue of endogenous growth and the place of technopoles within European networks. The president of France Technopole invited me to study the endogenous growth question.

5. A new approach to evaluation

How can one evaluate an emerging phenomenon which is at present more a source of unanswered questions than of concrete results? For success, at present, remains limited and relative. How is it possible to effectively evaluate the endogenous growth of French technopoles?

Following a reflection on the evaluation and planning of public policy, I both independently and with the collaboration of other experts, proposed an original method of evaluation.

Given the context of innovation, participants and experts would interactively define evaluation criteria. The goal was not to authoritatively impose criteria, but rather to ensure the participants' acceptance of a method which they themselves had helped to conceive and which could then serve as a tool for self- evaluation.

This study began with the designing of a questionnaire by the directors of some 5 or 6 technopoles and the designated expert, namely myself. This questionnaire was subsequently sent to all French technopoles. It included the following questions :

First Question :

Please list the various local and regional networks (universities-companies, between companies, others) which seem to you to be representative of the ethos of technopoles and which you feel reflect a will to establish horizontal relationships rather than the traditional vertical or hierarchical ones. List these networks in terms of structure, durability and effectiveness.

Please indicate which of these networks are, on the one hand, the direct or indirect fruit of the setting-up of your technopole and, on the other hand, those for which your technopole is simply an additional resource for existing networks.

Second question :

What contribution, in the form of new structures and synergy- enhancing means, has your technopole made to the identification, exploitation and dissemination of know-how ?

Third question :

In what way have those involved (elected officials, corporate heads, civil servants, academics) acted as catalysts ?

Do you feel that these catalysts have brought in their wake "new occupations" which build on interfacing and engineering? If so, attempt to define these "new occupations" using examples drawn from your technopole.

Fourth question :

Does your technopole take advantage of intra-regional cooperation tools? Which ones? Describe them briefly. Do they contribute to the development of inter-regional solidarity? In what way? Describe.

Fifth question :

In what ways do you feel that your technopole has benefited the development of your regional economic fabric (employment (type, quality), technology transfers, creation of new enterprises, establishments, etc.)?

Do you feel that your technopole, thanks to its catalytic effect at the local level, has improved national economic performance?

We have received replies to this questionnaire from some 15 technopoles. Based on their responses, we have undertaken a more detailed study of technopolitan innovations in terms of actions or methods which favour endogenous growth. Examples include the network of start-up nurseries coordinated by Promotech at Nancy Brabois and the laser pole at Nantes Atlanpole. Later, criteria will be defined, again in collaboration with the technopoles, which will allow us to evaluate the effectiveness of their interventions in fostering endogenous growth.

This objective test is based both on pedagogy and evaluation andis both feared and welcomed. While some technopoles questioned shared with us their difficulty in answering these types of questions, others are impatiently waiting for the results, to better position themselves at the local level.

The results of this study will be made available during the next meeting of the French Technopole association, during the month of May in Grenoble.

Conclusion

Technopoles are a relatively recent phenomena in France. They are waiting for their second wind and their present attempts at recovery are an indication of their fragility. The phenomenon nevertheless reflects the initial glimmers of awareness of the decisive role that local authorities and cities can play in the creation of an environment favorable to cooperation between researchers and industry. What began as a simple spatial question -parks-, has led to a problem of quite a different nature, that of local policies which use an informal space, the technopole, as a starting point in an effort to decompartmentalize institutions, to assemble the diverse ingredients, to act as the driving force for technical and industrial change and thus firmly anchor the notion of modernity in the economic history of the locality.

A true evaluation of this innovative phenomenon requires one to walk in step with it, to understand the thinking of its pioneers and to jointly define its points of reference.

CEC DG XII

MONITOR SPEAR NETWORK ON :

EVALUATION METHODOLOGIES FOR STRUCTURAL SUPPORT PROGRAMMES FOR RESEARCH AND TECHNOLOGY DEVELOPMENT (RTD)

WORKSHOP ON :

SCIENCE AND TECHNOLOGY PARKS IMPACT EVALUATION

TECNOPOLIS CSATA NOVUS ORTUS

26 - 27 MARCH, 1992

BARI, ITALY

Tecnopolis CSATA Novus Ortus : Out comings from self monitoring

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1. Tecnopolis CSATA Novus Ortus : general information

Tecnopolis CSATA Novus Ortus, in short "TCNO", is the name given to the first technopolis established in Italy.

It is operational since December 1984, in the area of Valenzano, a 16000 inhabitants town ten kilometres far from Bari, on the Adriatic sea, in the south-east of Italy.

To promote the development of knowledge intensive industrial activities, TCNO makes "temporary" working areas available to newly located industrial initiatives, so that they receive immediate support from specialised services, access to both a well equipped environment and various technological services, thus enhancing their capabilities to reach the level of commercial production in short time.

After the starting phase, which takes from three to five years, industrial initiatives are directed to relocate from the Tecnopolis site to other sites (industrial or services areas, etc.), i.e. to sites more suitable to their new productive needs, but still related with Tecnopolis. That's how conditions arise for the establishment of a "technopolitan district", as the social and technical system networks and surfaces from the Park.

Firms that want to locate knowledge-intensive activities at TCNO must come into co-operative agreements with it, to receive the advantage of the existing infrastructure.

TCNO and co-operating firms contract their own activities in the market, and TCNO also uses the existing infrastructure to attain its strategic goals.

It should be noted that TCNO does not supply any property based service.

The physical infrastructure (buildings and advanced equipment) is co-funded by State and CEC, and remain under public ownership, but TCNO is responsible for managing and operating the physical infrastructure, and assumes the operational risk and maintenance costs.

TCNO is a no profit Consortium of Universities, Banks and Firms.

In what follows TCNO experience is summarised either in assessing its own Science Park concept, or in recalling some relevant data and information.

2. Basic concepts

TCNO is located in an "objective 1" Region: so the basic concepts apply primarily to this specific character.

2.1. Regionalisation of RTD policies requires a **continuing local development observation** and specific **goals** to be attained and **criteria** to be adopted in impact evaluation studies

A **continuing local development observation** is required to link :

- local problems with specific solutions;

- opportunities for local development with specific exploitation.

Activities (either planned or operational) give linkages between problems and solutions, opportunities and exploitation (see also Gabriel Colletis : "... each territory has to be considered as a combination of specific activities...").

2.2. When in the Planning phase, the **ex-ante evaluation** should emphasise on programme quality and stakeholders credibility. In this phase, the Local Development Observation helps in specific goal setting.

When in the Operational phase, the **mid course evaluation** should emphasise on Science and Technology Park impact on Local Development, and should activate some feedback mechanisms to support the Guiding and Evolving phases in the Science and Technology Park life cycle. In this phase the Local Development Observation helps in comparing planned and actual results.

From the view point of a Funding Agency, mid course evaluations could give decisional support to a "phased" funding process, conditioned upon appraisal of results of the Science and Technology Park initiative.

A continuing local development observation is also useful as an educational tool for STPs Promoters and Managers. Actually, the Local Development Observation could induce a "cognitive" approach into the Science and Technology Park Organisation Management (see also Bob Hodgson : "...inputs > activities >outputs...").

A continuing local development observation could also be useful for a Funding Agency to set up local development - oriented RTD policies, providing for incentives and / or priorities to RTD activities to be carried out in Science and Technology Parks. In other words, awareness of local development problems / opportunities could help in setting up Science and Technology Park - based RTD packages, such to link regional development policies with innovation development policies (see also Gabriel Colletis : "... the technopolis is in the heart of knowledge investment network...")..

2.3. Goals to be attained through the Science and Technology Park initiative could be stated in terms of:

- attraction of exogenous knowledge intensive firms;

- support to innovation development in local industry;

- support to new local knowledge intensive firms creation.

Qualitative and quantitative specifications in goal setting arise from regional conditions, assessed via the continuing Local Development Observation, either in the Planning phase, or in the Operational Phases.

2.4. Specific evaluation criteria refer to specific goals.

Goals in terms of attraction of exogenous knowledge intensive firms should require evaluation criteria such as :

- technology / industry / services specialisation;
- value of "attracted" industrial production;
- jobs;
- impact on human factor availability (as required by "attracted" activities);
- business connections with local firms (either existing or to be created);
- impact on structural shift in local economy;
- attracted firms Headquarters location (local / external).

Goals in terms of support to innovation development in local industry should require evaluation criteria such as :

- technology / industry / services priorities, as arising from local problems and opportunities ;
- impact on human factor innovation (as required by innovation development in local firms);
- internationalisation;
- value of industrial production of local "clients";
- business connections with "attracted" firms (impact on local subcontracting);
- newly created local firms arising from the endogenous entrepreneurial basis (impact on local market development).

Goals in terms of support to new local knowledge intensive firms creation should require evaluation criteria such as :

- technology / industry / services priorities (connections with "attraction" policies and "support to existing industrial basis" policies);

- jobs;

- value of industrial production in newly created local firms;

- internationalisation;

- business connections with "attracted" and "existing" local firms.

2.5. Evaluation criteria induce specific **requirements**, and then specific **activities**, and then specific **results** expected from the Science and Technology Park initiative (let me recall again Bob Hodgson's suggestion "...inputs > activities > outputs ...").

A system view of requirements that characterise the Science and Technology Park initiative is provided by a crossed reference to **Phases in the Innovation life cycle**, and to **Support Systems**, allowing to identify specific **Support Factors**.

Phases in the Innovation life cycle can be stated as follows (see also E.J. Blakely, B.H. Roberts, P. Manidis - Inducing high tech: Principles of designing support systems for the formation and attraction of advanced technology firms - Int. Journ. Technology Management, Vol. 2, No. 3/4, 1987):

- **Research** (Basic, Applied, Generic, Market - driven, Technology - driven, Invention, Adaptations,...);

- **Development** (translating ideas, research principles, inventions and adaptations into a practical product; prototype tests or models building; performance, application and feasibility evaluation,...);

- **Diffusion** (commercialisation of a new product or process, joint venturing or other production arrangements, ...);

- **Production**.

Support Systems can be detailed as follows:

- Information and Communication;
- Strategic relations;
- Human Resources;
- University and Research;
- Quality of Life
- Entrepreneurial Climate;
- Government;
- Financial System;
- Physical Infrastructures;
- Urban Services;
- Specialised Services;
- Image in the Innovation field.

Specific Support Factors apply to specific Support System / Phase in the Innovation Life cycle crossings. For instance:

- Information and Communication / Production > multimedia info-com facilities and services;

- Strategic Relations / the whole Innovation Life cycle > formal and informal networking among stakeholders of economical development;

- Human Resources / Diffusion > entrepreneurs, venture capitalists, business consultants;

- University-Research / Development > programmes supporting mobility and exchange;

- Quality of Life / the whole Innovation Life cycle > community awareness of a global Innovation project ;

- Entrepreneurial climate / Research and Development > contracts from large firms to local knowledge intensive firms;

- Government / Research > procurement of Strategic RTD Programmes;

- Financial System / Diffusion > Investors Consortia;

- Physical Infrastructures / Diffusion and Production > Incubators;

- Specialised Services / Production > Conformance Testing Services;

- Urban Services / Production > Good Provision Services;

- Image in the Innovation Field / Research > top quality High Tech Private Labs.

3. Tecnopolis CSATA Novus Ortus : some details

3.1. about the strategy

TCNO strategy is to induce local development through innovation in social and economic environment.

It could be useful to interpret such a strategy through some concepts suggested by Michael Luger, Gabriel Colletis and Thierry Bruhat.

Luger suggests that a Science Park is a growth pole inducing endogenous development. This could be a relevant interpretation of TCNO strategy, where the growth pole is the Technopolitan District receiving new exogenous locations of top level National and Multinational Firms, and the endogenous development is the result of TCNO support to innovation development in existing local firms, and to new firms creation.

Colletis suggests that a Science Park is an actor in several formal and informal networks. Actually, TCNO is such an actor, involved in several networks at local, national and international level, together with similar Organisations, Firms, University and Research Institutes, Governmental Bodies.

Bruhat, in assessing the twenty years experience in Sophia Antipolis, concludes that the managerial competence in Sophia should pair with a new local development support competence. We can state that TCNO is coupling its competence in inducing local development, with the managerial competence in approaching the market of specialised services to support innovation development.

3.2. about the physical layout

TCNO is a company providing specialised services to support innovation development.

Physical locations of TCNO activities must be understood as a result of this main activity. Therefore today the physical layout of TCNO can be related (see Table 3.2.) as a three-level structure : Valenzano, Technopolitan District and Delegations.

table 3.2. : TCNO Layout

VALENZANO
TCNO HQ, R & D ACTIVITIES, EDUCATION & TRAINING
FIRST LANDING OF EXOGENOUS K - I ACTIVITIES, INCUBATION
OF NEW LOCAL FIRMS
SPECIALISED Labs
Bari University new developments
National Council of Research Area

TECHNOPOLITAN DISTRICT (metropolitan area network)
FINAL LOCATIONS OF EXOGENOUS ACTIVITIES AFTER FIRST LANDING AND
NEW LOCAL FIRMS AFTER INCUBATION
BARI INDUSTRIAL ZONE
BARI TERTIARY POLE
BARICENTRO BUSINESS PARK
Valenzano, Capurso, Casamassima industrial zones

TCNO DELEGATIONS
INFO - DEMO SERVICES
BARI ASSOCIATION OF LOCAL ENTREPRENEURS (A.L.E.)
BRINDISI A.L.E.
FOGGIA A.L.E.
LECCE A.L.E.
TARANTO A.L.E.
CASARANO (LECCE) SHOES INDUSTRIAL DISTRICT
MATERA

3.3. about the local development observation

TCNO is developing in Puglia region, ranking 4th in Southern Italy in industrial employees per inhabitants ratio (see table 3.3.a.).

Moreover, the Bari sub-region ranks 3rd in Puglia.

We can argue that the Italian National Policy of the last decades, promoting plant locations in Southern Italy through physical infra structuring and financial incentives induced a weak industrial basis, built up on jobs rather than on entrepreneurs. Actually, innovation development has much to do with entrepreneurial decisions, and little to do with industrial branches location.

table 3.3.a. : industrialisation in Southern Italy

SOUTHERN ITALY (1989)

EMPLOYEES IN INDUSTRY / INHABITANTS PER REGION

REGION		INHABIT.	EMPLOY.	EMP/INH.
ABRUZZO		1262692	68617	5.43%
CAMPANIA		5773067	180485	3.13%
MOLISE		335211	10178	3.04%
PUGLIA		**4059309**	**112370**	**2.77%**
	Taranto	600885	27893	4.64%
	Brindisi	409613	13806	3.37%
	Bari	**1530613**	**40122**	**2.62%**
	Lecce	814854	17354	2.13%
	Foggia	703344	13195	1.88%
BASILICATA		1530613	40122	2.62%
SARDEGNA		1655859	32890	1.99%
SICILIA		5164266	67426	1.31%
CALABRIA		2151357	21614	1.00%
TOTAL		**25991683**	**646072**	**2.49%**

Table 3.3.b. shows the distribution of industrial production units in Puglia per sector and manpower class.

Evidence is given of a large basis of endogenous Small and Medium Enterprises in traditional sectors (food, fashion, building material, metal products, textile, shoes).

Evidence is given also of two main goals in TCNO strategy:

- priorities in supporting innovation development in above mentioned sectors;
- attraction of exogenous activities in high tech sectors (Informatics and Telecommunications, Microelectronics, Space Industry).

table 3.3.b. : industrial units in Puglia per sector and manpower class (1989)

SECTOR	MANPOWER CLASS						
	0 - 9	10 - 19	20 - 99	100-299	300 - 999	>= 1000	TOTAL
FOOD	114	128	90	10	4	4	350
TEXTILE	6	48	39	6			99
FASHION	3	99	119	9			230
SHOES	3	32	48	10	2	3	98
WOOD	5	30	25	2			62
WOOD FURNITURE	3	31	18	1			53
PAPER		9	8	2		1	20
PRINTING		26	16	3			45
LEATHER		8	12		2	2	24
RUBBER AND PLASTICS	1	29	29	2		1	62
CHEMICAL	2	18	12		1	3	36
PHARMACEUTICAL		2			1	1	4
PETROLEUM AND COAL		14	8		3	3	28
BUILDING MATERIAL	19	127	100	14	1	1	262
METALLURGY		3	5				8
METAL PRODUCTS	7	88	81	19	11	11	217
MACHINERY	2	24	27	4	2	3	62
ELECTRIC PRODUCTS		7	8	2	1	1	19
ELECTRONICS		4	2	2			8
AUTOMOTIVE	1	14	20	5	6	10	56
PRECISION TOOLS	1	3	1				5
OTHERS		1			2	2	5
TOTAL	167	745	668	91	36	46	1753

Comparison between table 3.3.b. and table 3.3.c. gives evidence of:

- sectors where exogenous entrepreneurship rules local manpower (exogenous investments in Puglia - Metallurgy);
- sectors where local based firms rule external manpower (endogenous investments in other regions - Food, Leather, Pharmaceutical, Petroleum and Coal, Building Material, Metal and Electric Products).

Specific goals apply to above mentioned sectors : local sub-contracting for knowledge intensive activities in Metallurgy; selective business retention policies in Food, Leather, Pharmaceutical, Building Material, Metal and Electric Products).

Actually, TCNO and co-operating firms do cope with difficulties in selling advanced services to Metallurgy local Branches, which find their main suppliers in the same areas where their own headquarters are located.

table 3.3.c. : employees in industrial production in Puglia per sector and manpower class (1989)

SECTOR	MANPOWER CLASS					
	0 - 9	**10 - 19**	**20 - 99**	**100-299**	**300 - 999**	**>= 1000**	**TOTAL**
FOOD	4229	3156	4152	1606	1646		14789
TEXTILE	259	655	1468	1159			3541
FASHION	34	1340	4414	1303			7091
SHOES	41	478	1740	1427	1000	1030	5716
WOOD	116	424	875	240			1655
WOOD FURNITURE	36	405	707	180			1328
PAPER		142	297	399		2216	3054
PRINTING		348	661	558			1567
LEATHER		109	377		885		1371
RUBBER AND PLASTIC	11	446	1059	337		1100	2953
CHEMICAL	23	263	560		920	3061	4827
PHARMACEUTICAL		27			309		336
PETROLEUM AND COAL		191	267		1167		1625
BUILDING MATERIAL	118	1719	3283	2376	580		8076
METALLURGY		43	215	2051		20994	23303
METAL PRODUCTS	53	1212	3220	1073	6532		12090
MACHINERY	11	313	909	392	814	1768	4207
ELECTRIC PRODUCTS		88	443	429	462		1422
ELECTRONICS		50	90	749			889
AUTOMOTIVE	11	192	671	245	3928	5174	10221
PRECISION TOOLS	8	50	29				87
OTHERS		14			1396		1410
TOTAL	**4950**	**11665**	**25437**	**14524**	**19639**	**35343**	**111558**

Table 3.3.d. gives evidence of geographical priorities in TCNO policies supporting of innovation development in local industry:

- Food in Foggia sub-region;
- Textile in Putignano (Bari);
- Fashion in Lecce sub-region;
- Shoes in Barletta (Bari) and Casarano (Lecce);
- Metal Products in Bari and Taranto.

Table 3.3.d. gives also evidence of sectors where a structural shift should be supported (Electronics) and a local supply of knowledge intensive services and products should be developed (Chemical and Pharmaceutical in Brindisi; Paper in Foggia; Machinery in Lecce; Metallurgy in Taranto).

table 3.3.d. : industrial specialisation per sub-region - Puglia (1989)

SECTOR	SUB - REGION				
	BARI	BRINDISI	FOGGIA	LECCE	TARANTO
FOOD	-0.18	0.09	**0.30**	-0.07	-0.72
TEXTILE	**0.22**		-0.03	-0.01	-0.97
FASHION	0.14	-0.62	-0.98	**0.36**	-0.42
SHOES	**0.40**	-0.76	-0.91	**0.78**	-0.93
WOOD	0.21	-0.54	-0.61	-0.57	-0.86
WOOD FURNITURE	0.03	-0.35	-0.17	0.25	-0.89
PAPER	-0.05		**0.85**	-0.75	-0.86
PRINTING	0.32	-0.23	-0.06	-0.28	-0.66
LEATHER	-0.32		-0.86	0.60	-0.96
RUBBER AND PLASTIC	0.14	-0.00	-0.16	-0.47	-0.69
CHEMICAL	-0.64	**0.78**	0.28	-0.84	-0.87
PHARMACEUTICAL	-0.93	**0.43**			
PETROLEUM AND COAL	-0.56	0.20	-0.52	-0.84	0.19
BUILDING MATERIAL	0.02	-0.45	0.10	-0.16	-0.45
METALLURGY	-0.94	-0.88	-0.81	-0.91	**0.94**
METAL PRODUCTS	**0.24**	0.23	-0.42	-0.50	**0.31**
MACHINERY	0.12	-0.23	-0.72	**0.75**	-0.03
ELECTRIC PRODUCTS	-0.14	-0.75	-0.28		-0.88
ELECTRONICS	-0.61	-0.97	-0.84		-0.97
AUTOMOTIVE	0.14	0.22	0.18	-0.71	-0.70
PRECISION TOOLS	-0.32	-0.19			-0.50
OTHERS	0.17			0.76	

Table 3.3.e. shows the regional diffusion (Employees and Production Units) of Services (Financial, R&D, Quality Assessment, Marketing, Advertising, Education & Training, Data Processing, Software Production, Management) in 1990, and its 1987 - 1990 variation.

One can argue that the TCNO initiative belongs to a regional scenario characterised by a wealthy Services Supply (87-90 variations : + 38.5 % employees and + 27 % production units). In this scenario Bari shows a "maturity" character, where employees grow faster than in the whole region, and production units grow more slowly. Brindisi shows a "turbulence" character, where employees grow seven times as fast as in the whole region, and production units grow twice the regional percentage. Lecce and Taranto show a growth rate very near to the regional one in production units, while the growth rate in employees is 50% less than the regional one: it seems to be a "readjustment" phase. Foggia shows a "retard", where either employees or production units grow more slowly than in the whole region.

The amazing growth rate of employees in Financial Services (89.8%) and high rates in Education & Training (60%), Data processing, Software Production and management Services (54%) testify that TCNO choice to specialise in Advanced Services supporting Innovation is a proper interpretation of the market.

table 3.3.e. : Puglia (1990) - Services : Employees and Production units per Sub-region

SERVICES	SUB - REGIONS										PUGLIA			
	BARI		BRINDISI		LECCE		FOGGIA		TARANTO		PUGLIA		VAR.90/87	
	EMPL.	P.U.	EMPL.	P.U.	EMPL.	P.U.	EMPL.	P.U.	EMPL.	P.U.	EMPL.	P.U.	EMPL.	P.U.
FINANCIAL	815	511	1437	83	204	109	80	102	184	159	2720	964	89.8	14.1
R & D, QUALITY ASS.,...	797	266	72	37	69	51	121	66	1619	70	2678	490	-11.7	16.2
MARKETING, ADVERTISING	864	380	19	54	153	70	82	91	142	93	1260	688	25.7	8.3
EDUCATION & TRAINING	50	37	6	7	3	8	17	8	36	24	112	84	60	32.1
EDP, SW PROD., MGMT,...	5323	1747	519	196	809	422	894	347	1446	508	8991	3220	53.9	34.3
TOTAL	7849	2941	2053	377	1238	660	1194	614	3427	854	15761	5446	38.5	26.8
VAR. 90 / 87	40.6	24.8	279.5	52	13	28.4	18.5	21.8	8.7	27.3	38.5	26.8		
	CONCENTRATION		ACCELERATION		GROWTH		RETARD		GROWTH					

3.4. about the results

Referring to its strategic role (see paragraph 2.3.), TCNO induced in the last three years' results that are shown in table 3.4., in terms of "attraction", "support to endogenous firms' creation" and "support to innovation development in local firms".

table 3.4.: TCNO - induced local development : some indicators

FIRMS	UNITS			EMPLOYEES			TURNOVER (MILL. ECU)		
	89	90	91	89	90	91	89	90	91
EXOGENOUS									
PARK	4	6	9	73	110	164	5.33	8.25	14.00
TECHNOPOLITAN DISTRICT	5	6	7	440	540	620	33.00	41.58	49.60
NEWLY CREATED	1	5	8	2	18	32	NA	2.67	6.00
LOCAL CUSTOMERS OF TECHNOLOGY DIFFUSION SERVICES	20	53	150	=	=	=	=	=	=
LOCAL CUSTOMERS OF VALUE ADDED INFORMATION SERVICES	140	320	450	=	=	=	=	=	=
TCNO	1	1	1	194	223	238	13.91	25.13	46.24
TOTAL				**709**	**891**	**1054**	**52.24**	**77.63**	**115.84**

3.5. about the endogenous firm creation

Firm creation in manufacturing sectors in Puglia and in Bari sub-region is characterised in tables 3.5.a. and 3.5.b. .

Evidence is given about the appropriateness of the specific TCNO initiatives providing support to endogenous knowledge intensive firms creation.

Actually, Puglia and Bari show the existence of a structural opportunity towards enterprise creation.

Puglia ranks 10th out of eighteen Italian Regions, and second out of eight Southern Regions (labelled ">" in table 3.5.a.).

Bari ranks 42nd out of 78 Italian sub-regions, and first in Puglia (Apulian sub-regions bold-type in table 3.5.b.).

table 3.5.a. : Italian Regions

new businesses '85 - '87
Manufacturing
(Italy = 100 - ref. to working population)

	TOSCANA	138.7
	VENETO	138.5
	MARCHE	134.3
	LOMBARDIA	126.4
	EMILIA	111.7
	PIEMONTE	100.4
>	ABRUZZO	99.9
	UMBRIA	88.4
	LIGURIA	74.3
>	**PUGLIA**	**68.5**
	LAZIO	65.8
>	CAMPANIA	64.8
>	BASILICATA	61.8
	VAL D'AOSTA	60.5
>	CALABRIA	52.8
>	SARDEGNA	52
>	MOLISE	49.7
>	SICILIA	32.1

SOURCE :
F.ROVIDA , 1988

table 3.5.b. : Italian sub-regions

1. MACERATA	186.6
2. PISTOIA	180.8
....	
5. MODENA	172.1
....	
37. TORINO	94.9
38. BOLOGNA	93.1
....	
42. BARI	**87.9**
....	
57. FOGGIA	**65.3**
58. TARANTO	**64.7**
....	
65. LECCE	**60.2**
....	
73. BRINDISI	**48.3**
....	
78. TRAPANI	36.5

Origins of entrepreneurial ideas in TCNO experience are shown in table 3.5.c..

Evidence is given of low impact of University / research personnel in starting up new businesses in knowledge intensive fields.

table 3.5.c. : TCNO - New Businesses Creation Programme -
Sources of Entrepreneurial Ideas (more than 200 ideas submitted in '89 - '91)

ENTREPRENEURS	42%
TECHNICIANS	35%
UNIVERSITY STUDENTS	9%
BUSINESS EXECUTIVES	8%
UNIVERSITY PROFESSORS	6%
	100%

3.6. about funding

Table 3.6. shows a synthesis of capital investments and operations costs in the '83 - '92 time span.

table 3.6. : TCNO - Capital Investments and Operations ('83 - '92) - Millions ECU

CAPITAL INVESTMENTS		**53.33**
CO - FINANCED BY NATIONAL GOVERNM. - CEC :		
LAND	0.00	
BUILDINGS, BASIC INFRASTR.	26.67	
HIGH - TECH INFRASTR.	21.33	
EDUCATION & TRAINING	5.33	
OPERATIONS		**166.67**
CO - FINANCED BY NATIONAL GOVERNM. - CEC :	66.00	
CONTRACTED WITH PUBLIC AGENCIES / PRIVATE FIRMS :	100.67	
TOTAL TURNOVER		**220.00**

4. conclusions

TCNO experience has been summarised, to show how in depth Impact Evaluation could affect strategies and operations in a Science and Technology Park.

What has been reported in Chapter 2 (Basic Concepts) arises from the operational experience in TCNO, where Self Monitoring is primarily a learning tool to support the organisational life cycle of the Science Park company.

Usually I remember that the lower the local development stage, the higher the complexity level.of the Science Park initiative should be.

Continuing local development observation, and related evaluation processes, can help in managing such a complexity, either from the view point of the Science Park company, or from the view point of the public decision maker.

EVALUATING CAMBRIDGE SCIENCE PARK:

METHODS AND RESULTS

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INTRODUCTION

This brief paper draws on the work of my colleagues at Segal Quince Wicksteed Limited who have been observing and analysing the growth of new technology based firms in the Cambridge area since before I became associated with the firm. In 1984 the field work was carried out for the Cambridge Phenomenon (1) report, that was published in 1985 and reprinted with revisions in 1990. In between, the firm have been involved in other studies of Cambridge (2) as well as analyses that enable comparisons to be made with many other places throughout Europe and wider afield (3).

I have also drawn on work by others who have examined the growth of technology related activity in Cambridge (4) plus work on evaluating science and economic development programmes in which I have been involved with SQW (5).

The structure of the paper reflects the particular experience of the Cambridge area, as something of a case study, plus the need to focus on evaluation as an essential policy design tool. Because there are a number of peculiar features about the Cambridge story, as indeed there are about any case study, I have sought to draw out general evaluation issues rather than to concentrate on the descriptive and anecdotal. The paper is, therefore, structured under the following main headings:

- Cambridge: background and history
- Cambridge Science Park: contribution and dynamics
- Evaluation: approaches, issues and limitations.

CAMBRIDGE: BACKGROUND AND HISTORY

This is a very brief and selective presentation of the background facts about Cambridge and the development of science based firms in and around the university town. Several of the references provide a fuller description for those with a deeper interest. Here only that material necessary to understand the role of the Cambridge Science Park (CSP) is presented.

In essence Cambridge is a small country town. It has an immediate population of around 100,000 but a wider catchment subregional influence over an area containing a further 200,000. It is located within the fastest growing region of the UK but has historically been neither an administrative nor a business centre, indeed, in spite of the clerical origins of its colleges, nor has it been a religious centre.

However, the University and its thirty plus colleges do differentiate the town. By European standards it is only a medium sized university with around 14,000 students of whom some 3,000 are postgraduate. Broadly half the University is science and technology related and among its 3,000 or so academics there are many whom their international peers recognise as leaders in their field. It is by the quality and range of its research work (and the research work of the many related and unrelated institutes located in and around Cambridge) that it is known and it is this which provides the distinctive character of the city.

A further important distinguishing characteristic of the Cambridge story is its essentially restrictive development climate. The town itself is tightly bounded, as an administrative unit, and, with a number of strong but largely unsuccessful opponents, there is a general physical planning regime which seeks to restrict further development. Until recently, there has also been a generally weak infrastructure that constrains rather than encourages development although it is not simple to distinguish cause from effect. Within the word infrastructure, is included elements that are both hard (road, rail and air transport, for example) and soft (business services such as legal, accounting and venture capital, for example).

Within this mixture of positive and negative influences an interesting phenomena has been born. Its origins stretch back over a century - the first new technology based firm in Cambridge was started by the son of Charles Darwin in 1881 and still survives albeit in a radically different form. The phenomena is the rapidly accelerated growth of NTBFs that has been experienced over the last two decades. From a base of two firms at the turn of the century had grown around 200 by 1970, which doubled again by 1980, and is currently estimated to be in excess of 600 science and technology based firms. These firms are estimated to employ around 20,000 which is a smaller proportion of the employed population than the number of firms is of the corporate population, reflecting their relatively smaller size.

As suggested earlier, the University and the science base of the area are two of the crucial ingredients. The scale of their effect is enlarged, because of the culture and character of the University, as well as its scientific excellence. Its structure is ideal to foster networks (because of multiple allegiances to departments and colleges), its relaxed operating rules (in relation to IPR and private activities of academics, for example) and its size as a market for instrumentation and specialist science related goods all contribute strongly. This networking and neglectful indirectness is also reflected in the source of NTBFs. Few (one study estimated around 15%) have been direct spin outs from the University or research institutes. But, links and indirect origins can be traced for the majority of firms to the various science and engineering departments of the University.

A concurrent improvement in Cambridge's infrastructure and in the national government's broad policy stance to new small entrepreneurial firms also played major roles. Cambridge now has a motorway connection to London, the rail line has been electrified and London's third international airport is developing only 20 miles south of the city. The business services infrastructure also improved with leading national firms of lawyers and accountants and specialist venture capital organisations all coming to serve the growing Cambridge business base. The Thatcher years also created an importantly positive climate for enterprise and sponsored the growth of entrepreneurial new firms. These then provided the essential ingredients for the Cambridge Science Park to emerge as a success.

CAMBRIDGE SCIENCE PARK: CONTRIBUTION AND DYNAMICS

Key people in the University began to look at the whole question of relationships between their institutions and science based industry (Mott Committee) in response to both local interest and national concerns to mobilise technology for economic growth. The Cambridge Science Park emerged from and became the physical representation of this continuing process of debate.

The Park aimed to provide:

- a pleasant place, for science based businesses to locate
- a means of interaction with the University
- a network among tenant firms.

These are explicit aims of the Park development team and echo the general conclusions of the discussions that had been taking place in the University. The Park itself is located well away from the main University and college buildings so a positive attitude to academic liaison has been taken from its inception. The activities have been led by the Trinity development team, but are not limited to them, and include:

- organising small gatherings of those with common research interests

- providing a fund for joint research - Trinity College made available on a 50/50 basis a research fund to demonstrate its commitment to fostering R&D links

- information and newsletters on major events (lectures, seminars etc) and news of developments related to companies resident on the park

- Society of Applied Research, to give status and a formal home for those interested in applied research

- Wolfson Industrial Unit, to provide a gateway into a wider University network

- Industrial Liaison Officers were identified in all the laboratories through the University.

In addition to these liaison functions the park contributed three crucial elements to the acceleration of the phenomena. These are:

(a) land and planning: the site had been in Trinity College's ownership for a century so they were willing and able to take a long term view of its development potential. The particularly flexible wording of the development condition from the planning authorities also provided the opportunity to create a different type of landscape and premises

(b) infrastructure and buildings: with a strong professional team in support which enabled a rapid start to new businesses or incoming investments that previously had not been possible for individual firms to achieve even should they have possessed the resources and determination to do so

(c) social/contact centres: a central element of the first phase of the park was the Trinity Centre where people could meet socially to enjoy recreation and where firms could hire meeting rooms for both business and social meetings.

Importantly, the flexible planning permission granted to the park marked a positive change and gave a public signal that after long and serious reflection Cambridge is open for business. The open attitude is still, however, distinctly Cambridge - these facilities are now available, are effected largely through personal networks and come without any force or compulsion - all in all, very 'laid back'.

It is worth reflecting on the dynamics of the Science Park and the method through which its effects have been realised. But first the basic facts. The park was first mooted in 1969, had a champion in Dr John Bradfield, the Senior Bursar of Trinity College, and the first occupants arrived in 1973. The total land area is just over 50 hectares and the development has been carried out in four broadly similar sized phases. The largest building on the park, occupied by Knapp Pharmaceuticals, is some 15,000 square metres and the smallest is just over 50 square metres. This smaller scale of accommodation is found both in independent premises and in units within an Innovation Centre located on the park. This is not to be confused with the larger St John's Innovation Centre which lies across the main road on an adjacent site.

7)

The Cambridge Science Park is now fully occupied but is still far from static. Around 80 companies are found on the park (a small proportion of the 600 or so NTBFs estimated to be located within the Cambridge area) and total employment is around the 3,000 mark. The largest employer has over 350 employees and the smallest (of which there are several) only five. In terms of activity the firms fall into the following broad categories: 30% IT and electronics related; 20% bio sciences; 25% service activities; and 25% engineering (predominantly instrumentation) and other activities.

In addition to the direct activity accommodated on the park, it has undoubtedly played a wider dynamic role. Its success has certainly contributed to accelerating the development of other similar schemes. A typical and interesting example is the St John's Innovation Centre which is located nearby but plays a completely different role. It has been developed on a 8 ha plot and provides around 11,000 square metres of space largely for small firms, of whom a higher proportion than on the Science Park are direct University spin outs (some 26%). Again, as an example of the contribution of the personal networks, there is a group of 13 advisors available to firms in the Centre who are all Fellows of St John's College and are drawn from across the relevant departments of the University.

In a rather less obvious, but still important, way the Cambridge Science Park also became an important flagship for the accelerating phenomena. In spite of the fact that about 90% of the research rich firms in the Cambridge area are not located on the park they benefit indirectly from what it represents and the way in which its market image has changed both the climate for enterprise in the city and the reputation of the city wider afield.

The overall conclusion then, is that the Cambridge Science Park has made an important contribution to sustaining, and maybe even to accelerating the phenomena. But it is neither the source, nor the whole, nor the cause of the rapid growth of NTBFs in the Cambridge area.

EVALUATION: APPROACHES, ISSUES AND LIMITATIONS

Now to the central purpose of the workshop and the contribution to both understanding and method that can be derived from seeking to evaluate the Cambridge case study. Before going on, it is worth reflecting that any evaluation must begin with the aims of those promoting the initiative as the first level of evaluation must relate to the achievement of the initiative against those aims. In the Cambridge Science Park case the three explicit aims of the development have to a large degree been met, so it should rightly be judged a success.

A second aspect to remember is the perspective from which the evaluation is being made. The CSP is a private initiative, using private money to fund a facility achieving a commercial return. At the simplest evaluation level there is nothing more that needs to be added. In cases where public money is being used to subsidise initiatives then wider concerns of evaluation may arise but this does not strictly apply to the Cambridge Science Park, even though to an important degree the science foundation upon which the phenomena is based is funded by the public sector.

General approach

But, not surprisingly, I am not going to limit my perspective to this narrow view point and in the following comments I will draw on some of the lessons we have learned during other evaluation studies of both similar and different schemes. As a starting point it is often helpful to differentiate three levels at which evaluation can take place. These are:

- first, the input level: did we do well whatever we sought to do?
- second, the activity level: has what we hoped to stimulate been achieved?
- third, the output level: what additional value has been created by the scheme?

Input level

Here the concern is with the direct developments that have been created and, in the case of science parks, these usually include:

- investment: how much money has been spent, on what, including infrastructure, research and development, training and land and premises

- physical development: what scale of physical development has been undertaken including landscaping, premises, offsite infrastructure; and to what quality in relation to nearby more standard industrial projects

- new institutional forms: what has been achieved including any new partnerships to develop and operate the park, new liaison roles to the academic institution and new services that have been attracted such as technical venture capital.

Measures are usually straight forward and scalar in terms of the investment and physical development aspects but more judgemental and descriptive in terms of the degree of innovation in institutional form. Comparisons with other similar developments are also often useful to establish relative levels of economy, effectiveness and efficiently.

Activity level

Here at the second level the analysis is more concerned with the intermediate output of what is happening on or around the park that can be thought to have been stimulated by its provision. Typically the following aspects will be examined:

- return on investment: what financial return has been achieved, is it at a commercial level or has it been subsidised and over what length of time

- firm's location: what investments have been attracted to the location, which firms have arrived and what new activities have they introduced to the local economy

- new firm formation: has the rate of formation been stimulated and is the quality of firm or composition of activity changed for the better

- stimulated investment and jobs: how much additional investment has been stimulated by the offer of land on the park and how many and what quality of new jobs have been located there

- gross value added: what scale of new business has been brought to the area and retained, including multipliers, within the region.

The emphasis is on gross measures of activity and on the leverage that has been achieved as a result of the initial park development. Leverage is usually measured by the ratio of the gross totals to the initial input. Other measures relate to such items as the 'cost per job', which is the total public subsidy divided by the numbers of jobs stimulated. This can then be compared to similar measures on other development initiatives. Again, scalar measures do not capture all the impacts and judgemental and descriptive measures will need to be incorporated.

Output level

This is the third and final level of evaluation which is concerned with net, rather than gross, impacts and which seeks to take account of activity that has been displaced (to reach a true net measure) and to discount those actions that would have been expected to happen even without the science park scheme and which, therefore, are not genuinely additional.

The creation of value includes direct (usually measured by economist as the payment for factors of production, including wages, profit, rent and interest - but excluding intermediate inputs that have been included in the gross value added figures of the activity level) and indirect or multiplier effects. These latter multiplier effects have traditionally been a nightmare for regional analysts as they are difficult to identify and it is never clear how much is retained within the region being examined and what proportion leaks elsewhere.

Displacement is one of the key ideas in evaluation and for completeness it has both negative and positive components. On the positive side actions can be stimulated that are different (occurring earlier, being bigger or qualitatively better, are three aspects of this) from what would have happened otherwise. In the Cambridge case the development of the St John's Innovation Centre is a good example. On the negative side, the impacts that are relevant are those activities that have been 'crowded out' by the science park development. The objective is to measure net impact and it is important to relate the displacement measure to the right geographic level especially if the science park is seeking to play a regional development role.

Additionality is the second key idea in evaluation and is especially relevant for publicly funded projects. If the stimulated activity could have been expected to occur without the project or incentive then it should not be counted as a benefit at this third output level. However, it is rarely that simple as the majority of stimulated activities are influenced to adapt their plans (bigger, earlier or better, for example) but would probably have done something even without the project. Consequently, establishing the genuine net additional benefit of the project quickly becomes a predominantly judgemental activity in which it is usually essential to survey in some detail those responsible for key decisions.

Essential issues

Within this three level framework there are four essential issues that always arise in evaluation exercises. In the Cambridge case these issues are very evident so I have illustrated them by reference to the Cambridge story. The four issues are:

- impact: where does it start and stop?
- causality: in which direction does it work?
- impermanence: when is it appropriate to measure?
- constraints: how overwhelming are these?

Impact

I have already alluded to the methodological difficulties surrounding the measurement of impact in the previous discussion, but the very practical issues of where does it start and where does it stop also becomes important. For illustration, there are three major aspects:

- first, the establishment of a baseline. In the Cambridge case this was not done, as indeed is frequently the case elsewhere, because data collection is expensive and evaluation is not seen as a priority issue at the outset of a project. Often recourse has to be made to data collected for other purposes than for evaluation, which usually means it is incomplete and does not measure exactly what is required. As a basic minimum it is useful to have a systematic feasibility study for the science park which can provide much of the information to construct a baseline

- second, the definition of geographic limits: which is often important in regional initiatives and which is a particular issue in Cambridge. Because of the precious historical core of the town there are deliberate policies to direct development elsewhere. Should an impact study evaluate business growth in areas which are some distance from the CSP but the nearest point where company growth is encouraged (eg Peterborough)? The fact that this area is also subject to additional policy intervention complicates matters further. In addition, many Cambridge high technology firms have been incorporated into larger companies whose production activities are located elsewhere. The Cambridge base becomes an R&D department, but value added through production is created elsewhere (and sometimes outside the UK) so what should be included in an impact analysis?

- third, the identification of accelerative effects. These are the additional effects that through, for example, demonstration of achievement, have stimulated additional activity. Just to illustrate the point: the report SQW prepared on the Phenomenon was used to support a Board paper to commit Data General to locate some of its R&D activity in Cambridge. Without the science park, the report would probably not have been commissioned, without the report the new R&D investment might not have been made but the influence was very indirect and difficult to identify. How should it be included in an evaluation?

Causality

The issues here can be equally complex as the difficulties of proving causal links are tremendous.

At best, the limit of honest analysis is frequently a demonstration of association: things happened in a way that suggests they are linked and through that link causality is inferred. Sometimes where a clear sequence of events can be identified the balance of probability would at least allow claim for a strong influence between the first event and the subsequent outcome. But this is still someway short of causality.

In most studies we have undertaken there has been a substantial survey of decision makers in the population of businessmen (or academics or policy makers) to establish the sequence of events, the nature and significance of different influences and the detail of decisions and consequences. Even here, however, there are a whole range of dangers for the analyst. Perhaps the most significant is the danger of the convincing rationalisation of a decision after the event which does not reflect the true influences and is only possible with the benefit of complete hindsight. There is no substitute for experienced judgement in sorting out the genuine from the plausible.

Again a detailed survey of decision makers and other participants can help by shedding different perspectives on the same events and by delving beneath the colourful anecdote that often dominates individual recollections.

Impermanence

Inevitably, no single time stands out as the best for measuring the impact of a science park development. By its nature, the science park seeks to provide an environment that fosters different behaviour in an area of business where, although shortening all the time (except in some R&D intensive businesses like pharmaceuticals), the elapsed time from research to commercial impact can be decades.

Measuring initial impacts can easily be dismissed as too early to allow the new patterns of behaviour to even become established let along to bear fruit. However, this position can devalue the benefits of early examination and critical review of what has been learned and what can be improved. The essential perspective must be that of a positive approach to identifying how to accelerate the achievement of the science park initiative through improved performance.

Leaving an evaluation to a later date when the longer term changes can be expected to have been completed and to have borne fruit may be more reasonable in view of the long term nature of science park initiatives. However, problems of the diffuseness of effects and the difficulties of attributing causality can become insuperable. Besides, evaluations at too late a stage can sometimes be sterile exercises in recording events as they are too late to influence decisions and lead to improvements in performance.

The final difficulty which is worth bearing in mind is the impermanence of achievement and the essentially dynamic nature of what is being attempted. In our Cambridge Phenomenon (1985) report we highlighted eight companies that together embodied the positive and successful business characteristics of the story. Within a further five years an analysis of the same companies would have revealed a different tale. Of the eight: one had ceased trading, five had been taken over by other firms (some as positive acquisitions, some because the firms had become non viable as independent units) and of the two that survived only one remained genuinely independent in broadly the same form as found in the initial evaluation exercise. How then should success have been measured?

Other constraints

The final issues of any evaluation exercise concern the impact of other constraints that may be beyond the influence of the science park initiative but nevertheless condition its impact. The most obvious of these, and this is evident in the example of what has happened to the star companies mentioned earlier, is the effect of the economic cycle. This has been an overwhelming influence on business achievement over the last five years (both accelerative and depressive) in Britain as it has elsewhere.

An interesting additional aspect of the Cambridge story has been the concurrent impact of the Phenomenon, and the CSP as a flagship of it, in both tightening and slackening constraints. The growth of demand for sophisticated business services bought a major expansion of supply in qualitative and quantitative terms which itself removed a development constraint and helped accelerate the impact of the initial growth impetus. Concurrently, the rapid growth led to congestion on the physical infrastructure of the region and a massive escalation in operating (and living) costs which was particularly evident in the purchase price of private housing, for example. This in turn tightened a constraint, in the short to medium term, on further growth until new stocks of dwellings and infrastructure could be developed.

Some wider aspects of the Cambridge case study

To finish this brief paper I would like to raise three wider aspects of the Cambridge case study which suggest that even the relatively sophisticated evaluation described in the earlier paragraphs is incomplete.

The first, relates to the wider costs of accelerated growth. I have already alluded to the overcrowding and congestion effects that emerged at various stages. These at one level threatened to choke off the Phenomenon but an even more fundamental imbalance also became manifest in that at one point there arose considerable concern for the negative consequences of accelerated science based business growth on the viability of the University.

Competition from the new firms, and higher wages, for a limited stock of technical support staff began to threaten the quality of support within the academic research establishment. Escalating costs began to undermine the ability of the publicly funded University to maintain its excellence with a budget not expanding at a commensurate rate and increased the problem of attracting good junior academics who could not afford an attractive standard of living on low academic salaries. And, finally, there were some concerns with the deflection effect of encouraging entrepreneurial research staff to pursue commercial goals and core academic staff to compete for funds for directed research to the neglect of interesting fundamental research topics. The University has reacted to some of these effects and there are hopeful signs that they are not proving damaging. The fundamental dilemma, however, remains.

The second, wider aspect, relates to a broader regional and subsequently national policy perspective. This has two distinct parts. The first relates to the possible specialist role of Cambridge (and Oxford) as technopoles for the wider metropolitan region of Greater London. This is not necessarily a perspective that the university cities would either recognise or embrace but at a wider regional and national perspective there is considerable merit in continuing to foster these specialist roles for the overall national good.

The role of new technology based firms, the epitome of the Cambridge Phenomenon, in fostering the accelerated and flexible adoption of scientific and technological advances introduces a second national (and EC wide) policy dilemma. UK public R&D execution and public subsidies provided to businesses for R&D are predominantly captured by large corporate entities, as indeed at an aggregate level is the conduct of R&D funded by private firms. How can the new smaller entities break into this restricted circle and how can public R&D programmes be made more accessible, are both essential aspects of the same problem. True, a number of Cambridge SMEs do participate but in spite of their dynamism and technical excellence they have completely failed to lead to a change in the large company mould.

The third and final broader aspect that emerges from the Cambridge Phenomenon relates to the absence of a new large technology based firm in the story. Will one emerge, and when? Is the Phenomenon destined to be limited to producing a series of small niche businesses with only minor employment and wealth generating impacts? Does a large company need a completely different corporate culture to that found in Cambridge and can such a large firm be accommodated within the Cambridge mould?

These are all topical questions that have been deflected by the short term concentration on survival during the present deep UK recession but have certainly not gone away. However, a more balanced perspective is provided from an examination of the composition of firms in California's Silicon Valley. Some 70% of firms located in the Valley have less than 10 employees and only 50 firms have more than 1,000 employees. Also, the large and successful Hewlett Packard company that dominates the Stamford Research Park reached its 20th birthday before its employee size exceeded 1,000. So perhaps Cambridge is not so different in essential composition and timeframe, albeit on a much smaller overall scale.

Note

1 The Cambridge Phenomenon - The Growth of High Technology Industry in a University Town, 1985 (reprinted 1990)

2 Two examples of these studies are:

Strategic Planning Implications of the growth of high technology industry in the Cambridge Area, 1986

The Cambridge Phenomenon and its Future - A report by an ad hoc group, 1987

3 International comparative review of the role of a university in its regional economy (Univ of Warwick, UK, Texas at Austin, USA and Chalmers at Gothenberg, Sweden), 1987/8

New Technology-based firms in Britain and Germany, 1988

Universities, Enterprise and Local Economic Development - An Exploration of Links, 1988

Review of the UK collaborative research programme, LINK, 1990/1

4 The Cheshire Cat's Grin: Innovation and Regional Development in England. AnnaLee Saxenian, Technology Review, Feb 1988

The Cambridge Science Park: Planning and Development Case Study 4, RICS

Directory of Cambridge Science Park

5 Publicly funded research and development in the European Community - Improving the utilization of results, 1988

Evaluation of the Consultancy Initiatives, 1989

Evaluation of the SINTEF diffusion scheme, Norway, 1990

Science and technology policies and economic development: a review of international experience, 1991

Evaluation of SPRINT transnational networks, 1992

Science Parks
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I. INTRODUCTION

Science parks have become a common phenomenon at many western universities. At the heart of the science park movement was the belief that science parks would act as nuclei of regional technical enterpreneurship. The proximity of academic and industrial research would create a climate of symbiosis where multiple synergies for innovation would be present. In this way, both academic research and industrial innovation would benefit. Recently, however, criticisms have come to attack this point of view. Geographical proximity has been overemphasized, to the detriment of professional proximity, it has been argued.

The paper starts with a brief overview of the enthusiasm surrounding the initial development of science parks. It then goes on reviewing some of the findings from the field of technology management and R&D management. These findings allow for a more thorough explanation of recent criticisms on the relevance of science parks in inducing industrial innovation. Finally, the major issues emerging from this discussion will be illustrated through a survey of the company population on Belgian and Dutch science parks.

II. FROM ENTHUSIASM TO SCEPTICISM?

In order to keep abreast of scientific and technological developments, external sourcing of scientific and technological information becomes increasingly important to the modern corporation. Along with a growing awareness of the need for extra-organizational

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scientific and technological linkages, the belief that universities constitute a significant *underutilized* source of technological innovation has gained wide acceptance. For instance, a National Science Foundation study (1982) states that "direct links between universities and corporations currently constitute only a miniscule portion (less than one-half of one percent) of the national R&D-effort." Nonetheless, there exists a firm belief that universities could play a crucial role in promoting technological change. First of all, they make their contributions *indirectly* by advancing the frontiers of science, by critically reviewing and systematizing the accumulated technical knowledge, and, especially through the training of students and researchers. But, at the same time, universities can be viewed as pools of technical expertise and creativity to be tapped *directly* through the involvement of academic scientists and engineers in the process of industrial innovation. Stankiewicz (1984) argues that the emphasis on such direct links is growing. Jaffe (1989) demonstrates the existence of a significant effect of university research on corporate patents in such areas as drugs, medical technology, electronics, optics, and nuclear technology. In addition, he argues that university research acts indirectly on innovation through inducing industrial R&D spending. It is not astonishing then that governments, universities as well as industry have engaged in a wide spectrum of organizational experiments aimed at strengthening the links between the academic and industrial environment.

One experiment has been the creation of science and technology parks. According to the United Kingdom Science Park Association, a science park is a property based initiative which includes the following features:

- Has formal and operational links with a University, other Higher Education Institution or Research Center;
- Is designed to encourage the formation and growth of knowledge-based businesses and other organizations normally resident on site;

- Has a management function which is actively engaged in the transfer of technology and business skills to the organizations on site. (see Monck et al., 1988)

This definition reflects the concern of universities and other technical institutions to encourage the transfer of technology and business skills among the tenants of the park. It thus excludes those instances where there is no organizational commitment to stimulate or facilitate access to technology.

It is not astonishing then that the role models provided by Silicon Valley, Boston's Route 128, and Cambridge-UK have led to numerous attempts to imitate the emergence of high-technology clusters. These success stories convinced regional development planners that a scenario existed to create regional enterpreneurial technology clusters. The local university would act as a growth pole, being a locus of high technology information to established industrial firms and, at the same time, being a source of new technology based firms. The presence of a science park would facilitate the transition of academic scientists to become academic entrepreneurs. Physical proximity would ease the flow of scientific/technological information and the creation of a network of collaborations among different science park tenants. Resident companies would gain privileged access to highly specialized manpower in the form of graduate students and university researchers. Thus, one of the *fundamental premises* in the justification for the growing number of science parks is that high-technology industry gains competitive advantage through location alongside a university because of the enhanced information, collaboration and recruitment opportunities, see Stankiewicz (1984) and Monck et al. (1988).

The enthusiasm of government planners, university officials and industrialists has led to the creation of numerous science parks: Engström (1987) describes the existence of more than 150 US science parks; a 1988 Financial Times survey announced the presence

(8)

of 38 operational parks in the UK, while 9 more were planned; Belgium nowadays has 10 university science parks, the Netherlands 3. The list is still growing and this growth is not likely to come to an end in the near future.

Notwithstanding this enthusiasm, research studies have become increasingly sceptic. The NSF-study on university-industry relationships (1982) found that over 50 percent of the US-parks never approached their initial expectations and that they are generally not significant stimuli to technology transfer. Miller and Côté (1987) reach the same conclusion in their recent book, "Growing the Next Silicon Valley". Macdonald (1987) pretends that much of the enthusiasm surrounding British science parks is a product of self-interest and is in stark contrast to the (dark) reality that will eventually face many of them. Monck et al. (1988) concluded their survey (sponsored by the UK-Science Park Association) with the following statement:

> "These results suggest the need to reappraise the comparative advantage of a science park location. They indicate two alternatives. The first is that less emphasis should be placed upon direct or indirect links with the local university, since that can apparently be cultivated by firms located elsewhere. Alternatively, the results indicate that the level of university linkage developed by off-park firms has not significantly been bettered by science park firms."

III. SCIENCE PARKS: A THEORETICAL EVALUATION

A. *Interorganizational R&D-linkages*

Research on corporate technology strategy points to the increasing importance of external R&D linkages, see Fusfeld (1985) and Perlmutter and Heenan (1986). At the same time, however, Haklisch's (1986) systematic review of technical alliances in the semiconductor industry shows that such collaborations are not confined to a specific geographical context. Daly (1985) demonstrates the same world-wide network of R&D cooperations and information flows in his strategic analysis of the biotechnology industry. Thus, the explanation of science park advocates that geographical proximity will stimulate interorganizational information networks among science park occupants may be based on a biased understanding of the relation between physical distance and communication. Allen (1984) indeed demonstrates that physical distance has an overwhelming influence on *internal* corporate communications. However, his major finding is that beyond a distance of 30 metres the probability of informal information exchange reaches an asymptotic level. Thus, as far as informal, face-to-face communication is concerned, it does not matter whether you are in two separate buildings on the same science park or in two buildings 250 kilometers apart. As a further example, the worldwide membership affiliation of MIT's Industrial Liaison Program shows that geographical proximity may only be of secondary importance. This can be explained by the fact that person-to-person networks basically are of two types: spatial and professional. Spatial networks are based on a social and/or physical propinquity such as exists within the industrial research laboratories studied by Allen. Professional networks are networks such as the classical invisible college of academic science which links specialists of a particular discipline or profession and have no boundaries per se. Some professional networks are also spatial. Silicon Valley is a leading center of microchip design. With such centers one must stay in touch. Those in the same profession but located elsewhere must still be part of the spatial professional network of such centers and hence must by frequent contact maintain this membership. Geographical, or physical, proximity is not a necessary condition when task-related communications are considered. Evans et al. (1974) found that the number of communications did drop off considerably with distance, but work-related professional contacts override the distance factor. Van Dierdonck and Van der Poorten in a study of the diffusion of artificial intelligence in Belgium (1987) found frequent contacts of Belgian enterpreneurs with MIT and other

Route 128 enterprises. The professional network clearly has no specific geographical boundaries. What really matters is to become part of the broader professional network.

Social proximity is yet another factor which overrides geographical proximity. Corsten (1985) found that a majority of the companies in his sample contacted a particular university because either *(1)* graduates of that particular university worked at that company (44 percent) or *(2)* company representatives knew university scientists from contacts at conferences or seminars (23 percent). Thus, one may wonder whether the justifications given for the stimulation of science parks are over-emphasizing the benefits of geographical proximity to the neglect of professional and social proximity variables. Although these three types of proximity variables can occur simultaneously, this need not be the case.

B. *The interaction between science and technology*

According to Price (1965) science and technology each have their own, separate cumulating structures. Only in special and traumatic cases involving the breaking of a paradigm, see Kuhn (1962) and Dosi (1982), can there be a direct flow from the research front of science to that of technology or vice versa. Allen (1984) basically agrees with this point of view, although he recognizes the possibility of a gap-filling science: "Occasionally, technology is forced to forfeit some of its independence. This happens when its advance is impeded by a lack of understanding of the scientific basis of the phenomena with which it is dealing. The call then goes out for help." This call for help may cause a temporary, intense interaction between science and technology. Another remark on Price's thesis is that nowadays, technologies have emerged (e.g. biotechnology, artificial intelligence) which are much more rooted into academic science. Although conflicting views exist on the intensity of the link between (academic) science and (industrial) technology, one may wonder whether advocates of science parks are overrating the degree of coupling between science and technology. This coupling is true for certain technologies, but there is no proof that it holds across all technologies. To summarize, Allen et al.'s (1980) studies of the different types of communication along the R&D activity spectrum suggest the following conclusions with respect to science parks as facilitators of R&D communications:

> *research tasks* are universal. The external world is the universal, invisible college.The nearby presence of a particular university will not be a decisive factor, except perhaps if the organization's research has particular links with a specific laboratory of the local science park university.
>
> *development tasks* rely heavily on internal communications while external communications are managed by the emergence of technological gatekeepers. Moreover, locally oriented tasks such as development work are hypothesized to benefit more from outside operational (e.g. customers and vendors) contacts than from outside professional (e.g. R&D community as a whole, professional associations) contacts.
>
> *technical service tasks* consist mainly of cost/benefit analyses and incremental product/process improvements. These tasks rely heavily on hierarchical management control and there is little need for external interactions. Thus, we may wonder whether much input from science-based organizations is necessary at all.

Moreover, when referring to the science/technology interactions occurring in Silicon Valley or along Route 128, Dorfman (1983) reminds us that "the academic institutions that provided much of the momentum are steeped in a tradition of research at the frontiers of developments in electronics, computer science and instrumentation and compete with a handful of other universities for top ranking in graduate programs in these fields. It remains to be seen whether institutions of lesser rank can provide the same stimulus to innovation."

C. *Labor supply factors*

Labor supply opportunities have often been considered a critical location factor in high-technology industry, see Oakey (1981) and Dorfman (1983). For several reasons, which are discussed below, this labor supply factor is another hypothesized advantage of the science park environment.

First of all, the symbiosis of university and industry is believed to enhance recruitment opportunities for industrial R&D. Through collaborations with academia, industry gains access to high-talented engineers and scientists. Recent studies on manpower flows in artificial intelligence, see Van Dierdonck and Van der Poorten (1987), and biotechnology, see Faulkner (1986), show the omni-presence of manpower flows between academic and industrial R&D-laboratories in nascent, science-based industries. However, when focusing on science parks, Sirbu et al. (1976) found that "virtually no interchange of personnel was reported between government laboratories and industry at any of the sites. There is a modest flow of personnel from university laboratories to industry, but very little in the reverse direction." As far as the recruitment of university graduates is concerned, those authors reached the following conclusions: "Most of the US firms we interviewed recruited on a nationwide basis and none felt they drew disproportionally from local universities. They reported hiring 16.5% of their staff on average from local schools." Monck et al. (1988), in their study of British science parks, report similar findings. They were certainly unable to detect significant differences in recruitment patterns between off-park and on-park companies.

Second, science parks are believed to act as a catalyst for academic enterpreneurial behavior. The presence of a nurturing science park environment should facilitate researcher transitions from the safe academic world to the risky, uncertain business world. Roberts and Wainer (1968, 1971, 1988) provide us with an overwhelming data-base of MIT-entrepreneurs who clustered around Route 128. Segal et al. (1985) identified a family tree of 244 companies which directly or indirectly originated from 14 Cambridge University departments. However, when referring to those success stories, a few remarks should be kept in mind. First of all, in none of these two examples is there a clear proof that a local science park enhanced this spin-off phenomenon. Even in the case of Stanford Industrial park, not everyone agrees on its causal link to the high-tech spin-off phenomenon of Silicon Valley. Macdonald (1987) even goes as far as to argue: "While the University certainly did establish the park, it did so primarily because the industrial growth of the region had increased Leland Stanford's bequest so much that the University could no longer afford its retention as farmland. Unable to sell the land, the University was forced to make it pay for itself. Stanford Industrial Park is very much the product of Silicon Valley's industrial prosperity rather than vice versa." Second, although more and more universities acknowledge the potential of new venture creation as a technology transfer mechanism, academic entrepreneurs are still a curiosity at most academic institutions. Miller and Côté (1987) suggest that a majority of science parks have not been able to stimulate massive spin-off creation. To summarize, although it may be advantageous to an academic spin-off to locate on a science park (since the enterpreneurs then remain close to their nucleus) the extent as to which this happens in reality is rather ambiguous. Monck et al.'s (1988) study of British science parks suggests a similar ambiguity.

Third, it is often argued that proximity to a university offers opportunities for continuing education of company staff. Participation in such programs on behalf of science park tenants might offer a first step in forging more intense links between organizations on the park (including the university). This might then overcome some of the scepticisms described earlier. Indeed, it is often argued that informal linkages are a first and a highly necessary step in establishing more formalized R&D collaborations, see Stankiewicz (1984) and Faulkner (1986). Participation in continuing education programs may thus influence the social proximity factor discussed earlier. However, even when a technical/social network of contacts among science park occupants should occur, Macdonald (1987) suggests that it will only be a "miniature network" in comparison to the global scientific and technological network relevant to the different science park tenants.

D. *Benefits to regional development*

Regional development policies also had a major impact on the decision to create university science parks. For instance, Japanese science parks were not so much developed to foster interorganizational collaborations as to decrease the pressure on already heavily industrialized areas like Yokohama, Osaka, Kobe and Kyoto.

Dorfman (1983) further refers to agglomeration externalities as another advantage of a high-technology cluster location. For some firms in some industries and at some stages of development there are indeed important advantages to locate near to complementary and competitive enterprises as well as to customers. Segal et al. (1985) reach the same conclusion in their study of the Cambridge Phenomenon. However, when considering Silicon Valley, Route 128 or the Cambridge Phenomenon, we are confronted with phenomena involving a region's (multiple) universities. Typically, the new high-tech businesses became embedded in an existing business and technological infrastructure in a rather spontaneous manner. Most European (and American) science parks, on the contrary, are rather artificially created around a single university which is then believed to act as a growth pole. They are often isolated, with little or no local business texture present. Segal et al. clearly demonstrated the role of the inner Cambridge town in the growth of the Cambridge high-tech cluster. For the majority of science parks, it is rather difficult to speak of external economies of scale. At best, one can hope that they will evolve over a longer period of time. Thus, the advantages offered by the rich business environment on the park as described by Monck (1983) may well be an illusion at present.

Finally, environmental factors such as attractive parkland surroundings, residential neighbourhoods, cultural amenities, and easy access to transportation seem to be important only up to a certain treshold level (see Sirbu et al.(1976) and Galbraith (1985) and Monck et al. (1988)).

E. *The need for empirical investigation*

The previous discussion focused on a number of general issues facing the development of university science parks as they appear from the literature. The next section of the paper will investigate a number of those issues for the firms located on Belgian and Dutch science parks. This will enable us to assess the situation in Belgium and the Netherlands in particular, since the literature is rather general in nature and intercountry differences among science parks may account for the fact that the previous remarks have limited external validity.

IV. SURVEY OF BELGIAN AND DUTCH SCIENCE PARK TENANTS

This section describes the results from a survey of 208 firms located on Belgian and Dutch science parks. It starts with a brief description of the sample characteristics before focusing on the major issues as they appeared from the literature survey.

A. *The sample*

At the moment of the survey (fall 1988), 8 Belgian and 3 Dutch science parks were fully operational. All of them became possible through government intervention. Regional Development Agencies are heavily involved in the exploitation of the parks. The role of most universities is at least a consultative one. They all assist in the screening of candidate applications, while their involvement in the daily management of the science park varies.

TABLE 1

Sample and response rate

Sites	First year of operations	Sample N	Valid responses
Belgium			
Haasrode	1972-73	32	16 (50%)
Sart-Tilman	1976	23	8 (35%)
Louvain (LLN)	1976	34	20 (59%)
Evere	1978	28	11 (39%)
Heembeek	1980	7	6 (86%)
Anderlecht	1985	1	1 (100%)
Nivelles	1985	2	2 (100%)
Zellik	1985	10	4 (40%)
Total		137	68 (50%)
Netherlands			
Twente	1983	49	29 (59%)
Groningen	1984	9	5 (56%)
Leiden	1985	13	7 (54%)
Total		71	41 (58%)

Each science park is linked to a single university. Some universities can have up to 3 affiliated science parks. Some of the parks are adjacent to the university, others are up to 15 kilometers distant from the patronizing academic institution. Half of the science parks in the sample are less than 5 years old (table 1). Of course, the age of most science parks may be a biasing factor in surveys investigating this phenomenon. Indeed, science park advocates claim that it may take at least a decade for a cluster to be formed. For instance, strong useful links between academia and industry develop over many years through the gradual growth of experience and trust among individuals. However, the results of this and other surveys (see Sirbu et al. (1976) and Monck et al. (1988)) can at least provide some impressions of the science park potential. Moreover, there exist at the moment several science parks which are more than a decade old. This makes some predictions even less ambiguous.

In the Belgian case, 15 science park tenants were not included in the sample because of their activities (hotel, garage, tennis court, university laboratories, etc.). Thus, we were only interested in companies which might somehow benefit from interactions with academia or other high-tech firms. In the course of the survey, we learned that 7 of the 137 Belgian companies had left the science park in 1988. This reduced the Belgian subset from 75 to 68 useful responses, since the companies who left the science park did not fill out the questionnaire. Most of them declared that the science park location had only been a temporary solution to them and thus showed a rather low commitment towards the local science park environment. As far as the Netherlands are concerned, Twente is somewhat different from the other science parks. This science park is in fact an incubator facility: the Business Technology Center. It was established through the involvement of Control Data, a Regional Development Agency and the University of Twente. Sunman (1986) ascribes the rapid growth of BTC Twente to the commercial orientation of its founders (especially Control Data). According to the definition of the UK-Science Park Association, BTC can be considered as a science park development. However, the emphasis on being an incubator may introduce a bias in the Dutch results (e.g., companies in the incubator will usually be small). However, BTC equally stresses the importance of its scientific/technological environment to potential candidates.

The questionnaires were mailed out to the general managers of the science park companies. All returned questionnaires were eventually filled out by senior managers. Thus, we can be confident that the respondents had a broad view on the companies' activities as well as on the decision to locate on the site. The results then offer a first impression of what happens on Belgian and Dutch science parks.

B. *Company characteristics*

This section describes the characteristics of the respondent firms. After discussing the age and employment characteristics of the tenants, we investigate how many tenants belong to a multinational group for both countries. As one important objective of many science parks is to stimulate enterpreneurial behavior, we were particularly interested in the presence of spin-off companies on the science parks studied. We defined a spin-off as "A company created by employees who leave their employer (e.g. a university laboratory, an industrial laboratory) to start their proper firm in order to commercialize technological know-how acquired on their previous job."

As could be expected, the presence of the majority of respondents on each site studied is rather recent (see table 2).

TABLE 2

Age characteristics of responding tenant firms (mean age, median age and age range)

	Mean	Median	Range
Belgium (n=67)	$3^{1/2}$	2	0-12
Netherlands (n=40)	$2^{1/3}$	2	0-6

Thus, although 4 Belgian science parks were created in the 1970's, their growth really started in the 80's. Only 10 respondents were established between 1976 and 1979. The take-off of Dutch science parks was much faster than in the Belgian case. The role of BTC Twente, which accounts for the majority of the Dutch sample and the Dutch respondents, is obvious. The other Dutch sites may develop more at the rate of their Belgian counterparts. Although Belgium showed considerable enthusiasm in the early 70's, there has been a period of stagnation between 1977 and 1985. Since 1985, the interest of regional developers and universities seems to be increasing once again. The number of new tenants on Belgian sites may reflect this policy change (median age=2 years).

Total employment for the Belgian respondents (n=68) amounts to 3856. In the Dutch case this figure is 480 (n=41). In both instances, the majority of tenants is small (see table 3). Belgian science parks, however, were able to attract some major multinational companies (mainly in the sphere of electronics, informatics, and pharmaceuticals). Blue collar workers are a minority among science park employees. This is obvious since all science parks formally forbid traditional manufacturing activities. As we will see, a lot of respondents actually have production facilities, though, in terms of employment, these activities are of secondary importance. Science park authorities also appear to be rather flexible with respect to the application of the admission rules. In some instances, the policies of regional developers have aroused irritation on the academic side. Regional Development Agencies have sometimes been accused of attaching too much importance to employment statistics, to the neglect of the creation of a technology-oriented business texture.

A total of 9 companies on Dutch science parks (n=41, 22%) belong to a multinational group. This number is much higher in Belgium: 33 out of 68 tenants (49%).

This is reflective of the policy of Belgian science park authorities to attract foreign investments, whereas Dutch science parks are more geared towards stimulating indigeneous growth. This is further exemplified by the presence of spin-offs on the science parks studied. In the Dutch case, 15 out of 41 (37%) respondents acknowledged to be a spin-off. Six of them originated from a local university laboratory, two from another science park organization. The remaining 7 had no such relationship with other science park tenants. In Belgium, only 11 (n=68, 16%) spin-offs were detected among the respondents. Two of them originated from the local science park university. In the remaining cases, no apparent links with another science park parent were found. From those results, one may conclude that Belgian science parks have not been significant spin-off generators till now. This does not mean that academic spin-offs are absent in Belgium. We were able to detect the existence of at least 42 spin-offs at Belgian universities, see Van Dierdonck and Debackere (1988). The majority of them were less than 5 years old. Only, they do not seem to have a preference for a science park location.

TABLE 3

Employment characteristics of responding tenants

	Belgium (n=68)	Netherlands (n=41)
Total employment		
Mean	56.7	11.7
Median	23.5	4
Range	0-380	0-50
Blue collar employment		
Mean	5.4	1.7
Median	0	0
Range	0-50	0-30

One should also recognize that the Belgian academic community has long been, and in some cases still is, sceptical towards academic entrepreneurs. Moreover, not all scientists display the same degree of enterpreneurial behavior, see Roberts and Peters (1981) and McMullan and Melnyk (1988). The difference between Belgium and the Netherlands concerning spin-offs may also be a reflection of the different degree of involvement on behalf of the parent university in the management of the science park. Although regional developers play a crucial role in both countries, Dutch universities pursue their consultative role in a much more active manner. In Belgium only one university has been really actively involved in the promotion and management of its science park from the very beginning. Other universities have started following this example now, after they were rather passive in the past. Although it is dangerous to make causal inferences, it appears as if active university involvement (preferably beyond a consultative role) exerts a positive influence on the development of the science park.

Only a minority of respondents provided financial results. Some of them were unable to do so for various reasons (establishment on the site too recent; being part of a larger industrial group makes it impossible to sort out the results of the science park entity; the activities of the tenant are not profit-oriented), while others were simply unwilling to provide financial information. For those who did provide financial results, we can only say that the figures provided reflect the small-sized nature of the businesses present on most science parks.

C. *Company activities*

The broad range of activities undertaken by the respondents in this survey makes it hard to categorize them. In an attempt at classification, table 4 presents 7 main categories. In classifying firms in this way, it must be remembered that the same firm may undertake a number of activities at the particular location and that it can, in some cases, be difficult to identify a single main activity. This classification should then only be taken as broadly indicative of the activities of the surveyed firms.

TABLE 4

Respondents' activities

	Belgium (n=68)	Netherlands (n=41)
Electronics and data processing equipment	12	4
Medicine, biotechnology and pharmaceuticals	8	7
Telecommunications	4	2
Informatics	7	6
Consultancy	10	14
Teaching and training	5	1
Other	22	7

Those activities are not only very diverse. At the level of the individual science parks, they even do not always match with the university's specialization. So there is the example of a university which has a good reputation in biotechnology, while the majority of firms on its science park are well established micro-electronics firms. Moreover, the broad range of activities present on each park makes one wonder at the effectiveness of science parks in creating an atmosphere where ideas flow freely among researchers at different organizations present on the park. It is our belief that openness is indeed beneficial to technology development. However, this openness should prevail within the community of researchers working on a certain related set of scientific and technological problems. This R&D community is, however, not confined to the narrow geographic boundaries of a science park. Instead, it is a global phenomenon. The local environment on the science park is at best a miniscule node in the communication and collaboration network relevant to each researcher. The diversity of activities present on most science parks certainly questions their potential in bringing together a critical mass of researchers on one particular spot.

Finally, each respondent described the different functional activities present at his company: 13 Dutch respondents (32%) and 39 Belgian respondents (57%) reported internal R&D activities. However, the absence of internal R&D does not prevent companies from having contacts and even research contracts with the local university (cfr. infra). Small companies may actually use the local university as a kind of external R&D department. Moreover, 24 Dutch respondents (59%) and 44 Belgian respondents (65%) had marketing activities at the site, while 19 Dutch respondents (46%) and 34 Belgian respondents (50%) had production activities at the site. The presence of production activities in nearly half of the companies surveyed, and the absence of internal R&D in about half of the companies surveyed, are rather striking findings if one keeps in mind the missions of a science park.

D. *Reasons to locate on the park*

Respondents were asked to rank-order the three most important reasons for their choice to locate on the site. It is somewhat surprising that 20 Dutch (49%) and 35 Belgian (51%) do not mention the availability of external scientific/technological resources at all when discussing their location decision. About half of the survey respondents do not perceive the linkage potential with the local university and/or other high-tech neighbours an important factor in their location decision. Table 5 shows that only a minority of respondents mention such factors as crucial decision variables.

TABLE 5

External scientific and technological resources as factors influencing loaction decision

Availability of scientific/ technological resources rank-ordered as ...	Belgium (n=68)	Netherlands (n=41)
1st most important	7	8
2nd most important	14	9
3rd most important	12	4

Other factors influencing the location decision were: image of the site, easy access to highways or airports, financial incentives by public agencies (tax deductions, subventions), convenience of the site, available office space and services provided to young entrepreneurs (BTC Twente, Incubator Facility Leuven), etc. Only one respondent explicitly stated that recruitment opportunities were a motivating factor. Quite similar to the Monck et al.'s (1988) finding for the British situation, "it was the prestige and image of the site which was the most frequently mentioned factor influencing choice of location."

E. *Interorganizational linkages among respondents*

1. Contacts with the local university

A total of 34 (83%) Dutch respondents and 46 (68%) Belgian respondents confirmed the existence of contacts with the local university. Table 6 summarizes the types of linkages. Each respondent could check more than one category.

As already mentioned, tenants do not need internal R&D capabilities to become involved in cooperations with the local university. For instance, only 7 out of 12 Dutch tenants involved in collaborative R&D with the local university have in-house R&D-

capabilities. Thus, 5 Dutch respondents (see table 6) without internal R&D do have collaborative R&D with the local university.

TABLE 6

Number of respondents per type of linkage

Type of linkage	Belgium (n=68)	Netherlands (n=41)
Collaborative R&D	17	12
Academic consulting	14	12
Service (e.g. routine tests and analyses)	8	4
Informal contacts	18	16
Other	12	12

Other linkages include such activities as: organizing seminars together with a university department; the founder of the company was a student or researcher at the university; the company is a university supplier (e.g. medical equipment); key scientists of the tenant lecture at the university; the tenant supports the university's computer facilities etc. In many of those instances, the university benefits more from the presence of the tenant company than vice versa. This finding was also reported by Sirbu et al. (1976).

To conclude, although a majority of respondents has some type of linkage with the local university, only a minority of these linkages involves collaborative R&D. Our research at this phase was only intended to get an overall impression of the R&D environment on Belgian and Dutch science parks and, as a consequence, did not include a control group of off-park firms. Nevertheless, it is interesting to quote Monck et al.'s (1988) results here: "The most obvious and perhaps surprising observation is how apparently similar off-park firms' responses were to those of on-park firms. This is particularly clear in the R&D and personnel links. Park-based firms clearly place a greater emphasis on informal contacts with academics. In the more formal links such as the employment of academics, sponsoring trials, student project links and the employment of graduates, off-park firms have an equal or greater number of links."

2. Labor supply

Labor supply was one of the critical factors in the Dorfman study (1983). Table 7 summarizes the number of local university graduates employed at the respondents' facilities.

TABLE 7

Employment of local university graduates

Number of local university graduates employed	Belgium (n=68)	Netherlands (n=41)
0	35	24
1-5	25	15
6-10	2	2
11-15	4	0
20	1	0
30	1	0

The total number of local university graduates employed at Belgian respondents is 179 (total employment=3856). In the Dutch case we find 61 local university graduates (total employment=480). Given the scope of this preliminary survey, comparison with off-park firms is impossible. We also lack information on the relative number of graduates from other universities employed at the respondents. This makes interpretation of table 7 a bit ambiguous. However, the fact that more than half of the respondents do not employ local university graduates at all questions the importance of the labor supply factor within the micro-environment of the parks. This finding confirms Sirbu's (1976) suggestion that science park tenants recruit on a nation-wide basis.

Another potential advantage of a science park location is the easy access of tenants' employees to continuing education programs at the local university. Ten Dutch respondents (24%) and 18 Belgian respondents (26%) acknowledge to make use of this opportunity. This situation may well be subject to change in coming years as more and more universities start offering post-experience courses. However, at the moment, continuing education appears to be a rather limited phenomenon.

3. R&D projects

The 13 Dutch and 39 Belgian respondents who mentioned the presence of internal R&D capabilities, also specified the actual number of R&D projects in progress, the fraction of those projects carried out without external collaboration, and the distribution of projects involving external partners. Table 8 summarizes some of the results.

TABLE 8

Number of internal/external R&D projects at respondents having internal R&D capabilities

	Belgium (n=39)	Netherlands (n=13)
Total number of projects in progress	321	65
Fraction not involving external partners	168 (52%)	25 (38%)
Fraction involving external partners	153 (48%)	40 (62%)
-local university as partner	35	12
-other science park partner	3	2

Although formal, external R&D linkages are important, they are not really biased towards the local science park environment. In Belgium, 38 (out of 153, 25%) R&D projects were directed towards local science park organizations. For the Dutch respondents, this amounted to to 35%, or 14 projects. Of course, this does not yet tell us very much about the characteristics of the projects (content, duration, degree of innovativeness, etc.). But we must not forget that over half of our respondents did not have internal R&D-activities. We are confident that the respondents without internal R&D who are involved in collaborative projects together with the local university will not alter the obtained percentages much. We arrive at this assumption by looking at the individual respondents. The respondents in table 8 are without doubt the most important R&D-oriented tenants on the sites studied. The respondents who have no internal R&D capabilities, though are involved with the local university, are all very small and production or marketing oriented.

Table 8 also demonstrates that collaborative R&D efforts are not confined to a physical locus. The collaborative R&D-efforts reported in table 8 do not only have a national dimension (as well in Belgium as in the Netherlands, a lot of respondents having collaborations with the local university also have collaborations with a major part of the nations' other universities), but they take on international dimensions as well (e.g. projects together with other European and even U.S. universities).

The small firms reporting collaborative R&D have a strong bias towards the local university. Thus, this type of company might actually gain easier access to the R&D community by locating near a particular university. But even here, Macdonald (1987) warns us: " The notion that any single university department contains even all the technical information required by a high-technology firm, while evident in much of the justification given for science parks, would alarm most academics. Only a weak department can pretend to be self-contained: the strongest department is more likely to be but a node of an academic information network to which high-technology firms may seek access."

V. CONCLUSIONS

This discussion was a first attempt at providing some insight into the potential role of science parks in the process of technological innovation. It was argued that we should at least be offered some empirical insight into potential advantages and misconceptions related to this new development, since the number of science parks keeps growing and since those science parks are often claimed to offer a competitive advantage to tenant firms in terms of access to the R&D community. One key conclusion is that a science park location may indeed ease access to a single university, although our findings and the findings of similar foreign studies question the degree to which this really happens. Moreover, the university affiliated with the science park is at best one node in the global R&D community of interest to the high-technology firm. Scientific and technological developments occur within the context of broader R&D communities. Such communities are global in nature, encompassing researchers in organizations in the private as well as in the public sector. Macdonald's warning that a science park can create at most a "miniature network" among tenants is highly relevant in this respect and seems to be borne out by our findings on collaborative R&D at science park firms.

This leads to another remark. Given the ambiguous performance of most science parks, we believe it is time for a clear assessment of their mission. Our findings on some of the older Belgian parks clearly demonstrate that they have been successful in attracting tenant firms. However, in terms of fostering extra-organizational R&D linkages the situation looks a little different. There do exist linkages towards the local science park environment, though they are rather sparse. Nowadays, each university believes an affiliated science park is an absolute necessity in order to become an accepted player in the newly emerging arena of enterpreneurial science. They should remember, though, that a science park is not necessary the most effective way to become involved in industrial science and technology. A multitude of other mechanisms exist. At the same time, the discussion of the role models (Silicon Valley, Route 128 and Cambridge-UK) places their spontaneous development in sharp contrast with the artificial push experienced on most science parks. In these instances, science parks were consequences rather than causes of regional technological development.

To summarize, we have focused on a number of topics which may help explain the current differences between the expectations and the realities facing the development of science parks. Although it may sound rather sceptical, we should keep in mind the recent character of many science parks (a majority of them are less than 10 years old). This may necessitate a review of some of the statements made earlier as time goes by. However, at least some of the problems are unlikely to change with time (e.g., the issue of professional proximity versus physical proximity).

A final remark can be made, especially with respect to many European science parks, namely the short distances on the continent. For instance, the vast majority of Belgian universities lays within a radius of about 50 kilometers of the capital of Brussels. The same remark holds for the Netherlands, and even for the industrialized parts of the UK. Thus, do we really need to emphasize physical proximity in instances where everything is already so close?

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The Relationship between Space and Technology
Some Introductory Remarks

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THE RELATIONSHIP BETWEEN SPACE AND TECHNOLOGY - SOME INTRODUCTORY REMARKS

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Before considering the phenomenon of the technopolis itself, I propose to reflect for a moment on the way space and technology are represented, referring extensively to the existing economic literature in these two areas. In fact the term 'technopolis' itself prompts such an exercise, as it made up of two elements: technology and 'polis' - or city - which is an elementary form of structured space.

What we would like to show, before placing the technopolis in its logical position at the intersection of its two constituent dimensions, technology and space, is that successive economic analyses of space have sought to incorporate innovation, just as studies of innovation and technological change have placed increasing emphasis on the spatial/territorial dimension.

Although the technopolis takes many - perhaps too many - different forms, it is nonetheless an appropriate concept on which to bases an analysis, because it is the result of the convergence of the these two movements.

The plan for this paper is therefore as follows:

1. Representation of space and innovation
2. Technological change and the territorial dimension
3. The technopolis as the cradle of technology.

1. Representation of space and innovation

As R. Gordon[1] explains, the traditional theories regard space, like innovation, as an exogenous datum; business location decisions are taken within the rigid framework of a set of existing factors.

In these theories economic calculations are based on distance, although a distinction should be made between the analyses based on the work of A. Weber[2] which stress transport costs and those based on the work of A. Lösch[3] which emphasize spatial competition, that is to say competition

1 R. Gordon "Systems de production, résume industriels et regions, les transformation dans l'organisation sociale et spatiale de l'innovation", Revue d'Economie Industrielle, No 51, 1er trimestre 1990.
2 A. Weber "Theory of the Location of Industry", University of Chicago Press, 1929.
3 A. Lösch "the Economics of Location", Yale University Press, 1954.

between producers whose aim is to maximize their market catchment area.[4]

If we reduce the interdependent relationships between firms to commercial movements in the context of competition for goods and services (GORDON, op. cit.), it is as if the location of these interdependencies offsets the frictional cost of distance. As GORDON puts it, "allowing for a given cost and transport structure and the variable dependence of supply on the ability to move products, manufacturing industry will locate itself close to its market at the lowest cost, unless it needs to be sited closer to the source of supply because of a relatively greater proportion of local inputs".

The traditional approaches thus consider space either as a point or as a surface, but do not include innovation or technology in the analysis.

It is the German[5] and Scandinavian[6] geographical schools which have started to think more in terms of innovation (theory of contagion by waves in a homogeneous space[7]), drawing in part on the theories of industrial and urban polarization. However, as A. RALLET[8] points out, the theory of industrial polarization based on the work of F. PERROUX is in fact a-spatial. Although the ability of inter-industry relations to create regional economic poles is emphasized, the aspect of territorial competition between these poles is not considered.

Moving the polarization factor from industry to the city, the theory of urban polarization revolves around concepts such as the economy of urbanization and urban hierarchy. However, these two concepts seem to us to be descriptive or statistical concepts (RALLET, op. cit.).

The work of the European research grouping on innovatory environments (GREMI) has taken this a stage further, using comparative empirical research and the concept of the 'innovatory environment', in an attempt to combine the spatial approach and the industrial approach into one.

4 For a concise account of the differences between the theories of A. WEBER and A. LÖSCH, see V. JACQUIER-ROUX "Approach to location with a view to studying the spatial organization of multinational companies in high density R&D industries, IREPD, August 1991.

5 Cf. W. CRISTALLER "Die Centrale Orte in Suddeutschland", English translation: "Central Places in Southern Germany", Prentice Hall, New York, 1933.

6 T. HAGERSTRAND "Innovation diffusion as a spatial process", University of Chicago, 1967.

7 Th. SAINT-JULIEN "La diffusion spatiale des innovations", Reclus, 1985.

8 Cf. A. RALLET "Théorie de la polarisation et technopoles", Economies et Sociétés, series F (32) "Progrès et Croissance", No 8/1991, PUG.

This work, however, is more in the way of an attempt to renew the spatial or regional economy than a cross-linking of the regional and the industrial economy[9]

2. Technological change and the territorial dimension

Before looking at whether a territorial dimension has any relevance to the process of innovation, we should spend some time considering the representations of technological change in the light of some recent work based on the evolutionist or neo-Schumpeterian approach. We shall see that these representations lead us to take a differing view of space in the process of innovation.

The basic concept, from the neo-Keynesian to the neo-classical schools of thought, is technical progress. This is defined as the substitution of a set of superior techniques for a set of existing or currently used techniques. This definition refers not to a development or a process of innovation but to a process of adoption. The technical parameters are external constraints on economic choices, and the only question is which of the various available techniques to choose.

Under the standard theories technological advance is perfectly defined (ex-ante). Innovation - generally a new production process - is absorbed by a structure which is itself a datum. Consequently, the starting and finishing posts are fixed in advance. It is assumed that the economy will adapt to the technology.

Under the evolutionist approach, developed inter alia by G. Dosi,[10] the environment not only alters the conditions of technological change; it also changes itself as the process unfolds. Innovations are the result of a cumulative process, hence the emphasis on a sequence of choices creating an irreversible momentum. We have thus moved from an exogenous representation of technical progress to an endogenous representation of innovation. Technology is no longer a resource but a result. A number of conclusions drawn from this approach have an impact on the relationship between innovation and territory.

(i) Since it is the result of a process, technology is non-transferable. This means that a technology cannot be transferred from one space to another or within the same territory.

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9 Except for certain work, particularly the writings of J.C. PERRIN. By way of example the same author has also written "Industrial organization: the territorial component", Revue d'Economie Industrielle, No 51, 1st quarter 1990.

10 G. Dosi "Technological Paradigm and Technological Trajectories: a suggested Interpretation of the Determinants and Directions of Technical Change", Research Policy, No 11/1982.

(ii) There are no generic resources (technological or other, excluding capital), only specific resources. This means that there is no optimum form or mode of territorial organization but simply different forms of effectiveness and coherence which are the result of the combination of assets specific to each territory.

(iii) Location is becoming a factor in the creation of technology to the extent that it represents an opportunity to develop certain types of relations between businesses or productive phases.[11]

Clearly, we are very close here to the ideas of Marshall in relation to the "industrial district", a theory which revolves around the concepts of proximity and externality. It is these two concepts which, taken together, define a technopolis in our view.

3. The technopolis as the cradle of technology

As we have seen above, technology must be represented not as a resource but as the result of an innovation process. The technopolis is one of the places in which such a process can be created and develop. It can therefore be regarded as "organizational innovation of the territorial type" (Rallet, *op cit.*). The assumption underlying the technopolis is that proximity reduces the organizational distance which prevents the various players involved in the process of technological creation from coming together (Rallet, *op cit.*). It is therefore instrumental in reducing a number of costs, mostly related to the movement of information. The technopolis therefore enables us to reduce what have come to be known as "transaction costs". The higher these costs and the greater the obstacles to development of technology, the stronger the case for the technopolis. We can thus assume that depending on the country or region, which can be characterized for a particular form of organization, a technopolis is necessary to a greater or lesser extent in order to reduce transaction costs: the cost of looking for contacts, the cost of decompartmentalizing the firm's organization, the cost of moving information (monitoring) and so on.

The purpose of the technopolis is to generate what one might call visible effects of organization. Through appropriate territorial organization it is possible to give tangible form to the results, in this instance to

11 J.L. GAFFARD. The creation of technology. Business strategies and public policies. University of Nice, 1987.

create technology, something which measures taken independently of each other or within traditional (market) mechanisms could not have done. The characteristic feature of the technopolis is therefore that its visible achievements are determined by the proximity of those involved.

Conclusion

In conclusion we would like to make three comments:

(i) the first attempts to reflect the diversity of the types of technopolis,

(ii) the second seeks to define the concept of specific asset more closely, and

(iii) the third concerns the players involved in what one might call a 'knowledge investment network'.

(i) As we know, the term technopolis covers a very wide range of different situations; so much so that some, conscious of the paradox, have referred to it as a "non-reproducible model".[12] There are numerous typologies of a technopolis which we cannot go into here. One of the questions raised at a recent colloquium on technopolises[13] was the matter of their territorial status. In the light of recent work carried out for the European Community[14] we believe that a important distinction, and one which has an impact on the evaluation of the technopolis, has to be made between technopolises which belongs to a broader territorialized system of innovation and technopolises which constitute a localized innovation and production system in their own right.

(ii) While certain areas may compete with each other in terms of their ability to supply certain quantitative factors, other territories are not subject to such a constraint imposed by commercial relationships because what they have to offer is their uniqueness.

12 J. Perrin "Les technopôles: mirages ou nouvelles phases de la division du travail?", Culture technique, No 18, March 1988.
13 Research colloquium 'Technopolises and other territorial measures to promote technology transfer' Nancy, France, 16-18 October 1991.
14 MUST. 'Coherence or diversity of innovation systems in Europe'. Report for the FAST programme, CEC, 1991.

This supply depends on the ability of the territories in question to combine internal and/or external resources in an original form of coordination geared to the production of visible results from the network (see above). One of the key features of these territories is their ability to reduce firms' propensity for volatility, particularly in the case of large-scale firms.

Another aspect of the uniqueness of a technopolis is the density of material and immaterial, formal and informal relationships which create an irreversible momentum for those involved in the process of innovation. Since they benefit from the proximity effects of the network, firms in a technopolis cannot leave the network without suffering significant diseconomies.

The need to acquire new skills related to the technopolis, which is an essential component of a permanent and incremental process of innovation, highlights the essential role of training. In common with J. PERRIN (op. cit.) we believe that one of the main functions of the technopolis is to promote a catchment area of specialized employment in the scientific, technical and sociological fields.

As the structure of the technopolis is in part determined by the local labour market, in its turn the technopolis must impart a structure to that market in order to increase the supply of specialist skills.

iii. The third and last remark concerns the players involved in a technopolis as a 'knowledge investment network'. Despite the many different types of technopolis, they all contain firms specialized in engineering, engineering consultancy, software design, training and so on, as well as university research laboratories and other types of research laboratory. As far as the firms are concerned, certain technopolises consist almost exclusively of small and medium-sized businesses, while others are structured around larger firms. I should like to echo the point made by J.P. de GAUDEMAR,[15] that the supply of technology from a technopolis would have hardly any local impact unless there was at least a potential or latent demand, or even a potentially receptive base of small and medium-sized firms likely to derive benefit from the facilities offered by the technopolis either through subcontracting or through technological consultancy, or in R&D or training. This approach places the technopolis at the heart of a local or regional knowledge investment network.

15 J.P. de GAUDEMAR "Technopoles et politiques régionales les risques d'un développement "hore sol"", Economies et Sociétés, série F (32) "Progrès et Croissance", No 8/1991, PUG.

Experiences of a Tenant of a Science Park

Grant Lewison
General Technology Systems Ltd.
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EXPERIENCES OF A TENANT OF A PARK

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Abstract

The paper describes the experience of a small consultancy company which moved to the Brunel Science Park in 1990. Because the company offices are on the edge of the university campus, many interactions with the university are possible. They depend a lot on the needs and interests of individual staff members. They include the employment of university staff and students, mostly on a casual basis for short-term assignments, but sometimes undergraduates for a few months as part of their "industry placement" experience. Some university facilities are available on repayments terms, such as printing and library on-line services. Others are available free, such as use of the library and attendance at lectures. The university also provides a pleasant park-life environment and sports facilities which staff enjoy. Finally, there is discussions of the benefits to the university from the company over and above the rent paid as a tenant.

1. Introduction

This paper gives a rather personal view of the benefits we as a company have derived from our situation on a science park on the edge of a university campus in west London The intention is to suggest factors that evaluators of science parks should explore. The most often touted theoretical benefit of a university-based science park, namely technology transfer from the university to the world of commerce, is hardly relevant for us and I suspect that it is not that important for tenants other than small spin-off companies. But we, or at least I, derive real benefit in many other ways. Some can be characterized in time or financial terms, others are less readily quantified.

Our company was founded in 1973 and for most of its existence operated in rented accommodation off the High Street in Brentford. This is a somewhat down-market urban area whose main advantage is good communications. It is near Heathrow Airport and has easy access to two motorways to the west of London and the inner peripheral highway. The company was founded to provide consulting services in the technologies of space, aircraft, electronics and telecommunications, and their management. It operates in the field of the management of technology, often for national governments and intergovernmental organizations such as the Commission of the European Communities. Currently it has some 12 Directors and full-time consultants, 6 support staff, and a variable number of associates.

The university is named for one of Britain's great nineteenth century engineers who laid out the Great Western Railway from Paddington to South Wales and Cornwall. This railway line passes close the site to which the former Acton Technical College moved in 1967-8, shortly after it received its Royal Charter. Brunel was one of the new universities founded in the 1960s to provide for an expansion in higher education, particularly in science and technology. It shares with the University of Surrey a commitment to "thin sandwich" undergraduate courses. These give four six-month "industrial placements". The students are employed by industrial or commercial firms, or other organizations such as Government laboratories, in order to gain practical experience - and, incidentally, earn money. It is an effective form of education and one result is that Brunel graduates are among the most employable in the country, despite the recession. However the university has been finding it increasingly difficult to place the students during the last years. The total numbers - 3260 undergraduates, 1170 graduates - are small by the standards of UK universities but they are increasing quite rapidly.

The science park occupies a small part of the Uxbridge site, 2.5 hectares at the south-east corner of the 60 hectare campus. It has three two-storey brick buildings, of which two are for general letting and one is used exclusively by a non-profit distributing Research Association, the International Tin Research Institute. It also consists of a number of small units contained within university departments which start-up companies can rent in their first months and years. There are also a few units on the Runnymede campus of the university, 18 km distant. Altogether there is 7000 m2 available for rent and there are 22 tenant companies and some 152 employees work there. Firms are in principle engaged in scientific research associated with industrial production, preferably in collaboration with Brunel University.

2. Employment of staff and students

Our company is not a spin-off from the university and so none of our staff have any particular connection with a department or faculty. Nevertheless, several faculty members are regarded as "associates" who can be retained by the company to work on individual assignments as occasion arises. The possibility of the inclusion of their names and rather impressive academic credentials in our proposal documents is helpful, although within the context of bids for work from the Commission of the EC it would sometimes be better to offer the services of academics in a different Member State. We have in fact used Brunel academic staff on several occasions for commercial assignments for which they are paid by the day.

Another use of Brunel faculty is to give quick and informal scientific advice, normally over the telephone. Our location on the Science Park makes us "part of the family". This emboldens me to ring up, say, a chemist to check the spelling of some esoteric chemical substance in a scientific report that I am editing, or a physicist to check whether a particular abbreviation should be in upper or lower case.

However my principal employment so far has been of research students. They are permitted to take time off from their three-year PhD studies to earn money on "casual" work. We pay them at the rate paid by the university for demonstration work, which is their main alternative employment if they can get it. Currently this is about 17 ECU per hour which is quite high for casual work. But for this we get highly skilled and motivated people who are sometimes literally at five minutes' notice (the time taken to walk up from their lab to our offices), and to whom we have no commitment other than the job-in-hand. Currently I have two such students. One does computer analysis of the data from postal questionnaires; the other does bibliometric work. Both have become rather expert in their respective tasks and they are now regarded as "junior associates" who can feature in project proposals. The work is not completely irrelevant to the students' research and the money (mostly tax-free) is a welcome supplement to their grant, which has failed signally to keep up with the rise in the cost of living since the 1960s.

I am shortly about to hire two undergraduates to work on a full-time basis for a few months. This work will be part of their industrial placements discussed earlier. GTS will use them to carry out intelligent clerical work, such as coding of questionnaires and very detailed work on bibliometrics. The undergraduates should be ideal for this purpose and they are rather cheap (about 6 ECU per hour). Again, we have only a limited commitment and they earn money in a location close to their residence (they can stay in student accommodation on campus, for which there is much less demand after the end of term).

Another possible use of students is to employ foreigners because of their language skills. Brunel has a register of foreign students and has identified ones from, for example, each of the countries of eastern Europe. I am planning to use one of them for a few days on a clerical task involving a good knowledge of an eastern European language.

3. Use of university facilities for work purposes

Our use of the university facilities can be divided into two parts, those for which we pay an economic charge and those provided essentially free as part of our agreement to rent space in the Science Park. The major use in the former category is of the university print-shop. They can do colour printing and all the normal activities associated with publishing such as collating, folding and binding. I have used them to print a 20-page questionnaire and to do several smaller jobs. Not only are their charges very reasonable but they are within five minutes' walk.

The library is, of course, a major resource in any university and many of my colleagues and I have used the Brunel library on numerous occasions. We use principally the reference section but from time to time we consult periodicals, borrow books, order articles form the British Library through the Inter-Library Loan scheme, or arrange for on-line scanning of databases. In particular, I use the CD-ROM version of the Science Citation Index, as well as the printed volumes, for bibliometric studies.

We have made some use of the computing department for the purchase of computer hardware and software, and in principle we could use their mainframe computer although the need has not arisen so far. Nor have we needed to commission tests from the university laboratories although I understand some other Science Park companies have done so.

However we do use the university catering facilities, such as the Senior Common Room dining room, for the entertainment of visitors. We are also planning to receive a young Italian visitor for a few weeks during the summer, and may then make use of the student accommodation on campus some of which will be of unoccupied and available for rent. The Science Park itself has conference facilities, including both small and large meeting rooms, which are often useful for meetings if our own space is not suitable or used for other purposes.

Finally in this context it is worth mentioning that the University and the Science Park quite often receive foreign visitors and delegations some of whom are taken to our offices to see a "typical" tenant. The links we are thereby enabled to make provide us with a somewhat wider network of people and contacts in distant countries and thereby reinforce company marketing.

4. Use of associated and leisure facilities

Science parks are well known for providing their occupants with a pleasant, park-like, environment and Brunel is no exception. We are surrounded by lawns and beds of flowering shrubs, with spring bulbs, roses and foliage plants. The restful atmosphere is a welcome change from the noise and smells of a city and I was myself attracted by it when I attended an interview prior to joining the company. It more than compensated for the extra journey time compared with their previous location.

The university amenities such as the sports center are made available to science park tenants on the same terms as they are to members of the university. We have played badminton and squash, and attended aerobic classes. There are also tennis courts nearby for those who feel competent to appear on them. We are also able to attend concerts and lectures on the campus, and several of us go regularly to the free monthly recitals of chamber music. The library holds exhibitions of art and crafts from time to time and we have visited some of them.

Since the site of the university is somewhat remote from the nearest town (2-3 km), there are shops and a bank on the campus, as well as a student cafetaria and a mobile food shop. The presence of the university has also created a demand for public transport and in consequence there is a rather better bus service than one would expect in the outer London suburbs. Altogether, the science park enjoys a high level of amenities and services which make life rather agreeable. At present the only real lack is of bicycle shed!

5. Contributions by the company to the university

The decision by the university to reserve a small part of the site for a science park was made some time after the move to Uxbridge. The university obtains rent as a return on its members and departments earn money for their services. But I suggest the main benefits are of two kinds and ones not easily measured in money terms.First, the science park acts as an advertisement for the university through the international and national activities of its tenants. Sometimes this is overt as when proposals are made for joint projects between GTS and associates form the university. More commonly it appears as an attitude of openness to commercial relationships.

The second benefit is the intellectual stimulation to both students and faculty members provided by contacts with GTS and other companies, who are working on real problems for clients and can therefore inject a sense of commercial reality into academic life. For example, a member of staff of GTS acted as a tutor for a summer school project on the operation of a space station. This may also extend to the written word. GTS subscribes to a number of specialist journals in its fields of interest which are not carried by the university library: members of the university are welcome to come and consult them. With one journal we have agreed to circulate it to and store it in a university specialist unit after it has been read within the company.

6. Conclusions

This short paper has indicated most of the ways in which GTS interacts with Brunel University through the Science Park. The interactions are very much at the behest of particular individuals rather than the result of a formal company policy, and indeed some of them are not very well known. As we spend more time on campus, we confidently expect to make increasing use of the resource on our doorstep. But it would have been very hard to foresee all these interactions when the decision to relocate here was made. If our experience is at all typical, science parks may have an advantage for their tenants much greater than conventional ex ante analysis would suggest.

Technology Centers and Science Parks and their Effects on Job Creation in Structurally Weak Areas.

F. Dietrich -ExpertConsult
Munich Germany

TECHNOLOGY CENTERS AND SCIENCE PARKS AND THEIR EFFECTS ON JOB CREATION IN STRUCTURALLY WEAK AREAS

Munich, Germany
F. Dietrich

Planning, construction and operation of a technology centre are the first steps toward encouraging the growth of small and medium sized enterprises. The opening of a technology centre or science park makes it possible for major regional development goals to be met in the medium to long term. These aims are :

* Technology transfer
* Innovation
* New job creation
* Improved competitiveness
* Increase in productivity
* Greater attractiveness of location
* New business creation
* Better image for the region
* Relocation of businesses to the region

The greatest advantage to combining a technology centre with a science park is the fact that businesses which have "outgrown" the technology centre after three to five years can be persuaded to stay on the region, often without even a change of address. The creation of synergetic effects and the development of the local area to an innovative and business-oriented location are pre-conditions for attracting out-of-town or out-of-state companies to the science park.

Of course, none of this is possible without a targeted development of the "hard" and "soft" locational factors, for example road connections, public transportation, environmental protection, adequate housing and quality of life. The success of a science park is particularly dependent on a high-quality infrastructure. A few examples follow:

* Good transportation connections (near highway)
* Available public transportation
* Intelligent, space-saving solutions to parking problem
* Signposting with company logos to direct visitor traffic

* Small shopping area for daily necessities
* Bank/post office
* Park benches in open green areas
* Restaurants/cafés
* Hotel (two to four star)
* Recreational possibilities

* Environmental planning
* Link between open spaces and functional areas
* Tree-lined streets
* Landscaping
* Open spaces planned with sport and recreational possibilities in mind.

The success of a technology centre or science park is of course measured against the impact made on employment.

A direct impact on employment is made by :

* Founders of the firms located in the technology centre and their for the most part highly qualified employees
* Members of management of the technology centre or science park

An indirect impact on employment can be achieved through :

* Construction of the technology centre or science park
* The supply network between tenants and local manufactures/suppliers
* Contracts given by tenants to local manufacturers for pilot or mass production
* Impulses sent out by the technology centre and its tenants encouraging innovative activity in the region and as a consequence improving the competitiveness of established corporations

* The prospect of improved image, synergetic effects and the promise of advantages held out by location in the proximity of the science park, which can influence national or international corporations to relocate near the science park.

For example, in 1990 the Dortmund Technology Centre, a part of the Dortmund Science Park, had the following documented effects on job creation :

1. Direct effects

   A few brief comments on the type of employment are of interest here: Of the persons working for firms located in the technology centre, roughly one-third are independent contractors or students and only 23% are regular employees. Amongst businesses that have left the technology centre and moved into the science park, however, only 10% are independent contractors or students and 40% are regular employees. The number of part-time employees (33% in the technology centre) is reduced to 10% in the science park.

2. Indirect effects

   Here are just a few ways in which so-called indirect effects were made on employment :

* Construction industry (cost of technology centre DM 65 million)
* Advantage of proximity to technology centre and improved image
  - relocation to science park
  - approximately 1,200 jobs
* Multiplier effects

From Technology Centre to Science Park
Advantages of Combining a Technology Centre with a Science Park

- Availability of space for firms which have outgrown the technology centre
  → no change of address necessary
- Companies have a long-term tie to the location
- Creation of synergetic effects
- Development of an "innovative and science-oriented location"
  → attractive spot for businesses looking to relocate

BC/BP 03

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From Technology Centre to Science Park
Contact between Technology Centre and Science Park

Encourage cooperation between firms in the technology centre and firms in the science park through:

- Common use of the technology centre infrastructure
- Seminars and other events in the technology centre
- Doing business with each other
- Joint business and research projects

BC/BP 04

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Impact of Technology Centres
Regional Development Objectives

- Technology transfer
- Innovation
- New job creation
- Improved competitiveness
- Increase in productivity
- Greater attractiveness of location
- New business creation
- Better image for the region
- Relocation of businesses to the region

BC/BP 09

ExperConsult

Impact of Technology Centres on Employment

- Direct impact on employment through
  - companies located in the technology centre
  - companies expanding out of the technology centre
- Indirect impact on employment through
  - companies locating outside the technology centre in the hope of profiting from synergetic effects and improved image
  - multiplier effect via distribution network

Impact of the Dortmund Technology Centre on Employment
Indirect Effects

Multiplier effects (chain reactions)

- Income is created through new jobs
  → demand → investment → impact on employment
- Profits earned by companies located in the technology centre
  → demand for more capital goods
  → impact on employment
- Demand for products and services by companies located in the technology centre
  → impact on employment

BC/BP 11

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Impact of the Dortmund Technology Centre on Employment
General Facts

- Opened in 1985 with 4,800 square meters of floor space
- First expansion in 1988 to 5,000 square meters
- Second expansion in 1991 to 12,000 square meters
- 35 firms are now located in the Dortmund Technology Centre

Impact of the Dortmund Technology Centre on Employment
Direct Effects

- 500 employees among the firms located in the technology centre
- 240 employees among the firms which have already moved out

BC/BP 13

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Invited comments following workshop discussions:

J. Campos Rodrigues, Challenge
L. J. Tsipouri, University of Athens.
Comments by G. Colletis, IREPD,
Comments by G. Lewison, Brunel Science Park
Comments by D. McQueen, EHIT Zentrum

Impact and Evaluation of Science Parks - Some Remarks
Challenge-Inovação e Tecnologia, Lisbon, Portugal.
J. Campos Rodrigues

1. The indicators for Science Park evaluation are necessarily related to those that define the scientific and technology strength of an economy, such as:

   - Jobs created, using S&T skills
   - Intensity of the relations between University and Industry
   - Evolution of the specialisation pattern of the industry, and of the weight of the technology-intensive activities
   - Number of patents registered
   - Evolution of business expenditure on R&D.

If they succeed, Science Parks will contribute positively to all these indicators, but only in a long term.

The successful cases that we have been talked about in this Workshop took between 10-15 years to have visible results on those indicators. In this context evaluation seems to be an impossible mission.

2. The objectives of a Science Park broadly defined are to create an environment favorable to the establishment of a critical mass of scientific institutions and technology-oriented business, that induces a chain reaction that will promote the "explosion" of the economy of the region.

Three major issues come out of this concept :

   - The critical mass
   - The "reactivity", greater than 1, needed to naturally feed the chain reaction
   - The detonator to start the reaction.

We still don't know how to monitor all these issues in order to forecast whether or not the Science Park will succeed. What we can learn from the different experiences is that the level of excellence of the Research Institutions plays a fundamental role in the process, acting as the detonator of it.

This is, it seems, clearly assumed in Bari strategy. First they develop some centres of expertise (seeking excellence) so that in a second phase (10 years later), they may be able to feed the science park or to be an attraction pole for outside companies.

But we are not able to define the needed critical mass, and we don't know how to measure the "reactivity" of the process, which will depend on different parameters related to the global environment of the region (social, political, economic) and of the project itself (management capabilities, leadership, believe, credibility, business plan, marketing, etc.).

3. In the short term, we are restricted to two perspectives :

- project monitoring concerning its accomplishment in regard to the initial business plan (goals, objectives and strategic plan).
- economic and financial evaluation of the project (but treating it as a business, has the threat of reducing the Science Park to a real estate development more or less technology-oriented).

4. In order to replicate in a top down approach the proven bottom up sequential developments, it is necessary for us to be aware that:

   - Science Parks are an element of a global scientific and technology policy, but are not the magic measure to solve the scientific and technological gap existing between regions. Isolated they will be no more than "cathedrals in the desert".

This brings us to the issue of measurement of the aditional impact of Science Parks on the economic development of a region. All we know is that empirical evidence exists on the relationship between the level of R&D expenditure of an economy and its development. The strengthening of R&D capability of a region means getting synergies among different measures and initiatives. In order to perform an evaluation of the efficiency of a given situation, it will be necessary to perform an extensive exercise in order to define the input output matrix that correlates these different measures with the relevant indicators. But I doubt that this is a practical and useful exercise.

5. Another issue will be how to evaluate alternative measures to the launching of a Science Park, that could have in the short/medium term a better cost/benefit relation.

But this evaluation depends on one hand on the dimension of the budgetary restrictions and on the other hand on the concept (or the model) upon which the Science Park is intended to be built.

6. A final remark relates to the fact that Science Park impacts and evaluation are being reduced to the regional/local level.

With this remark I would like to put emphasis on the fact that we are facing a global economy in an open market, and that the internationalisation of the economies is a reality that should not be forgotten.

The indicators to be utilised, even in a long term perspective, need to consider these new realities, mainly the markets in which the R&D centres and firms created are competing and their capabilities and strengths to develop themselves in an international context.

EVALUATION OF SCIENCE PARKS, SOME REMARKS ON THE EXPERIENCES IN MORE ADVANCED COUNTRIES

Lena J. Tsipouri, University of Athens, Greece

The "fashion" for the creation of Science Parks has gone through two phases in the technologically advanced countries (AC), a first in the late 50's and early 60's starting in the U.S., and a second with widespread experiences after the mid 80's. During the latter Less Favoured Regions (LFRs) in the EC have promoted initiatives for creating their own parks. This had implied a recent need for improving tools (indicators, knowledge on best practices) for both ex ante and ex post evaluation of Science Parks initiatives.

Up to now evaluation experiences come exclusively from technologically advanced countries, where the role of market forces and private capital is more pronounced, due mainly to a higher demand for entrepreneurial estate and to a longer established linkage between academia and the productive sector. In LFRs this gap is expected to be filled by public support (EC, national, local). Thus, specific problems arise when trying to apply the same methodologies for LFRs, which are briefly discussed below in terms of issues, possible indicators and policy implications.

a) Existing evaluations in advanced countries converge to the conclusions that the creation of Science Parks is a long term exercise and as a consequence ex post evaluation needs a lengthy time horizon. Besides the role of personal commitment as a factor of success is stressed. Thus an **effective administration, speed and continuity,** appear to be the most important prerequisites of success. It can be argued that these are qualities that can be taken for granted in AC, but less so in LFRs. Besides these concepts are not measurable and no clear or generally valid indicators can be used. One can take as proxies the share of private capital participating in the founding capital of the Park, the frequency of changes of high rank administrators and the time table. But each one of these proxies can also prove to have adverse effects, as private investors expect a faster return on investment, than the average time needed for the success of a park, changes may be necessary to improve the institutions etc. Policy implications for a success strategy may lead to suggestions very difficult to materialise when public funds are at stake, like the justification of extra-funding to specific individuals, shortcuts in administrative procedures, etc.

b) The evaluation has to be related to **the goal of the creation of the Park,** which may be regional development, technological development, image boosting or pecuniary goals. These primary goals are not self-evident for every park. Besides they may be complementary or competitive to each other.

Regional development issues, are the most easy to measure with indicators like job-creation and turnover, number of new businesses established, their life cycles etc. The real problem here is that of additionality, namely how to isolate the events that would have occurred anyway from those that are purely due to the existence of the park and the incentives it offers. The methodology used is to investigate on a personal basis on the likelihood of establishment of the company in the region, would the park not exist. In LFRs the additionality issue is of particular relevance, since many parks are announced to be created in order to host spin offs, extended campus facilities or semi-public organisations.

Technology creation due to the agglomeration function of the Park is another typical goal, based on the linkages with R&D facilities. Nevertheless it has not been confirmed from empirical evidence that physical proximity is a motive force, since professional or social proximity appear more important. Technology creation can be measured with the usual R&D output indicators, although the additionality barrier appears here even more pronounced than before. As a policy issue for LFRs, it is important to make explicit from the very beginning the relation of the regional versus technology creation goals: the latter may be easier to achieve, within the framework of a supply push policy in specific endowed disciplines, but the former is usually the cover for public support.

Image boosting of the core university, the local authorities, the funding authorities or the companies establishing in the park may also be a primary goal of the initiators, although not usually explicit.

Profit making for the investors.

In LFRs experience until now shows that all four goals are proposed as equally important and highly promising, while evaluation in advanced countries shows that success in one goal can be clearly contradictory to others. For example cases were reported where "Developing technology versus developing jobs" was in a full antinomy.

c) Evaluations in AC tend to show that there is **no correlation between size and success.** Several experiences show that there is no threshold which guarantees success or increases the likelihood of failure. If any indication on the size, it is rather that there is **a tendency to go bigger than necessary** and due to this approach to jeopardise the whole undertaking. Thus indicators on the size of the park are only necessary in order to link them with its environment and funding possibilities rather than its likelihood for success.

d) In the US it was found that **success is highly correlated to the specialisation of parks,** which has sometimes been planned and sometimes resulted during the implementation phase. There is no indication that alternative results should be expected in LFRs, so indicators on the planned and achieved concentration by discipline should be an important measure for park evaluations.

Nevertheless, as a policy issue, it is expected that LFRs will have a more generalistic approach to their parks in order to be able to address a broader range of clientele. This issue has to be treated cautiously in business plans.

e) The **capital versus technology base of tenants** is strongly diversified between countries. It seems that in the US and the UK Science Parks host more productive enterprises, whereas in Sweden and in France the majority of tenant is in the tertiary. While this is connected to the general economic environment, local fiscal policy, etc. and it cannot be linked to the success of the park itself, it has a significant impact on the environment and can be linked to the additionality issues. Again this is an important goal to clarify and measure, in order to know what to expect in each park.

The above mentioned remarks are only to prove that experiences from AC may offer some techniques for ex ante and ex post evaluation, but do not prescribe general recipes. It is suggested that LFRs should not only learn from the success stories, but it is equally important to get indications on failures in order to avoid already committed errors, because the ultimate goal, when evaluating the creation or the success of a park in a LFR is not to imitate institutions that succeeded in another environment, but to create success stories in the own environment. Finally it is important not to use the notion of the Park in order to create an **excuse function**, i.e. create something else and name it a Technology Park, which gives high prestige to the initiators. An extended campus or an industrial zone should be called by its name and not a Science Park.

Lena J. Tsipouri
April 2, 1992.

Some brief comments G. Colletis (IREPD)

1. The difference between technology considered as a resource and technology considered as a result is neither semantic nor imagined.

Presenting technology as a result, i.e. the result of an innovation process, makes it easier to grasp the nature of this process.

Innovation is an iterative and incremental process, in other words one based one irreversible choices.

Technology is the result of this process and can therefore by interpreted only in terms of a learning/creation process.

The notion of "technology transfer" stems from an incorrect representation of technology, which rejects the concept of technological creation and presuppose the existence of ready-made technologies which are simply transferred with a few adjustments here and there. This explains the disastrous failure of policies based on technology transfer.

2. Assuming the existence of a process of technology creation, we can further assume that a technopolis can constitute a space for "creative communication", facilitating innovatory learning. The relevant intermediate concepts are "networks" and "cooperation".

3. There are numerous typologies of the technopolis. However, not enough emphasis is placed on the precise conditions governing their location. How do technopolises integrate within the regional technological infrastructure? How does the "country effect" come into play?

4. The disadvantage of prior evaluation is that it evaluates that which does not yet exist. Post-hoc evaluation assesses that which no longer exists. We ought therefore to concentrate on endoformative evaluation (that is to say a simultaneous assessment with interaction between the evaluator and the subject).

Comments by Grant Lewison

My impression is that the evaluation that have been presented here, while very interesting and quite varied, may have missed some important aspects of "life on a science park" through their focus on macro-economic data and indicators. It is often necessary to talk (not circulate a questionnaire) and to address ordinary professionals and not just the top manager to learn about the company-university interactions. One of the most important may be the academic environment as an inducement to prospective employees who might seek greater security in a large company instead of in the small science park firm. Another might be the use of University facilities such as library or the ability to hire students on a part time or casual basis. High academic quality in the university may contribute individually to a science park's success through the quality of its environment, reputation, facilities and students.

Comments by McQueen

The following is some suggestion for possible indicators for evaluating science and technology parks. The idea is not that each park be able to provide all indicators, but rather, that each park should be able to provide at least some of them. The indicators should cover a wide enough spectrum of activities and situations that every park be able to express itself through them, and perhaps get some ideas of what more could be done through studying the indicators which they cannot respond to satisfactorily at the present time.

Employment created (inside and especially outside the park):
- by industrial sector
- locally, nationally, internationally
- rate of employment growth

Number of contracts
- national, international
- local
- concerning inputs to the park
- commercially oriented
- academically oriented

Identifiable interactions
- R&D contract, etc
- personnel exchanges, etc
- cooperation agreements

Cultural changes induced by the park
- in financial institutions (attitude toward small companies, etc)
- at political levels
- within the associated university (is commercial activity acceptable)
- in the community at large

Identifiable outputs
- R&D contracts
- patents licensed
- spin-off companies formed
- companies attracted

Identified strengths
- University departments
- regional characteristics

Present activities
- what are you doing now ?
- what will you be doing in two (five) years ?

On another level, I should like to see the concept of science or technology park widened to include other professional and non-professional area represented in universities. The sociologists, linguists, pharmacists, business students, etc, should not feel excluded from "technology" parks in my opinion. There are good examples of spin-off companies from these areas which contribute at least as much to employments, etc, as do the companies producing hard products.

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It contains the full set of papers put forward during the Workshop as well as additional comments subsequent to the discussion. It also contains a Foreword by the Editor which summarizes the key points made in the discussion.

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