Spillovers and Innovation, Environment and Space: Policy Uncertainties and Research Opportunities

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1 Introduction and Overview

The previous chapters demonstrate convincingly that the concept of externalities remains a fruitful source of research and policy studies worldwide and it shows few signs of being exhausted. As the introductory chapter makes clear, spatial and other externalities once constituted a series of esoteric assumptions that helped account for deviations from perfectly competitive markets. However, the concept has since expanded to account for a wide and growing set of issues whereby the unintended actions of certain agents affect other independent agents, negatively or positively. This expansion had two additional effects. First, other disciplines and theories have adopted the concept of externalities in various forms to reformulate unintended interdependencies in realms parallel with economics, often enriching the theoretical insights of several such fields simultaneously. Second, the expansion of issues, disciplines and analysts introduced these concepts to more areas of policy and decision-making, particularly as previously unrecognized positive externalities brought to light wholly new areas of beneficial side-effects (Putnam, 1993).

Other book chapters illustrate a selected subset of topics, mainly a subset with which the authors of this chapter have been concerned. We will not attempt here to systematically summarize or classify the contents of these chapters; rather, we wish to focus selectively on aspects of externalities as reflected in the chapter title. Our aim is to highlight certain areas we feel merit further or more intense attention on the part of scholars and policy analysts. We begin first with the general field of environmental externalities, which is one where a considerable body of policy and theory evolved more or less together, mainly from a concern to mitigate or eliminate negative externalities. However, as we point out, environmental policy is increasingly based on incentives that reflect a sophisticated understanding of applicable positive externalities as well. Positive externality concepts have multiplied exponentially in theories, literature, research and increasingly policy-fields affected heavily by new and endogenous growth theories, particularly the effects of spatial distributions of growth factors. The following highly selective comments will be limited to these topics.

Externalities linked with environmental matters are usually thought of as typical examples of negative externalities constituting a barrier to development. There are usually two ways these are dealt with in the framework of economic thinking, i.e. the various policy options to internalize these negative consequences of economic

activities (to be discussed below) and the positive preventive strategies available in principle to overcome these obstacles. The issue to be tackled in the second case starts from the simple thesis that natural resources are necessary production factors, the productivity of which can be enhanced by R&D and innovation in companies. It is particularly the notion of "sustainable development", postulating in various more or less rigorous forms that a stationary state of the stocks of natural resources is to be maintained for the benefit of future generations, that is central to the discussion. If this policy aim is to become compatible with economic development, the stocks of "human capital" need to increase in the future. The technical progress necessary to promote "eco-efficiency", from invention to diffusion follows an analogous logic to the general challenge posed by making any scarce production factor more productive. The major difficulty arising in this context is the different objective function steering the process. While the aim to increase productivity in a Schumpeterian world serves as a vehicle for pro-active companies to get ahead of the competitors, this is usually not seen as a successful strategy with respect to environment-oriented innovation, at least without the proper internalization of negative environmental externalities. Full internalization is difficult to achieve, as was already pointed out in the introductory chapter to this volume. The first best solution, as suggested by Pigou (1932), faces all the theoretical drawbacks alluded to in the introductory chapter of this volume, but also hinges on the ability of researchers to establish the full social cost of emissions caused by polluters. The instruments of environmental policy typically considered generally represent "second-" or "lesser-best" solutions.

An enormous change of view concerning what externalities represent in regional economies has taken place, which continues to redefine research and policy agenda alike. What were once seen as market imperfections or failures ripe for remedy are now considered evidence of how firms, individuals and governments logically seek advantage in a globalizing economy. The new growth theory assumes monopolistic rather than purecompetition, which helps better explain why private and, indirectly, public productive assets accumulate persistently in specific cities and regions; it also helps clarify firms' indifference to, or avoidance of investments in, peripheral areas that lack basic pre-conditions, despite heavy policy interventions. It is no coincidence that business strategists such as Michael Porter, whose rivalry concepts reflect a qualified form of monopolistic competition, are now taken more seriously when considering advantage- seeking behavior of firms that prefer regions and clusters capable of reinforcing or sustaining privileged market positions. At the same time, our altered view of how growth occurs reflects both endogenous innovation and the emerging knowledge economy that have become leading forces in restructuring industries and regions open to global frameworks of trade, capital and labor mobility, transport and communications.

Many different strands of research are rapidly converging from various disciplines that attempt to understand the still opaquely-perceived growth dynamics now underway; these appear, in turn, to have propagated wholly new varieties of development policy that address the partially-understood forces that governments at all levels hope somehow to shape. The present collection of essays provides good insight into several important policy objects and the underlying development forces policies hope to

influence. The second part of this chapter will focus on selected aspects of *industrial clusters, universities and related knowledge spillovers*, in which key policy uncertainties beckon understanding and research opportunities abound to study embedded mechanisms of endogenous innovation that lead to development.

2 Negative Externalities and Space

Negative externalities are potentially created by any transformation process such as the economic activities of production and consumption. In the transformation of inputs into outputs, residuals are created that have a potentially harmful effect on the eco-system, including human beings. Space enters this process naturally as the residuals produced are fed back into the eco-system by being emitted into nature's receiving media. These constitute natural resources such as air, water and soil which serve multiple uses. Once having been deposited in these media, the residuals diffuse over the space the resources cover. During this diffusion process chemical and physical transformations tend to occur and the emissions from various sources accumulate in the receiving medium and are partly or totally absorbed in various sinks. The consequential residuals' concentration, if total natural regeneration is not possible, produces potentially negative impacts upon the eco-system including the anthropogenic economic sub-system, thus causing negative externalities. As pointed out in the contribution by Wang and Nijkamp in this volume, this diffusion process can take various forms and thus can create different basic starting points for policy design. The best known examples are the one-way and the reciprocal trans-frontier pollution cases; the former are typical of river systems where the water flow makes polluters easily identifiable, while the latter, often associated with air-pollution, converts a spatial unit polluter into a victim simultaneously in many cases.

In policy design, space is often neglected as a consequence of assumptions made in the theory of environmental economics. Within a policy area, it is frequently (often tacitly) postulated that the ambient concentration of residuals is uniform, thus constituting the case generally investigated, i.e. the existence of a "public evil", which is an equal load for everybody, but may affect people and nature differently. In principle, permanent and temporary residents of such an area cannot escape the negative impacts, a fact believed to constitute an important incentive for common action. In many cases, however, this assumption does not hold, as the residuals' concentration actually varies over space, thus providing incentives for individual action to improve the personal environmental quality by relocating. Especially in urban regions, this motive for migration of households can be an essential driving force behind processes of urban sprawl. Although this fact has been known for some time, the strength of this phenomenon, which obviously varies between regions and countries (a well documented fact, e.g. Berry and Horton, 1974 use "isopleths" analysis to show the varying distribution of pollutants over urban space for some U.S. and European cities; Stanners and Bourdeau, 1995), still needs to be explored further. A particularly interesting feature of scientific and political relevance is the nature and elasticity of the trade-offs in relation to other factors of location choice (see e.g. Schubert, 1979). A multi-disciplinary research approach is also warranted in this case.

A topic less often explored is the concept of "social space" and its bearing on the development of environmental policy approaches. One of the most interesting propositions in this respect was made by Coase (1960), in which the attribution of property rights to a party in a negative externality conflict involving a limited number of persons provides the basis for direct negotiations and the option of designing a contract in which the conflict is settled and internalization is achieved. The start of such contract negotiations depends critically on the social relations between the persons involved, as the "social distance" between them has a bearing on the trust the future partners have to develop to design and comply with the contract. A similar argument can be made with respect to other co-operative activities requiring mutual trust, such as public-private partnerships (see the contribution by Gindl and Wukovitsch in this volume). The "social distance" is related to the friction encountered in communication, the determinants of which still merit attention by researchers.

3 Space and Environmental Policy

The problems of internalization and the various policy approaches to achieve it have been studied quite well in the literature (an excellent review is presented in this volume by Wang and Nijkamp). An important policy problem still remains somewhat elusive in this context, i.e. the delimitation of the relevant policy areas within which institutions are to be set up: spatially sensitive policies remain limited to the administrative competence defined within institutional boundaries (see e.g., Hoel and Shapiro, 2004). Obviously the reach of residuals' diffusion fields is neither confined to administrative boundaries, nor does it remain constant, partly due to short term variations in the physical movements of the receiving media (e.g. winds, water currents), but also because of changing overall volumes of emissions. These, in turn, depend on the economic growth process in the area and abatement measures taken by companies and households. The problem is further aggravated by the fact that the basic spatial units aggregated to form the "pollution management districts" often do not have the appropriate size or physical features. Relevant areas are sometimes excluded because they are within the jurisdiction of another country. Clearly these critical issues pose challenges to new forms of governance and they could greatly benefit from (necessarily multi-disciplinary) research.

4 Environment-oriented Policy and Innovation

As was pointed out above, the necessary long-run condition for sustainable development is the increase of the productivity of "natural capital". Product and process innovation with an environmental focus is the vehicle towards achieving this goal in companies (e.g., Fischer et al., 2004). The question immediately arises whether there is a difference between innovation in general and environment driven innovation activities.

Cleff and Rennings (2000) maintain that the main difference is the importance of the regulatory set-up. The general innovation literature emphasizes technology push factors and market pull factors as the main driving motives. The regulatory set-up is

not only defined as a command and control mechanism, but also as general interaction between governmental and non-governmental actors. This implies a new management oriented approach where "public administration is reorganized and fully integrated within the whole process" (Schrama and Sedlacek, 2003, p. 228). Additionally, policy co-ordination or integration, including environmental objectives in other non- environment related policy fields, need to be considered (see Gouldson and Murphy, 1998, Schrama and Sedlacek, 2003, p. 235ff.). Regulatory incentives, hence, have a particular role in stimulating environment-oriented innovations (e.g. Blazjeczak et al., 1999, Klemmer et al., 1999). The analysis of the impacts of policy measures, especially regulation, has confirmed the important role played by the political realm in innovation processes (Marin and Mayntz, 1991).

The role of policy, hence, has been clearly established by recent research. A question remains, however, about the effectiveness and efficiency of policy instruments. This query has various aspects. First, different relevant policy fields have to be distinguished, such as environmental policy, technology policy, particularly those programs with an environmental focus, and various sectoral and spatial policy areas (e.g. economic, transportation, energy etc. policy, urban and regional planning). Secondly, significant differences between instruments available within a policy area are claimed to exist. Economists are generally convinced that price-related environmental policy (e.g. green taxes, tradable emission permits) tends to be most efficient in the long-run (e.g. Pezzey, 1992, 2003), while administrators and political scientists tend to favor stringent command and control approaches. The empirical evidence available to reject any of these hypotheses is still weak (an empirically-based analysis is presented in Gale et al., 1995), in part simply due to the fact, that price related policies have not been applied widely yet, and where they do exist they have usually been introduced rather recently, making good analysis difficult.

An assessment of the effectiveness of technology policy faces great uncertainty and demanding efficiency assessments remain well out of reach. Specific technology policy initiatives with an explicit environmental focus are rare. If they do exist, the time span in which they can be studied is generally still very short (see e.g. Schrama and Sedlacek, 2003, Ulph, 1997). An important dimension to consider in such studies is the goals of the policy. The process of technical progress is characterized by two principal elements: the creation of new technologies and their diffusion in the economy (see e.g., Isik, 2004). The incentives provided in pertinent policy programs can have quite different effects on these elements. They could even be contradictory.

The instruments available to promote environment-oriented innovation in general and specific elements in particular would certainly merit more attention by researchers, as considerable funds (mostly public) are invested and the risk of betting on the wrong horses could be considerably decreased.

It must also be said that the complex interactions among other policy fields mentioned and the resulting effects on innovation and the environment are even less known. Analyses to detect and trace these effects through the economy hinge critically on the development of a more general "system's model".

The influence of *market forces*, however, must not be neglected in the context of environment-oriented innovation. These incentives play a role in different types of

markets. There is an influence of "green consumer demand", in the form of products desired that are environmentally superior to others, or the production process is critically viewed concerning possible negative effects on the environment.

Regulation often plays a critical role in the creation of new markets, which would hardly exist without it. The "technology developing" organizations (public, private, non-profit, etc.) rely on policy incentives that stimulate effective demand from "technology using" companies (the technology developers can be integrated in the same organization, e.g. as "R&D departments, etc.) for their products and services. Environment-related technology markets are particularly sensitive to changes in policy.

The relative strength of the various market and non-market forces that exert an influence on environment-oriented innovation is still being intensively debated. It seems to vary by country and historical development phase (Sedlacek and Schubert, 2004). More empirical evidence based research could make a considerable contribution to better policy making.

Positive externalities produced in innovation networks

One of the important questions arising in the context of the production of positive environment related externalities (in the case discussed here, innovation) is the form of organization which is best suited for this purpose. Discussions on this query have increasingly focused on the usefulness of networks. Characteristic contributions to this debate are e.g.:

> *"Innovation is increasingly recognized as requiring the convergence of many sources of knowledge and skill, usually linked in the form of a network."* (Pyka et al., 2002, p. 169, similar arguments can be found in Porter, 2000, Rosenkranz, 1996). The *"networks themselves emerge as a new form of organization within the knowledge production"* (Küppers and Pyka, 2002, p. 6).

The network structure and the type of partners involved seem to be the most essential element that distinguishes between innovation in general and innovation with an environmental focus. Various groups of actors are involved: those directly active in the innovation process (i.e. technology developer, technology user, supplier firms, etc.) and those supporting the network (i.e. policy makers, financial services, consultants, etc.). Both groups form a *"self maintaining social structure"* (Küppers and Pyka, 2002, p.7) - the innovation network. As pointed out above, the creation of such environment-oriented innovation networks is mainly influenced by external stimuli, provided by regulation and the instruments applied in the various policy fields.

The question of organization of innovation activities has two elements to consider, i.e. the structure of the network and its change during the different phases of an innovation project. The various functions necessary (such as knowledge creation, financing, etc.) to make the network operational and the partners who represent it determine the *structure*. One of the crucial elements is the flexibility and readiness to work towards a common goal in an atmosphere of mutual trust. The spirit of co-operation is particularly difficult to maintain for the representatives of governmental agencies, as they are

usually trained and socialized in their job to represent the law and thus are often not prepared for planning and development tasks. This fact certainly presents a challenge for the development of appropriate training programs.

Innovation projects take time. The work takes place in *phases*, which constitute necessary elements (idea - information - decision - implementation - monitoring). These stages do not necessarily have to follow each other in a simple, linear sequence (see e.g. Kline and Rosenberg, 1986). Defining innovation as a dynamic process, it can be described as a trial and error sequence in feedback-loops. Many open questions remain about the dynamics of innovation network activities. An essential feature is the readiness of partners to learn from failures, but which are the factors that determine successful learning behavior needs to be investigated further. The absence of hierarchical relations between the partners and the degree of formality in co-operation are seen to play a role, but in some cases the absence of formal contracts (particularly "division of the cake" issues in success case) have been blamed for failure during final project phases.

5 Clusters as Externality Arenas

Regions and agglomerated economies are the classic "externality arenas", where the accumulated events of long path-dependent histories produce location-specific assets that now yield economic advantage. A widely discussed contemporaneous arena within which positive externalities produce strong development potentials is an industrial or regional cluster. Clusters appear to be face-valid expressions of developmental externalities to even the casual observer. However, the literature on clusters and their variants has one of the lowest value-added-to-effort ratios of any subject on our general topic, which is another way of saying that genuine contributions per publication have been disappointing. Some of this can be blamed simply on its sheer popularity among many audiences, which stimulates the release and distribution of much derivative material by markedly different agents, often for promotional, marketing or policy advocacy purposes, rather than advancing the stock of original research and general understanding.

Feser's chapter describes this popular phenomenon and documents its size and growth, which has shown little subsequent sign of abating. He then examines the penetration of cluster ideas into the policy portfolios of Latin American governments and compares it with U.S. cluster policy and practice. The Latin American experience is instructive because it simultaneously reflects the popularity of clusters and their suitability in changing systems of political economy that have suffered with the rapid advance of globalization and attempts to liberalize economic institutions and practices. Other studies of cluster development in transitional and developing economies cited by Feser reveal a genuine hunger for locally-oriented development policies that also fit within global systems of production and trade. This raises the question of how suitable industrial clusters are to a variety of political economic settings, or perhaps whether certain aspects of clusters fit some political economies better than others.

This question results logically from the diverse origin of industrial cluster ideas in advanced economies of Europe and North America. In both settings, a large but

partially- connected stock of conceptualizations in economic geography, business and regional science has been drawn upon to identify and provide evidence for the following range of beneficial clustering effects:

1. home-market region and potential scale-economies permit establishment and growth of traded sectors (general agglomeration/scale externalities),
2. input cost reductions and specialized outsourcing possibilities permit unique locally-realized operational efficiencies and expansion of traded products or services (pecuniary spillovers), and
3. locally captured knowledge and innovation gains generated by interaction with competitors, suppliers, customers or organizations help drive dynamic improvements in production and product development (technological spillovers).

European and U.S. analysts differ somewhat concerning how these effects arise and are sustained: U.S. analysts tend to favor historical chance, technological disruption, external impacts, and first-mover advantage in markets while European views emphasize the creation of favorable conditions for firms and clusters through government or 3rd party policies, although all factors can be documented in the case experience of both continents. The unanswered question is how and which of these benefits can be expected to arise in the transition and developing (or even peripheral EU/U.S. regions) economies that lack key features of U.S. or EU environments.

The first effect results from historical patterns of settlement, urbanization and concentrations of demand that favor the emergence of final markets. As Schmitz (1995, 1999) and others have noted, clusters operate frequently and most effectively in urbanized portions of developing countries where production scale arises logically from urbanized demand patterns. Scale efficiencies must be "created" in rural and peripheral areas of developing countries where raw material factors are often located and many people still live at low densities. Transitional economies of former USSR have the opposite problem: existing production sites were initially selected and output scaled to targets based on some collective need, which was generally measured only in quantity (not quality). Inherited output capacities for low quality goods far exceed evolving demand within newly reorganized nation states that often remain incompletely developed in terms of product and factor markets. It is therefore important to recognize that cluster policies could differ radically in various countries and settings.

Indeed, Krugman (1991) hypothesized that a general reordering of site specialization and sectoral concentration will eventually result from EU integration of its then 12-member states, thereby implying a longer-term shift in cluster development *within EU countries*. Similar hypotheses might apply to the cities and regions in NAFTA countries, although changes of lesser degree would probably result from expanding trade and capital mobility, rather than labor mobility. Additionally, there are substantial variations in cultural practices, social capital, and business systems among regions in the U.S. or the EU that deserve far more attention concerning their potential impact on cluster development and success. Taken together, one might readily conclude that further study of the core processes of city and regional development could yield potentially useful insights into the formation of home markets, scale economies and export markets.

The second cluster effect could be considered a Marshallian consequence of the first: commonly shared factor inputs such as specialized and cost-efficient labor, unique inputs or capital goods, and tailored public infrastructure and services are eventually offered at "pecuniary" discounts to local cluster firms that specialize in scale- efficient export production. These are often characterized as localization economies that arise naturally within trajectories of capitalist development, the externalities of which accrue to a particular cluster's subset of firms and industries. National and regional differences do affect the degree to which these effects can be secured through various policies to benefit local clusters. Since the pecuniary factors mentioned here can be strengthened through a mix of policies concerning local business practice and public expenditure, regime differences may have potentially profound effects upon cluster viability. As only one example, the creation, attraction and retention of skilled labor implies locally relevant policies that affect residential environment and quality of life, mobility of innovatively creative workers, well-springs of entrepreneurship, etc. These are hotly contested issues in the U.S., mainly at journalistic levels, and are receiving attention recently in Europe as well. Since little serious scholarship has been devoted to the subject, there is not much convincing evidence concerning the relative importance of amenity-milieu factors identified by Goldstein and Renault in their chapter. Stronger efforts to understand the policies that affect successful stimulation of new firm startups or the attraction and accommodation of inward investment in supporting sectors would also prove valuable. Further, the willingness and ability of relevant governments to expend wisely on key public infrastructure and services is poorly understood at best.

The presence of pecuniary effects in specific clusters may also produce extra-cluster incentives, whereby otherwise unrelated sectors and firms are able to take selective advantage of pecuniary advantages borne of the original localized cluster. Jane Jacobs and others who stress the importance of urbanization economies point to this possibility, particularly in larger urban regions with robust local market demand, although the relationships *between* localization and urbanization externalities has not been examined closely to date. These widely recognized factors have more often been studied in isolation, with surprisingly little research dedicated to investigating *groups* of pecuniary factors, even though all are considered important. The far more common practice is that policy analysts and even some researchers assume these factors are necessarily present in regions that support above-average concentrations of output, as revealed through simple cluster-mapping efforts (usually location quotients or similar concentration indices).

Pecuniary advantages of the type described here are generally absent in developing countries, since the institutional framework conditions or pre-requisites must be established before firms acquire typical capitalist incentives or policies to promote cluster-supporting activities. Clusters in emerging economies of Asia and some Latin American economies appear to have made rapid improvement in these conditions, but this is a largely untested observation as well. The case could be made that research lags in these places because suitable measures of pecuniary factors are undeveloped, or that unambiguous measures of clusters or their viability are similarly absent, but this is another way of stating that necessary research concerning basic measurement

and conceptualization lags well behind the premature application of assumption-based policies.

The third cluster effect refers to the uncompensated flows of knowledge and innovative practices that leak from some firms to benefit others within a cluster. These inter-firm leaks or spillovers are said to be among the most significant sources of competitive advantage enjoyed by cluster firms, who expect to lose and gain spillovers in a positive-sum game. The reasons such spillovers do not devolve to zero- or negative-sum games is based on the observation that only firms with active programs of internal R&D are in a position to understand and apply innovative knowledge that might spill their way and that temporary product market niches thereby earned provide sufficient incentive to pursue innovations. The ability to conduct internal R&D usually depends upon minimal levels of profitability and the value of tax- deductible R&D expenditures, both of which are supported by cluster effects 1 and 2 as outlined above. Therefore, clusters could be said to provide hospitable conditions and incentives to innovate, the benefits of which accrue to it and neighboring cluster firms. Combined with the insights of endogenous innovation as a key component of the new growth theory, innovation is now seen far more as the natural outcome of monopolistically-competitive capitalist systems and the driving force behind growth. From this perspective, it is a short step to the basic principles behind what are known as innovation systems, where national versions (NIS) were first elaborated in a series of key studies, which were then followed by regional (RIS), generalized to spatial innovation systems (SIS), and eventually to learning regions[1]. In two large OECD studies of innovation systems, clusters were equated with "reduced-form innovations systems" in which key elements function identically in both concepts. The convergence of innovation systems and clusters in a policy repertoire has attracted more attention from all OECD member countries except the U.S., primarily because much more active national government involvement in both is envisioned, although activities at the state level in the U.S. are significant and growing.

6 Universities as Externality Agents

It is by now an article of faith that the "knowledge economy" could not have arisen in the U.S. as it did without the research function of universities - particularly elite public and private research universities - becoming heavily endogenized as market-responsive knowledge-producing institutions. A common denominator was the growing dependence on new knowledge and in particular knowledge generated by local university R&D, often functioning within self-organized regional innovation systems. Research universities are generally perceived as location factors of growing importance to corporate investment decisions (Dorfman, 1983; Andersson, 1985, Andersson, Anderstig, and Harsman, 1990, Hall, 1987), either as sources of public good "spillovers" or perhaps, as Breschi and Lisson (2001) have insisted, as increasingly

[1]Concepts pursued here represent a logical regional subset of the full set of processes and institutions seen as key elements in the innovation systems literature (Braczyk, et. al., 1998, Cooke, 1998, de la Mothe and Paquet, 1998, Cooke, et. al., 2000, Bergman and Feser, 2001, den Hertog, Bergman and Charles, 2001), which assumes the presence and importance of university spillovers.

organized suppliers of knowledge using a myriad of possible commercial transactions (Sampat, 2003).

The warp-speed of this process as the 20th century came to an end all but dispensed with quaint ideas of aloof and insular universities as "ivory towers" focused purely on the pursuit and profession of ultimate truths, nearly always holding indifferent to casual interest in (or mild disgust with) their commercial surroundings. Economic "endogenization" of universities has also gotten underway in Europe, as the Bologna Process continues to harmonize higher education practices throughout the EU. Generally missing from this process, however, are the institutional incentives and competitive pressures to expand research and innovation- creating functions that now account for the majority of budgetary support in the best U.S. research universities. This is also reflected when one reviews the widely-scattered case studies of clusters on the two continents: in comparison with the U.S., the role of universities appears markedly less important in EU cluster dynamics. The generally lower levels of EU research (% GDP) that prevail preponderantly in commercially-untainted national research laboratories, academies of science or similar state-sponsored innovation institutions seldom drive clusters.

The chapter by Goldstein and Renault summarize the impacts research universities could have on their regional host economies: *productivity gains, greater business innovation, new sources of business startups, regional creativity, and an overall increase in capacity for sustained regional development.* To investigate the general effects of universities - particularly their changed role during the last third of the 20th century - on U.S. metropolitan regional economies, they conduct a quasi-experimental test of regional changes in labor productivity: "Our measure of regional economic development is average annual earnings per worker. [A]verage earnings per worker focuses on the quality of jobs in a region as the most important dimension of improvement in regional economic well being" (p. 80). Their results demonstrate convincingly that the presence of a research university is significantly related to greater increases in local earnings per capita (or labor productivity) *after* universities became much more active research agents capable of exploiting knowledge gains, although it is not possible to know from the evidence available *which university-related mechanism is responsible.* While human capital creation is perhaps the most likely mechanism, the productivity impacts estimated here could have been realized through several possible mechanisms, as the authors' questions make clear:

> "*Through what mechanisms, or channels, does knowledge production – broadly considered – within universities lead to economic development outcomes in the surrounding region*? Is it, for example, through economic transactions between actors or units within the university and external organizations, through spillovers, or through milieu effects, which are particular kinds of localization economies?" (italics added, p. 72)

Universities appear to be important sources of knowledge to firms in host U.S. regions, a general proposition which can be tested empirically with only slight risk of mis-specifying the probable causal direction: knowledge is far more likely to flow *from universities to firms* that can exploit such advantages commercially. However, univer-

sities are not the only nodes from which knowledge and related factors might spill into a regional economy, which then complicates our understanding and testing of knowledge spillover mechanisms. As the chapter by Varga, Anselin, and Acs demonstrates, knowledge-generation nodes include other research organizations that go well beyond universities alone. The authors deploy a knowledge-production function approach to modeling regional high-tech patent applications that might arise from university *research* expenditures, industrial *research* and development (proxied by high-tech research laboratory employees), and total high-tech employees (proxy for networks of innovative firms). Even though research from both universities and corporate research laboratories is likely to spillover to firms, the authors are careful to acknowledge that such a

> "... model does not allow for explicit modeling of *the way knowledge spillovers occur* and as such it is difficult to separate spillovers from the correlation of variables at the geographical level.." (italics added, p. 94)

In other words, while regional units of analysis do permit one to infer generally that spillovers often flow from known knowledge generators to knowledge commercializers, variations in regional patent applications could just as easily reflect correlated variations in the "internalized intellectual property" of regional universities (Bayh-Dole Act beneficiaries), corporate research laboratories, or high-tech firms, all of which seek and avidly hold patents with *absolutely no spillovers having occurred.* Moreover, use of regions, clusters or other spatially defined units as "externality arenas" do not permit one to distinguish the extent or effects of spillovers when the flow and mechanism of knowledge transfer within these arenas remain unanswered questions. Clearly, we need better concepts of spillover mechanisms within regions to avoid attributing internal innovation to external spillovers. This inherent limitation poses the familiar problem of how spillovers are best conceptualized as theoretical constructs or mechanisms and as empirical objects suitable for measurement and testing.

7 Spillovers as Externality Mechanisms

General externality concepts in the form of positive spillovers that propel commercial innovation have become the object of intense analysis, although clear spillover definitions remain elusive and resist specification. Consequently, spillover research papers and articles repeatedly mention the need to specify better the actual knowledge spillover mechanisms. Audretsch and Feldman (2004) argue that better conceptual understanding of basic geographic location and agglomeration externalities

> "... was a significant step in generating innovative activity, [however] it provided little insight as to *how and why knowledge spills over*, nor did it illuminate the mechanisms that serve as conduits for the transmission of knowledge." However, recent research "... *literature on knowledge spillovers and the geography of innovation has begun to consider the mechanisms by which knowledge spills over and is put into economic use and*

> *the degree to which these processes are geographically localized.*" (underlining added) p. 2 and p. 19.

Their review establishes from the outset how geography and spatial units of analysis were first introduced in knowledge production function studies, the results of which improved steadily with numerous refinements, particularly later introduction of spatial lags and citation trails. Spatial arenas properly "internalize" core externalities and permit one to test theoretically expected evidence of spillovers that cannot convincingly be established by relying upon firms or industries as units of analysis. Evidence grew stronger and more convincing as the spatial units declined in size, from nations to states to regions. It is this evolving pattern of studies that led to concepts of "localized knowledge spillovers", referred to frequently as LKS.

Efforts to specify spillover mechanisms associated with an LKS view might be expected to evaluate the character or nature of interactions among aggregated agents that lead to spillovers. Seminal studies and literatures surrounding so-called "MAR", Jacobs and Porter effects fall clearly in this camp. Progress helped distinguish between pecuniary effects and other market mechanism effects, the spillover potential from specialized vs. diverse industrial structures, and the nature of competition for local pecuniary and technological advantages or in monopolistically competitive export markets. Subsequent literatures that stress the formation and value of social capital, affinity networks, and venture-capital density also fit well within this de facto framework, although there has been no systematic effort to elaborate this framework. Were one to do so, it might be worth inventorying and classifying quite systematically all spillover-enabling features of: *market mechanisms* (e.g., pecuniary advantages, rivalry, competitiveness, output and factor markets, etc.), *sectoral structures* (specialized vs. diversified, SME, FDI and entrepreneurial start-up ratios, cluster components), *labor pools* (skills, occupations, cohort detail, mobility), *residential quality of life* (amenities, opportunities, risks, well-being), *social fabric* (social capital, affinity networks), *public-good externalities* (political homogeneity, Thiebout effects, club goods) and so forth.

Even a fully-elaborated LKS arena framework is unlikely to permit one to infer precise mechanisms of *what* spills over, between *whom* and to *which* proximate effect; moreover, such attempted inferences might indeed lead to confusion. The LKS arena framework permits stronger specification of the overall conditions that enable or stimulate spillover potentials within externality arenas; however, improved specification of the spillover mechanisms per se between the agents are best acquired from other perspectives. These confusions are apparent from their working list of "mechanisms for spillover transmission," which indiscriminately mix agent-level concepts with arena-level concepts of spillovers (Audretsch and Feldman, 2004). Their list contains familiar items mentioned by others in the literature, most of which mention vaguely-described spillovers; these fall considerably short of understandable and testable mechanisms, despite serious intentions to do so. Perhaps some of the difficulty results from attempts to infer internal mechanisms at work *within* the geographic units of analysis that first enabled scholars to detect and estimate the net impact of such

spillovers.[2] As Caniels and Romijn (2003) put it,

> "... so far, all the existing approaches in the debate have adopted a regional (i.e., meso) level of analysis, without looking closely at the behaviour of individual actors (notably firms) that make up the region. Yet firms are the key actors in innovation and learning processes. It follows that a good grip on the micro-economic processes that underpin innovativeness is essential for gaining a better understanding of the driving forces of regional dynamism" (p. 6).

Accordingly, Caniels and Romijn (2003) attempt to open the LKS black box of firm spillovers. They do this by introducing a firm's view of micro-motives, a view that draws heavily upon evolutionary economics to demonstrate the importance of continual learning processes to innovative processes. In brief, they apply two widely accepted learning mechanisms ("trial and error" and "organizational search") to a collapsed set of Marshallian agglomeration advantages ("specialized labor pool and supplier base" and "technological spillovers" to identify six potential spillover mechanisms. Another somewhat more successful attempt to disentangle and classify these dimensions starts from conventional meso-level concepts of regional economics, gradually adding firm behaviour extracted from the evolutionary economics paradigm (Johansson, 2004). Johansson essentially triangulates in conventional economic terms key externality features (sources, consequences, and nature of meso-externalities) and spillover types (intra-market/pecuniary, quasi-market/club, extra-market/technological) to create a geometry of the evolutionary firm's vertical and horizontal relations in which spillovers might arise. A resultant matrix yields the economic nature and essential features of specific mechanisms classified by the firms' horizontal and vertical geometry. The result is a nearly exhaustive taxonomy of spillover mechanisms, with accompanying suggestions of how some might be operationalized. Further investigations and expansions along these lines hold promise for disentangling and better specifying the potential spillovers that might arise among firms and with their economic environment.

However, both approaches omit consideration of other economic agents previously implicated in spillovers, except very indirectly. Omitted are universities, independent or corporate research laboratories, public bodies, and other interested knowledge-generating or transferring organizations discussed earlier, which are typically among the key elements discussed in the innovation systems literature. What are their micro-motives and are they changing? Even answers to these questions would not account for the motivations that animate "human agents" who are known to be very heavily involved in spillovers.

[2]The difficulty is similar to that of understanding what causes regional employment to rise or decline when one measures the change only in net terms, rather than decomposing the total employment changes by sectoral and occupational components, including entry and exit to the region of both employers and employees.

8 Knowledge Workers as Spillover Agents

Organized legal agents (i.e., firms, research universities or laboratories, etc.) purposefully develop intellectual properties, pursue core R&D activities and actively manage knowledge as part of their ongoing activities. Knowledge and information is transferred between organized agents when actions are taken by some human inside the organization, although *knowledge workers* as spillover agents generally receive much less attention than the stocks and flows of knowledge they embody, discover, synthesize or manage. Their specific activities may include participation as staff on joint research projects, working with external consultants (firms, universities, etc) hired to provide specific knowledge and technology inputs, attendance at conferences and symposia to extract new information, systematic reconnaissance of libraries, journals, data archives, etc., and the casual industrial espionage absorbed effortlessly in the tacit- Marshallian "atmosphere" of social contact circles and among value-chain partners.

Tacit-knowledge transfers and acquisitions remain extremely distance-sensitive, which effectively reduces the potential contact field of knowledge workers to a local region capable of being traversed by auto or public transport, although occasional reassignment of a firm's knowledge workers to other locales has also been proposed (Rallet and Torre, 1998, pp. 44–45). Intelligence generated or absorbed by these and similar means accrue directly to – and is embodied in – knowledge agents. Only indirectly and perhaps later is such knowledge transferred to parent organizations, which attempt to stimulate its collection and internal exploitation by improving the internal incentives system and by adjustments in corporate culture.

Much intelligence remains embodied tacitly (Karlsson and Zhang, 2001) in knowledge agents and is potentially mobile, as originally envisioned by Marshall. Once (potentially) mobile, agents are no longer simply knowledge agents employed in some organization; they are the "knowledge spillover agents" (KSAs) who increasingly appropriate and profit from their embodied knowledge through mobility. Audretsch and Keilbach (2003, p. 5) express the incentive as follows:

> "When the lens is shifted away from the firm to the individual as the relevant unit of observation, ... the question becomes '*How can economic agents with a given endowment of new knowledge best appropriate the returns from that knowledge?*'"

They go on to argue that the most rational appropriation - at least in the U.S. - is the entrepreneurial route, i.e. spinoffs and startups originated by university scientists. A seminal series of research studies has focused on precisely this issue by examining new firm startups in advanced fields of science (e.g., biotechnology) as a function of highly qualified co- located scientists in the same fields, where various combinations of patents or articles in journals of record (including citations) are used to determine qualifications of what are termed "star scientists" (Zucker, Darby and Brewer, 1998, Zucker and Darby, 2001, Zucker, Darby and Armstrong, 1998, Zucker, Darby and Torero, 2000, Zucker, Darby and Torero, 2002). In distinguishing the unique value of scientists, the authors argue such scientists posses *more* than routine human capital,

which is:

> "... seen as earning a normal return on the cost of investment, both direct costs and foregone earnings. We believe that some innovations, particularly "invention as a method of inventing" [Griliches, 1988] may be better characterized as creating rivalrous human capitalintellectual human capitalcharacterized by natural excludability as opposed to a set of instructions for combining inputs and outputs which can be protected only by intellectual property rights" (p. 291).

Clearly, those who posses such talents and abilities are able to appropriate and capitalize on them to benefit themselves and often their surrounding localities: "The primary pattern in the development of the industry involved one or more scientist-entrepreneurs who remained on the faculty while establishing a business on the side." (p. 291). Even if renowned scientists leave their original location, others may find continuing local advantages embedded in the form of "enduring social capital" (Agrawal, Cockburn, McHale, 2003).

Property rights can also be appropriated in other ways without leaving one's post. Torero (2000) applied similar methods to locate the officers, executives, scientific advisers or advisory boards, etc. filled by "star scientists" in established semi-conductor firms reporting initial public (equity) offerings or other activities requiring public disclosure. To these corporate involvements must be added spatially unrestricted sale or licensing of patents, equity participation or board membership in acquiring firms, etc. Appropriation of embodied knowledge by scientists may, however, be somewhat less likely in Europe, since the U.S. model of intellectual property (Bayh-Dole, see Sampat, 2003) is seen to promote more spinoffs from U.S. universities: "A major obstacle to better application of research results is the way intellectual property issues are handled in Europe" (Commission of European Communities, 2003, p. 15 and 2004). There are other possibilities for KSA to exploit knowledge endowments as well, including better employment conditions at a new organization or within one's original organization, which is usually possible only with alternate employment prospects that a KSA might reasonably be expected to consider.

Moreover, mobility need not be considered as transitive networking among future employers, as mobility could indeed re-circulate KSAs among a sub-set of likely institutions. Indeed, Rallet and Torre (1998) argue that infrequent mobility of corporate researchers to other sites is often sufficient to transfer key tacit knowledge inputs at critical R&D stages. Impediments to elective mobility among European knowledge workers are far less frequently encountered in the U.S. (Drenth, 2003). Strong cultural, familial and linguistic preferences are of course important factors that bind people to organizations and locations everywhere, but so too are the very high professional and financial risks one takens if: when the most skilled knowledge workers become frozen solid in present positions due to:

1. mobility penalties implied by moving between increasingly unstable European health and pension systems (TIAA-CREF provided uniformly portable pension

systems for academic and research personnel in U.S. since the early 20th century),
2. academic credentials not fairly assessed by distant employers (university degrees and accreditation presently being harmonised under Bologna process),
3. lateral mobility/experience remains unrewarded by subsequent employers (i.e., loyalty valued).

The role of knowledge spillover agents in the knowledge transfer process has not thus far received the attention it deserves by European or U.S. policy-makers. Mobility of knowledge spillover agents includes the reciprocal movement of scientists between universities, laboratories and industry[3], as well as the initial mobility of newly trained students (e.g., ERASMUS and SOCRATES programs, plus new EC student mobility programs). In this respect, the role of continuing, life-long education and the potential contribution of underrepresented social groups among such agents also deserves greater recognition.

9 Summary and Outlook

The volume presented covers a wide variety of aspects of the theoretical and policy consequences of external effects. Advances and gaps in the research in this field were pointed out and discussed and the subjective views of this chapter's authors about future research directions were identified. Given the level of detail and the wide spectrum of the issues presented, which general points emerge in the opinion of the authors regarding the future of this field?

- *Space* plays an essential role in the theory of externalities. Space can be defined in physical and in social terms, distance between different "nodes" constitutes an essential element of analysis. Modern network theory profits from this consideration, while the "governance" and local knowledge spillover issues now given major attention would benefit from better spatial conceptualizations. Policy design needs to take space into account if they are to become more effective.
- Policy studies of programs to promote positive externalities and prevent or reduce negative external effects by their very nature touch upon various academic fields. The organization of research, hence, has much to gain from integrating *multi-disciplinary concepts* in its approach. The openness of the scientists representing various fields to multiple concepts and methodologies of research team members is an essential prerequisite for further progress.
- Given the importance of externalities in theory and practice, and the inseparable link to public policy, higher education has responded to this fact only very modestly. Policy studies programs in existence tend to emphasize a portfolio of narrow policy realms, which themselves are seldom multi-disciplinary, nor do such programs incorporate externality concepts to their full potential.

[3]Many European countries have programs designed to stimulate the KSA mobility among sectors and regions or to repatriate former "brain drain" KSAs.

- Policy design must focus on the *phases* of a program, from the creation of the program objectives and ideas to implementation. The dynamics implied across program phases still have received very little attention in the application of externality concepts. Thus only minor guidance is provided by theory for policy formulation. Policy studies tend to neglect the significance of the phases, analyses pertain principally to single elements, and the results often remain unintegrated.

It is the firm belief of the authors of this contribution, that the topic areas discussed in this volume have a promising future and offer researchers a broad spectrum of theoretically fascinating themes to address. Increasing demand from the public to increase the effectiveness and efficiency of public policy should attract the attention of scholars, policy analysts and managers as well.

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