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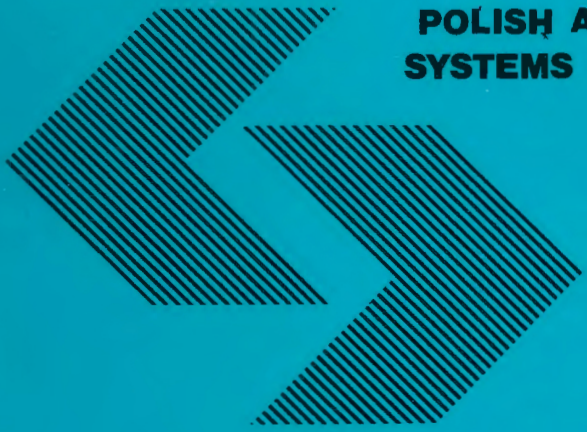

STRATEGIC REGIONAL POLICY

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EDITORS

PART I

WARSAW 1985

SYSTEMS RESEARCH INSTITUTE
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STRATEGIC REGIONAL POLICY

Paradigms,Methods, Issues and Case Studies

A. Straszak and J.W. Owsiński
editors

Documentation of the workshop on "Strategic Regional Policy", December 10 - 14, 1984, Warsaw, organized by the Systems Research Institute, Polish Academy of Sciences and the International Institute for Applied Systems Analysis

PART I

Warsaw 1985

III. TECHNOLOGICAL AND SCIENTIFIC ISSUES

WHENCE REGIONAL DEVELOPMENT POLICY? -AND- IS THERE A ROLE FOR SCIENCE AND TECHNOLOGY POLICIES?

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PREFATORY NOTE

The second part of this paper briefly reviews an examination (in progress) of science and technology policy, undertaken from a national (as opposed to regional) perspective, from which an essentially negative response to the second question in the title is derived. The first part of the paper, in contrast, is explicitly focused on issues of regional (not science-cum-technology) policy and constitutes a partial response to the general flow of the Warsaw conference at which it was presented.*

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* this is an updated version of the paper, as of February 1985 (eds.).

1. DISPARITIES IN RATES OF REGIONAL DEVELOPMENT AND GROWTH: ORIGINS AND POLITICAL RESPONSES

Especially in the decades since the second world war, increasing "openness" of national economies, significant changes in relative prices, and technological developments which have been decidedly nonneutral with reference to sectors of the economy and factors of production have led to pronounced regional disparities in patterns of development and rates of economic growth. For example,

- changing relative prices and availabilities of different primary energy sources have resulted, directly or indirectly, in severe depressions in certain regional economies and to rapid development in others. Thus, low relative prices and expanding supplies of petroleum, through the early 1970s, were reflected in economic stagnation or contraction in coal-rich regions in both the U.S. and Europe. Subsequent petroleum shortages and price surges led to substantial rates of investment and rapid development in newer and/or previously marginal petroleum producing regions.

  rapid increases in *potential* agricultural productivity implied the possibility of, simultaneously, radical increases in agricultural output and radical declines in agricultural employment, with markedly nonneutral regional consequences.

  reflecting changes in technology and in energy prices, the structure and geographic locus of primary materials production changed significantly, both inter- and intranationally. Differentials in relative energy price increases have significantly altered the global distribu-

tion of primary metals production, while energy price changes and related technological developments have fostered recycling and consequent decentralization of metals production, as reflected in the increasing economic importance of "mini-mill" production of steel in the United States.

Unless each "region" is simply a microcosm of the global economy, identical in structure to all other regions, such developments necessarily have very unequal regional incidences. The competitive positions of different regions change differentially, the interregional distribution of investment and, potentially at least, of population changes, and significant differences in regional rates of economic growth are observed.

If developments underlying differential regional growth were fully anticipated, if goods and services could be traded freely (and costlessly) across space, if capital, labor (population) and useful knowledge were perfectly (and costlessly) mobile, and if externalities associated with capital and population movements were absent, then there would be little basis for public policy concern with these developments. Although some regions would grow, in the aggregate, at rates less than those observed in other regions, and while patterns of development would vary across regions, these differences would have no welfare significance. Movements of goods and services and of factors of production (capital and labor) and of knowledge relevant to production would ensure that wage rates, rates of return to capital, consumption possibilities and, hence, levels and rates of change of economic welfare would be invariant across space.[1] In fact, of course, the

[1]Here, of course, it is necessary to distinguish between "observed" and "true" incomes, consumption possibilities, etc. Thus, it might be the case that, even if all of the indicated assumptions were fulfilled, observed wage rates, for example, might be lower in one region

rather stringent assumptions required for this conclusion will not be strictly fulfilled. Thus,

- many of the developments leading to differential regional growth have not been anticipated, leading to signficant investments (in technology, physical capital and human capital) the economic rationales of which have been undermined by subsequent developments;
- tariffs, quotas and other trade barriers, in addition to transportation costs, serve to alter the terms on which goods, services and knowledge can be traded across space, reducing trade flows (if trade is not precluded all together);
- migration costs and other contraints on population mobility have served to preclude effective adaptation of the spatial distribution of the labor force;
- capital market inadequacies and overt constraints on capital movements have had directly negative consequences and have interacted adversely with barriers to population and labor force migration, since constrained labor force migration implies that capital movements even greater than would otherwise be necesseary would be required for economic efficiency and exploitation of emerging economic opportunities; while

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than in another. However, this would reflect the valuation by persons in the low-wage region of physical, cultural or social amenities available only in that region. Observed wage differentials, then, would reflect the value placed on these unique amenities by the marginal worker, i.e., the one closest to indifference between remaining in the low-wage region and migrating to the next-best-alternative region. But, recognizing the value of these region-specific amenities, the lower observed wages and levels of consumption in the region would be of no welfare (or public policy) significance.

- in some instances capital movements and population migrations have had at least partially adverse consequences as a result of actual (if not inevitable) negative externalities.

It is in this context of incomplete, imperfect and constrained adaptation to evolving economic opportunities and constraints that regional issues have come to the forefront of public policy concern.

1.1. Political Origins of Regional Disparity as a Political Issue: A Digression

While developments giving rise to regional disparities in rates of growth would necessarily be imperfectly anticipated, and constraints on product flows and factor movements (capital and labor flows) would inevitably be observed, regardless of political influences, regional disparities as a source of public policy concern are, to a significant extent, of political origin. This is implicitly indicated by the very fact that regions as conventionally conceived are coincident with political entities, i.e., nations or their political-administrative subdivisions. Although significant theoretical effort has been devoted to the development of nonpolitical definitions of regions (in terms, e.g., of social or economic interdependency across space), applied, empirical work in spatial economics almost without exception employs political demarcations of regional entities.

While the focus of spatial economic analysis on politically defined entities can indeed be argued to be appropriate, this is the case for a reason which is rarely explicitly recognized: Perhaps the most important explanations for regional disparities in rates of growth (*per capita*) are political. Political interventions into and constraints on economic action are vastly

more important, quantitatively, in explaining divergent patterns of growth over time than are, e.g., imperfect foresight or inevitable (nonpolitical) constraints on product and factor movements. Thus, whether directly (through centralized decisions of governmental agencies) or indirectly (through responses to governmental tax and expenditure policies), political actions exert major influences on those interregional flows of factors of production and of goods and services which, in theory, should significantly dampen (and, over time, eliminate) regional disparities in economic welfare.

These political influences on regional development and on regional adaptations to changing economic circumstances, and the role of political factors in the spatial delimitation of regional economies, are clearest in the case of the politically imposed constraints on factor movements, especially on the movement of labor (and of population) across politically defined regional (national, and also intranational) frontiers or boundaries. The adverse consequences are most graphic in the cases such as those of nomadic populations whose traditional migratory behavior, in response to recurrent climatic changes (e.g., periodic draughts), is suddenly constrained by the imposition of nonpermeable national frontiers, resulting in severe depravation, even mass starvation. Even in less dramatic instances, however, welfare losses can be extremely great when migration in response to interjurisdictional wage differentials is constrained by restrictions on emigration or immigration. Similar but possibly less obvious welfare losses can be traced to politically imposed restrictions on (or barriers to) international capital movements.

In short, if regional disparities constitute a significant public policy concern, this is largely attributable to the fact that these disparities themselves are, to a significant extent, the product of public policy actions. These (differentially) regionally significant public policy actions, however, are generally not motivated by regional considerations. Rather, these regional impacts are only byproducts, commonly unintended and unrecognized byproducts, of policies pursued for entirely different, unrelated purposes. Thus, for example, tax policies which differentially treat different legal types of entities (corporations *versus* unincorporated business *versus* individuals) or different industries (agriculture *versus* extractive *versus* manufacturing *versus* services *versus* ...) will have differential regional impacts related to the unequal representation of different types of business organizations or industries across regional economies. Similarly differential regional consequences will be observable in the case of military expenditure, social services expenditures and transfers, infrastructure investment, etc., although rarely will regional impacts constitute an *avowed* (or even, in most cases, a *covert*) justification or argument for a specific policy or constellation of policies.[2]

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[2] An example of a public policy action (Federal urban highway construction subsidies) with unintended and regionally nonneutral consequences (encouragement of modal transportation shifts from mass transit to the automobile) is examined in Stephen P. Dresch, "Urban Highways and the Demise of Private Mass Transit in the United States," *IIASA Working Paper WP-83-120* (November 1983), which expands upon a thesis set forth by the author in "Save the infrastructure— by auctioning it off," *The Christian Science Monitor* (December 9, 1982). Ostensibly undertaken for purposes of national defense, it can be plausibly argued that the urban components of the Federal Interstate Highway System, in conjunction with other urban highway construction, accounted for approximately five-sixths of the 40 percent decline in transit ridership relative to employment which was observed over the period 1963 to 1977. The differential regional (and intraregional) impacts of this Federal program can be readily imagined.

1.2. Classes of Regional Disparities

Before turning to the issue of possible public policy responses to disparities in levels of regional development and in rates of regional growth, it is useful to distinguish between two primary classes of disparity, *constrained* and *unconstrained*. Constrained disparities are observed when, although conditions for full interregional equalization are not observed, limitations on interregional disparity exist, and a feedback process by which disparities are constrained is operative; any disparity greater than the limit induces actions which serve to reduce the disparity to a magnitude less than the limit. In the unconstrained case, in contrast, there exists no defined limit to the degree of observed interregional disparity and no feedback mechanism serving to constrain disparities.

1.2.1. Constrained Disparities

Consider, for example, the implications of costs associated with the movement of goods and services, labor and capital across regional boundries. Because of these costs relative prices and wages and rates of return to capital need not be equalized across regions; differentials up to the relative costs of transportation (of movement of goods, people and capital) can persist indefinitely. However, as long as these mobility costs are finite, they serve to determine an upper bound on interregional disparities; differentials greater than the bound set by transportation costs will induce flows of goods, labor and/or capital which serve to restore differentials to magnitudes less than or equal to the bounds.

It can be noted here that, in the constrained case, to the degree to which these mobility costs represent true economic costs (the value of resources utilized in the movement of goods, people or capital), observed interregional disparities cannot be interpreted as economically inefficient. While some larger social entity may consider it "unfair" that some people enjoy lesser economic welfare than others, no mechanism (other than transfer payments) designed to reduce the disparity would involve gains greater than the costs incurred; at most the society can undertake compensatory transfers of command over goods and services from persons in relatively advantaged regions to persons in relatively disadvantaged regions.

Obviously, constrained differentials need not reflect true economic costs; alternatives include, e.g., the presence of monopoly, imperfections of information, or public policies (such as an exit tax on outmigrating labor), any one of which could drive an effective wedge between prices, wages and returns to capital in different regions. In this situation efficiency gains would be associated with actions which served to reduce the maximum sustainable interregional differentials.

In any event, the constrained case is one of relatively little concern, in that the situation of the relatively disadvantaged region is not degenerative. In an economic regime of real growth, the disadvantaged region can be viewed simply as subject to a time offset, i.e., to exist at some point in the past by comparison to more advanced regions. Moreover, if the maximum sustainable differential is constant or declining over time in absolute terms (as would be expected to be the case if the differential were the result of transportation costs), then the time offset will decline continuously over time, i.e., the relative differential (and the time offset) will

asymptotically decline to zero.[3]

1.2.2. Unconstrained Disparities

If constrained disparities are of relatively little concern (depending, of course, on the degree of permissible disparity), the unconstrained case is of potentially great concern but may also be relatively impervious to corrective action. More specifically, the source of the unconstrained disparity is most likely (almost inevitably) governmental, in that, left to their own devices, at some level of disparity (deprivation) individuals would attempt to migrate if that were at all feasible, while the foreclosure of migration as an option ultimately and necessarily requires coercion (the perogative of a *de jure* or *de facto* government).[4]

For obvious reasons, little of interest can be said concerning unconstrained disparities. However, it does appear that even apparently unconstrained disparities are, beyond some point, constrained. Thus, for example, whatever the penalty associated with the detected attempt to move goods, labor or capital, and whatever the probability of detection (as long as this probability is less than unity), if the degree of deprivation becomes

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[3]Consider a constrained differential between wages in different regions, attributable to the costs of interregional migration. If real economic growth is due to labor-augmenting technological progress, then wages in the advantaged region will increase at the rate of technological progress. If technological progress is sectorally uniform, then migration costs will decline at the rate of technological progress, while wages in the disadvantaged region will rise at a rate greater than (but declining toward) the rate of increase of wages in the advantaged region, i.e., wages in the disadvantaged region will asymptotically approach wages in the advantaged region. Even if the "interregional transportation sector" experiences no technological progress, it will still be true that, relative to wages in the advanted region, transportation costs will decline, giving rise to wage growth at a more rapid rate in the disadvantaged region, implying again that wages in the disadvantaged region will asymptotically approach wages in the advantaged region (albeit at a lesser rate than in the case of sectorally neutral progress). Similar arguments apply to constrained differentials between relative prices of goods and services and between rates of return to capital.

[4]"Government" for present purposes does not, in short, require or imply a conception of "legitimacy" in any sense.

great enough the attempt will be made, or other actions (e.g., revolution) will be taken to remove either the barriers to mobility or the sources of disparity.[5] Thus, while unconstrained disparities may be of great concern at a point in time (and may be of especially great concern to the agency responsible for the absence of constraint), from a sufficiently long time perspective unconstrained disparities in fact are converted into constrained disparities, although the magnitude of the constrained disparity may be quite substantial.

2. DIFFERENTIAL KNOWLEDEGE AS A SOURCE OF REGIONAL DISPARITY

A number of possible sources of interregional disparities in economic welfare have been suggested in the foregoing. The remainder of this paper is devoted to the analysis of one particular generic source of disparity, differential knowledge, frequently identified as, in fact, an explanation for interregional differences in income and wealth. In this discussion, it is useful to distinguish between knowledge of technological capabilities, considered in this section, and fundamental scientific knowledge, the subject of the final section.[6]

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[5] It is for this reason that any government attempting to impose constraints on mobility must be concerned with the containment of disparities.

[6] The related issue of "human capital" is not explicitly dealt with in this paper. For an analysis which concludes that educational and related human-capital-formation policies have only tertiary relevance for national (and, by implication, regional) growth policies, see Stephen P. Dresch, "Human Capital and Economic Growth: Retrospect and Prospect," in U.S. of Congress, Joint Economic Committee, *U.S. Economic Growth from 1976 to 1986: Prospects, Problems and Patterns*, vol. 11, *Human Capital* (Washington, D.C.: Government Printing Office, 1977).

2.1. Technological Knowledge

The basic setting of the discussion of technological knowledge can be quite simply developed. A "technology frontier" can be posited to exist at any point in time. That frontier shifts outward as a result of investment in technology, i.e., through the creation of technological knowledge. At the moment of its creation the "premier creator" (to distinguish this entity from a possible subsequent "recreator") holds at least a *de facto* monopoly on that knowledge, i.e., realization in use of a technology at or near the frontier requires, *inter alia*,[7] that knowledge defining the frontier, knowledge which, at the moment, is the possession only of the premier creator.

An important point to note here is that, while knowledge may be created at a point in space (although there need be no significance associated with that fact), there is no reason in principle that it must be employed at that point in space. Thus, the *de facto* (or *de jure*) monopolist is able, technically, to employ that knowledge technologically wherever that is most profitable. In the absence of constraints knowledge and technology (not unlike capital) will move so as to maximize profits,[8] in the process serving to equalize factor prices over space.

If, as just indicated, at the moment of its creation the premier creator holds at least a *de facto* monopoly of rights to the use of new technological knowledge, actual use of a new technology (embodiment of the technology in

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[7]Other possible requirements for realization of a new technology include, e.g., physical capital investment and investment in the skills and capabilities of workers.

[8]This is precisely what multinational corporations are asserted to do (and ideally do in fact).

goods and services) serves to diffuse, at a greater or lesser rate, the knowledge underlying the technology. Thus, progressively over time the premier creator looses his monopoly through diffusion resulting from its concrete application. Thus, both factor prices and knowledge itself tend toward equalization.

Even more importantly with reference to the immediate monopoly of technological knowledge, the technological frontier is not smooth, continuously differentiable and concave. Rather, it is highly irregular, and any new movement need not develop directly from a prior move; while existing knowledge is a critical input into new knowledge, new knowledge can be created without direct access to any particular component of prior knowledge. Thus, again progressively over time, the premier creator finds his segment of the frontier bypassed and surrounded as a result of other movements of the frontier in the same neighborhood. In consequence, any monopoly which he might retain becomes valueless in use (but not necessarily valueless as an input into new knowledge, although its value for this purpose may be difficult or even impossible to ascertain *ex ante*).

Thus, the essential problem confronting the temporary technological monopolist is to determine a time path of exploitation of his knowledge such that he maximizes his profits, recognizing (a) that more rapid exploitation will imply earlier diffusion of knowledge (and hence loss of his monopoly position) and (b) that at some point his knowledge will be surpassed (with the incentive of potential competitors positively related to the magnitude of the monopoly profits which he, in the short run, is able to command). Hence the dilemma of the temporary monopolist: If he exploits his monopoly slowly, maximizing profits with recognition of the effect of the rate of

exploitation on the rate of diffusion (and consequent loss of monopoly position), he increases the incentives of others to render his monopoly technology obsolete. Whatever the resolution of this dilemma, however, the strategy of the temporary technological monopolist will have few if any significant implications in the regional dimension.

Obviously, a private party will have an incentive to invest in the creation of technological knowledge if, and only if, the (temporary) monopoly profits outweigh the costs. However, technological knowledge the tempory monopoly profits to which might not warrant private investment might yet have social benefits greater than the cost. Also, even if temporary monopoly profits are sufficient as an incentive to the creation of technological knowledge, social benefits would accrue to the provision for immediate, free access to that knowledge. Thus, there could well be a justification for a social entity (government) to undertake or (to subsize private parties to undertake) the development of technological knowledge, with the intent of providing free access to all "members" (e.g., citizens) of the social entity.

Such a social entity, however, confronts an even more serious dilemma than that faced by the private temporary monopolist. To maximize the benefits to its members, it has an incentive to diffuse knowledge within its "boundaries" (not necessarily spatial) as rapidly and completely as possible. With reference to nonmembers, it has an incentive to exploit the technology so as to maximize its monopoly profits, but must recognize that the rate of exploitation will be positively related to the rate of diffusion and loss of monopoly position. Moreover, a high rate of diffusion to members may also lead to diffusion to nonmembers, since each member will have an incentive to make a *sub rosa* sale of the technology to nonmenbers. Finally,

the lower the rate of effective diffusion to nonmenbers, the greater will be the incentives of nonmembers to recreate or bypass the monopolized knowledge.

Perhaps the most serious problems confronting a social or collective entity desiring to facilitate or accelerate the creation of new technological knowledge are (a) to determine how in fact to bring about the creation of such knowledge, (b) to determine the value of that knowledge, and (c) to determine the contribution of social facilitation to the actual creation of the knowledge. Serious discussion of these issues is beyond the scope of the present paper. However, it can be noted that

- by the time a particular (previously unrealized) possibility can be identified and the means to its realization determined, it is likely that all of the fundamental knowledge required already exists;
- the identification of possibilities and the means to their realization is a serrendipitous process, generally closely related to practice, but not necessarily closely related to practice in the area of the "end use" of the new technology (if such an end-use area even exists prior to the discovery of the new technology), as a result of which it will be difficult to know where even to begin to survey for new possibilities;
- having identified any possibility and the means to its realization, it will be difficult to determine the value of that realization, since the requisite knowledge may be, e.g., (a) quickly rendered obsolete by other unanticipated developments, (b) critical as an input to other subsequent developments, ...; and

once realized, the dependence of the creation of any technology on public subvention will be similarly difficult to determine, since such subvention may have been (a) irrelevant, (b) critically necessary or (c) adverse to the creation.

In any event, it is precisely at the point at which a social entity intrudes into the process of creation and diffusion of technological knowledge that potential regional issues arise. In the first place, governments, the domains of which are defined spatially, represent the primary social vehicles for intervention directed toward the facilitation of the development of technological knowledge. In the second, although, in the absence of government, temporary private monopolies would have no inherently regional implications, governmental actions designed to protect the temporary monopoly positions of private developers within their jurisdictions may have significant regional implications. Specifically, governmental interventions to preclude diffusion may make it more profitable for the temporary private monopolist to realize his technological possibilities in one jurisdiction rather than in another. For example, if the initial possessor of technological knowledge had to rely on his own efforts to defend the security of his knowledge, he might be indifferent between any one of many locations for its exploitation; however, if a governmental entity offers protective services with reference to activities undertaken within its jurisdiction, then his locational choice might well be altered. And, to the degree to which governmental assistance is effective, diffusion will be delayed.

The net effects of governmental intervention in one jurisdiction are, however, uncertain. Diffusion will still take place, only more slowly. On the

other hand, protection of temporary monopoly profits may encourage the creation of additional technological knowledge, some of which might otherwise have been conceived as insufficiently profitable by private parties, with ultimate benefits also for other jurisdictions as that induced knowledge is also diffused. Thus, in the final analysis it may well be in the interests of all jurisdictions to act jointly to offer at least limited protection to the temporary monopoly positions of creators of technological knowledge.[9] However, more active interventions designed to foster the creation of technological knowledge must inevitably confront the conundrums indicated above concerning the strategies by which this might be achieved.

The foregoing has ignored the possibility that governments may have a direct interest in new technologies, as, e.g., with reference to military capabilities and national defense. While serious treatment of this issue is beyond the scope of the present paper, the greater incentives of governments to preclude the diffusion of technological knowledge of this type must be recognized. Two points, however, should be noted. First, to reduce the possibility of diffusion to a potential adversary, it is probably also necessary to preclude diffusion to noncritical domestic uses as well, since the greater the realization of the technology in noncritical and relatively freely available form, even domestically, the higher the likelihood that the potential adversary will be able to obtain the knowledge; thus, the attempt to protect critical technologies may also result in their effective economic sterilization. Second, to the degree to which constraints on diffusion are effective, the incentives of the potential adversary to invest directly in the

[9]This is precisely the justification for international patent policies, including recognition by individual nations of patent rights awarded by other nations.

creation of new technologies are increased; confronting less severe constraints and less delayed diffusion, the potential adversary might well elect to avoid the costs of creating new technology and rely instead on imported, even if somewhat obsolete, technology.

In summary, in the absence of external (presumably governmental) constraints private holders of temporary monopoly rights to technological knowledge will have an incentive to employ that knowledge (spatially) so as to maximize profits. Only if those profits can be increased by restricting the spatial locus of exploitation will new technological knowledge have regionally disparity-enhancing effects; in other cases knowledge exploitation should be regionally equalizing.[10] Diffusion will, in any event, eventually occur, and the only effect will be to create a "time offset" for disadvantaged regions. To the degree to which all governmental entities act to enhance the temporary monopoly profits of technology creators within their jurisdictions, welfare can be increased by widening the geographic sphere within which temporary monopoly rights are protected, new technologies can be exploited and diffusion is permitted to occur.

2.2. Fundamental Scientific Knowledge

[10] In apparent contrast to this argument, it is frequently contended that the exploitation of new technologies requires high levels of human-capital intensity of labor and hence that new technologies will differentially benefit those jurisdictions undertaking the highest rates of investment in their labor force. In the first place, however, there is little or no evidence that the exploitation of knowledge, as opposed to its creation, requires differentially human-capital-intensive labor. Secondly, a given jurisdiction will have a relative advantage, if at all, only if it underwrites greater investments in human capital than its labor force would undertake voluntarily, while voluntary (private) human capital investment decisions should already have taken into account the earnings possibilities offered by technology-creating employers; thus, the differentially high, publically underwritten human capital investment will have had a cost greater than its benefit.

If the public policy significance of technological knowledge in relation to regional disparity is, at best, tenuous, as the foregoing implicitly suggests, the issue of more fundamental scientific knowledge is of even more tenuous relevance. At the outset it is necessary to clarify the distinction being made here between technological and scientific knowledge. Most simply stated, technological knowledge is concerned with the *means* by which to achieve specific (and expressable) ends. Scientific knowledge, in contrast, is concerned with the systematic *understanding* (and statement) of some relationship or nexus of relationships. In Derek de Solla Price's terms, an extension of technological knowledge is extrinsically useful (for the achievement of some objective), while an extension of scientific knowledge enters only into the body of scientific knowledge.

Now, it is certainly true that scientific knowledge may be of benefit to the creator of technological knowledge. For example, knowledge of nuclear physics is of critical necessity to the would-be creator of a thermonuclear weapon or a nuclear reactor. However, in the absence of nuclear physics no one would attempt to create a nuclear weapon or reactor, and, more to the point, no one would be able to identify that missing scientific knowledge which, if available, would permit creation of a nuclear weapon or reactor, i.e., these entities would be literally unimaginable. By the time specific "applications" of scientific knowledge become conceivable, that knowledge already exists, at which point the only important issues are technological.

Obviously, there exists a gray area in the interstices between creations of technological and scientific knowledge. The most important, as noted by Price, is that, to be knowledgeable concerning the *current* state of scientific knowledge, one must be involved at least marginally in its

creation. To even begin to ponder the engineering questions associated with a nuclear reactor or weapon, one must know the fundamentals of nuclear physics. By definition, only those working (possibly unproductively) at the frontier of scientific knowledge (not to be confused with the technology frontier) can be aware of shifts in that frontier, and only they are in a position to transmit that knowledge to others not toiling at the frontier. However, that transmission necessarily occurs with a lag. If, on average, ten years is required to transmit findings at the scientific frontier in a form accessible to nonparticipants, and if, on average, scientific knowledge doubles every decade (roughly the doubling period of the world scientific literature), then a nonparticipant is necessarily working with 50 percent obsolete knowledge. Thus, a technologically competent and oriented participant in the movement of the scientific frontier may be able to perceive possibilities of which a technogically equally competent nonparticipant would be unaware.

The critical stipulation in the foregoing is "technologically competent and oriented." If the sole function of a participant at the scientific frontier is the further movement of the frontier, then he has no technological function. The cardinal fact of the period since World War II is that, misperceiving the relationship between science and technology, technology has been sacrificed to science. While some level of investment in "science for its own sake" may be warranted (as a conspicuous social consumption good), from the vantage point of technology many toiling at the scientific frontier should have the production of technology as their primary activities, where the latter activities many be only tenuously related (and often not related at all) to their more "avocational" efforts at the scientific frontier.

Differently stated, having competently scientifically trained engineers (specifically, engineers whose training took them up to the then current research front) devote some fraction of their working hours to the study of the most recent scientific journals (which can be interpreted as participating, at least vicariously, at the research front) may be technologically beneficial, while having them devote full time to work at the research front (equivalent, technologically, to having them spend full time reading scientific journals) will necessarily be technologically unproductive).[11]

These considerations become particularly compelling when the severely skewed distribution of scientific talent is recognized (with perhaps five percent of active scientists contributing almost 90 percent of fundamental scientific knowledge). Thus, the marginal scientist (the last to join the ranks of those toiling at the scientific frontier) can be expected to contribute little to the body of scientific knowledge, and, if he is contributing little or nothing in other domains (e.g., the technological), there is little (or no) justification for his presence at the research front.

In short, only to the degree that it is necessary to offset the obsolescence of persons whose primary function is technological (i.e., the production of technological knowledge) can support of work at the scientific frontier be justified with reference to technology. This is especially the case in

[11] A question might be raised here concerning the possibly adverse consequences of training up to the research front for subsequent technological performance. Specifically, the qualities and orientations instilled in the course of training at the research front may be fundamentally unsuitable for subsequent technological activities. For example, David Clarke, in *Arguments in Favor of Sharpshooting* (1984), argues specifically that scientific training is incompatible with the concern for design which is the essence of technological work. At the least, this suggests that the "portfolio" of technologists might beneficially be somewhat diversified, including some persons originally trained to (and continuing to monitor) the research front but others whose training did not involve work at the research front (i.e., who were simply "taught" the existing state of scientific knowledge) but rather focused specifically on technology.

light of the relative inappropriability of scientific knowledge; if the temporary monopoly of technological knowledge is difficult to sustain, that of scientific knowledge is even less so, since, at the moment of its creation, the only persons with any possible interest in scientific knowledge (other than simple curiosity) are other scientists working at the research front. If the scientist has little incentive to foreclose access of others to the increment to knowledge which he contributes (and many incentives to broadcast that increment as widely as possible, since only his scientific peers will appreciate his contribution), then it is difficult to see that any other party will have a real interest in doing so. Conversely, the technologist devoting parttime to the monitoring of the research front will have available global developments at the front, and any further local effort on that front will be unlikely to contribute significantly to the movement of the front[12] or to the advance of technological knowledge.

3. Conclusion

Society (acting through the agency of government) may well be justified in encouraging the development of technological knowledge, simply because of the social benefits associated with that knowledge (which private parties will be only partially capable of capturing, and which it is inefficient to permit private parties to capture in any event); however, it is not clear by what mechanism society (government) can effectively intervene in this process. With reference to the creation of scientific knowledge the case for

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[12] This conclusion is only reinforced by the frequency with which a scientific discovery is made simultaneously by a number of widely separated individuals, i.e., if removing any given individual from work at the scientific frontier would have little or no real consequence, then it would certainly appear that adding an individual would be similarly inconsequential.

social (governmental) action is even weaker; only as an adjunct to action undertaken to facilitate technological knowledge can subvention of the creation of scientific knowledge possibly be justified.

As an explanation for regional economic disparities, technology, *per se*, and certainly science seem to offer very little. To the degree to which such disparities have technological explanations, these are almost inevitably related to more fundamental constraints on the interregional functioning of the global economy, and it is these constraints which should be the focus of policy concern.

DISCUSSIONS

Paper by S. Dresch

Discussion participants: R. Bolton, P. Joynt, A. Straszak, U. Loeser, L. Kajriukstis, S. Dresch.

Levely discussion centered around two issues:
How are regional problems and decisions delimited and formulated - are they substantially based or "merely" political?, and:
What is the link between science, education system etc. and technological and economic change?
With regard to the first question instances were quoted where regional problems arise in a natural way out of geographical and economic circumstances, waiting only for proper solutions, engaging also political structures. The cases quoted referred to riversheds and to geographico-economic East-West situation in South America, where large areas along the Western coast have much greater development capacity than is presently released, due to economic, but also political conditions.
As to the second question it was stated that the relations in question are of the necessary, but not sufficient condition type, so that simple reasoning can fail both ways. The situation is further made even more vague by the lack of clear definitions in the domain.

Paper by A. Mouwen and P. Nijkamp

Discussion participants: A. Straszak, R. Kulikowski, L. Lacko, S. Ikeda, A. Kochetkov, A. Mouwen.

This discussion, which to a large extent continued the themes of the paper itself and of discussion to the previous paper, focussed mainly on conditions and mechanisms of knowledge and technology transfer from science to production practice. Within this context social and spatial mobility of scientists, research centers and knowledge-intensive firms was assessed. Instances were quoted of large, scientifically self-sufficient firms moving out of bigger urban centers, with the small ones

moving in, for instance, to get closer to the research resources. On the other hand the example of Tsukuba was shown to indicate the real possibility of speeding up the regional development around a large scientific compound - by attracting businesses which could profit from cooperation. This development occurred over 15 years, and there is another one, chip-oriented, underway in Japan in the Kyushu region. Thus, while it was deemed important to secure the link between science and actual promotion, other conditions may play an important role, e.g. communication infrastructure or competitiveness. Experience from one place may not be fully transferable to another, and hence differences between the Dutch and the Swedich case. Knowledge-based development requires special orientation of investments - it was said that in the case of the Netherlands approx. 4% of GNP would be devoted R and D.

Paper by K. Polenske and Wm. Crown

Discussion participants: G. Bianchi, P. Joynt, K. Polenske.

The main question raised concerned the way in which the interregional coefficients can be obtained, since this was deemed to be far more difficult than for the technical coefficients. The procedure taken in the work presented started with trade tables, on which a balancing is performed. Then goals transportation data come in. Both these steps, however, do in fact still leave out some cells in the matrix. Hence, an expert-based range estimation is applied and final row and column balancing is performed. The whole procedure is implemented with two main computer programs MATHER and PASSION.

Paper by T. Vasko

Discussion participants: M. Steiner, A. Straszak, J. Owsiński, T. Vasko.

First, a clarification was asked for as to the meaning of information space. The answer consisted in statement that a general innovation is composed of simple innovations such as market innovation, product improvement etc., and that any simple innovation can hardly have an economic effect. Thus, innovations appear as compounds in the simple innovation space.

Then, a portion of discussion was devoted to identification of the logistic curves involved. Besides the very identification question, where the starting time-point was deemed of special importance, the problem of interplay of product values: exchange value, use value and production cost, was emphasized. Answering another question the speaker said that by looking at the innovations side he gets the idea that the new general economic upswing has had began by then, but that other analysts, e.g. C. Marchetti, see it coming in only about a decade.

Paper by R. Funck and J. Kowalski was not discussed since it was presented after the workshop.

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