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TOWARDS A MODEL OF TECHNICAL CHANGE AND REGIONAL ECONOMIC CHANGE

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Introduction

Regional change takes place through qualitative as well as quantitative changes. The quantitative transformations typically are the easiest to measure, by means of indicators such as employment, manufacturing output, income, or new investment which are used to monitor growth and decline in regional economic conditions. The qualitative changes, on the other hand, represent a more difficult to calibrate, but no less important, means for altering the structure of a regional economy. Stöhr [30] and Stöhr and Tödtling [31] suggest that short-term change is more often associated with quantitative indicators, whereas long-term economic development depends on structural and qualitative factors that concern socio-cultural and political-institutional variables. For example, some of these changes are social as well as economic, such as increases in educational attainment, female labor force participation, or the range of occupations available in a region. In addition, the linkage structure of interregional trade and information flows determines the relative status of a region vis-à-vis other regions. There are also more fuzzy, long-term changes that affect the "ethos" of a regional economy [10, 11]. Many of these short-term as well as long-term transformations are influenced by technological change. Some traditional factors studied as affecting regional change, such as infrastructure improvements and natural resource exploitation, may be interpreted as the outcomes of technological changes in other regions. More important regional transformations relate to the mix of quality of labor skills and of degree of technology embodied in capital within a region. A realistic consideration of these and related factors makes little use of standard neoclassical formulations, as Marris and Mueller [18], Nelson [21], and Rosegger [27] have pointed out.

To pursue the idea that technology is related to regional change, consider a variation on the familiar theme of regional industrial specialization and diversification. It has been common in regional research to posit that a mix of different industry types is a more desirable condition for a region than an overwhelming dominance or specialization in a single industrial sector. Diversification is thought to be particularly desirable as a means to withstand cyclical employment declines that affect different industries at different times. The argument falters, however, when it is recognized that employment loss is

* Associate Professor of Geography, University of Florida, Gainesville. The support of National Science Foundation Grant PRA-8019861 is appreciated. The paper has benefited from the comments of Jerald Barnard and Nancy Ettlinger. A preliminary version of the paper was presented at the Thirteenth Pittsburgh Modeling and Simulation Conference, April, 1982.

also likely (and perhaps more so) from a lack of competitiveness as it is from cyclical fluctuations [28].

The competitiveness of a region's industries is associated principally with innovative activity and the subsequent production of relatively new products and production of older products with best-practice technology. These conditions tend to prevail in regions which have the organized research and development (R&D) facilities of firms and the plants in which new products and processes are tried and improved. When a product or process involves standardized production methods, it no longer needs much technical attention and tends to be produced in large-volume production plants [35]. It is this production of standardized products that is especially vulnerable to both business cycles and competition from aggressive competitors. Abernathy et al. [1] point out the problems which technological competition, both product and process related, has had on the American auto industry. For a variety of reasons that Watts [36] has recently reviewed, branch plants are at a rather severe disadvantage in comparison with new-product related activities. In particular, they are unlikely to continue to produce competitively as the best-practice frontier and new-product developments advance.

The remainder of the paper outlines some elements of a model of regional change where firms' decisions regarding technology, products, and processes affect locations differently. The discussion applies principally to firms in manufacturing industries, but also to firms in information-oriented service industries where similar competition exists with respect to a rapidly changing service (product) mix and a persistent effort by firms to develop new services. Examples of such firms include those in data communications, computer software, and information-base services.

Technological Change, Firms, and Regions

In industry, the distinction between product and process R&D is critical. Product R&D is undertaken both to discover and exploit new products and to make often minor improvements in existing products in order to extend old markets or to enter new markets. Product R&D is where firms tend to concentrate their efforts, and most expenditure is for product improvements [20, 25]. Only new products, however, generally can be relied upon to provide new sources of employment, and new jobs in large numbers can be expected only from more radical innovations that have widespread application [28]. Even new products grow "mature" and competition begins to focus on cost of production and service [25]. The principal means of reducing costs is through rationalization of production, involving consolidation of production in fewer, more specialized plants that incorporate process innovations to make tasks more routine and to require less skill on the part of labor [4, 28, 35]. As international competition has become more significant, firms have tended to compete both on the basis of cost via rationalization of production and utilization of new technology as well as on the basis of product quality and differentiation (which involve both product and process R&D efforts) [1, 25]. The overall effect on employment has been a reduction in work-force that has

not been complemented by new-product related expansion [28]. (New service industry jobs are difficult to evaluate as substitutes, since they are usually filled by different groups of workers and they tend to pay less well.) The productivity gains afforded by employing fewer workers allow "jobless growth" to dominate recent economic change, especially in Europe [19, 28].

Regional considerations enter through the regional specialization that is present in all economies. Generally, administrative, technical and R&D work on new and improved products and processes takes place in large urban areas where firms' headquarters, support services, and worker amenities are found. If products are quite unstandardized, either because they are new or because they involve only small production volumes, production will take place at or near the source of technical skills [8]. On the other hand, when production can be standardized to take advantage of lower labor skills and costs, plants are dispersed away from large, high cost urban areas [4, 7, 9].

Regional Decline: The Flip Side of Growth**

The scenario above focuses, as does the extant literature, on growth and its mechanisms. Only rarely, but increasingly in recent years, has consideration of regional decline entered the literature outside a policy context. The preceding section suggests that manufacturing jobs are likely to drift away from regions which are unable to compete in either labor costs or new-product and process generation. Regions that do not possess either a highly skilled labor force essential to R&D or a competitive low-skill and low-wage labor pool are those most vulnerable in the face of current industrial change. Consequently, the traditional basic American industries — steel and autos — and some newer barometers of industrial success, such as chemicals and consumer electronic products (television, stereos, calculcators), are being exposed to greater international competition and are not faring well in all cases. Plant closures, corporate divestitures and diversification indicate the degree to which plants and firms fail to compete. The ultimate regional consequences of ongoing growth/decline depends largely on the mix of industries, firms, and activities found in a region. Some regions can "revitalize" themselves, as New England appears to have done; others may not possess the requisite ingredients for arresting decline, much less to turn it around.

To interpret these factors within a process of dynamic regional change requires addressing the complex outcomes of the decisions of a large number of firms whose decisions only occasionally coincide regarding product mix, capital investment, and production technology [27]. Such data at a spatially disaggregated scale are difficult to obtain, so it is too early to suggest that we can fully understand the processes at work. The next section of the paper attempts to outline some of the elements that might be included in a model of regional economic change with such corporate decisions. Although there is not space to extend the discussion to its sources in all cases, the reader may find relevant the reviews by Malecki [17], Nelson [21], and Thomas [32].

** I am grateful to Geoffrey Hewings for suggesting the inclusion of these ideas.

Elements of a Model of Regional Change and Technology

The basic framework of such a model is complex, because a large number of factors, directly or indirectly, ultimately influence regional change. The inputs to and outputs of technological change are the more conventional elements in the model. Inputs to technological change include financial allocations by government and industry for product and process R&D. For firms, the financial input represents a set of decisions concerning the product mix to be produced in the future and the set of production technologies (often embodied in capital equipment) with which to produce existing as well as new products. Different firm strategies may focus on newness and product differentiation as opposed to cost leadership, or on a combination of the two [25]. From a regional perspective, the critical decisions concern the locations: (a) where the R&D (whether product or process oriented) will take place, (b) where new or improved products will be produced, and (c) where new processes will be put into place and in what sequence. These decisions essentially determine the technological structure and potential of a region for an individual firm and often for its competitors as well.

The decision of R&D facility location is a major one, since R&D is unique in its reliance on skilled professional scientific and technical workers who are not a ubiquitous resource [2, 13]. Scientists and engineers prefer to live in attractive urban areas where the possibility of employment in other firms is present, and such preferences constrain corporate R&D locations [4, 13]. Large agglomerations of R&D, therefore, may attract other firms or generate new firm "spin-offs" as researchers utilize their knowledge in a new firm. See Pennings [24] for an attempt to find the urban area characteristics related to new firms. The corporate decisions regarding the nature and location of R&D workers to employ and the close connection of R&D with other corporate functions will determine the level of R&D capability in a given region. The concentration of R&D in relatively few places and the prevalence of headquarters — R&D site selection suggests that regional specialization in technical work is fairly inflexible in corporate perceptions [12].

The outputs or results of R&D have a range of regional implications. Basic scientific research may result in patented inventions without immediate transferability into new products. However, most R&D will be oriented toward marketable industrial and consumer products that provide firms with a portfolio of products of different ages and maturity. Product-mix decisions by firms also affect regions and their workers. New products, which are produced at relatively high cost and with considerable skilled labor inputs, must be produced near their R&D source rather than at isolated locations [29]. Similarly, improvements to production processes will tend to be made at these sites of first production. Few-of-a-kind production common in government-funded projects (space vehicles, breeder reactors, new weapons, etc.) also tend to have production closely related to R&D. As standardization is perfected and production volume increases, the skilled labor input needed decreases and lower-cost plant sites may be chosen. There is growing evidence in Britain, for example, that there are two nearly distinct sets of locations for (a) R&D and new product and process technology and (b) other

production that needs only unskilled labor [23, 34, 36]. The U.S. economy may be somewhat more complex, but similar regional economic distinctions appear to be present [4]. The regional impact of this locational discrimination by firms is that those regions with R&D activities and their workers tend to retain and attract further such activity, whereas regions without the necessary technical labor force rarely can achieve new product manufacturing or R&D.

A set of exogenous environmental factors that may both enhance the input side of technical change and serve as catalysts for the output side may also be identified (Table 1). These factors include those that result from corporate decisions and some that are more difficult to attribute to any particular decision but which represent the result of the cumulative decisions of many firms.

Table 1. Regional Environmental Factors Affecting The Impacts of Technology on Regions

Regional Industrial Mix
Regional Product-Cycle Mix (product maturity)
Regional Infrastructure (communications, transportation, business services)
Regional Capital Availability
Regional History of New-Firm Formation
Government R&D Activity in the Region

Corporate decisions regarding the products or services to be produced at given locations generate a surface of regional industrial mix and product mix. In addition to the traditional industrial mix, which indicates the degree of capital and skilled and unskilled labor in a region, it is important to characterize regions according to their mix of activities along the product life cycle [14]. Firms utilize some regions as R&D and new-product regions and others as branch plant locations, largely because of the availability or lack of technical workers. Although there is little long-term empirical evidence to date, these regional designations by firms may be difficult to change. On the other hand, they may be associated with regional life cycles of industries that counterbalance cumulative locational decisions [22]. In addition, the combination of industrial specialization and innovation activity makes even more specific the industries in which innovation is possible in a region; few areas are the locations of technological activity in a large number of industrial sectors [12, 13].

Among the catalysts important in regional technological change, infrastructures of communication, transportation, and business services combine to further the advantages of certain regions. City size or agglomeration economies are associated with higher levels of communication potential, transport accessibility, and business services. Goddard et al. [6] point out the often severe disadvantage faced by peripheral regions with respect to such infrastructure as advanced data communication networks, airline connections, and the location of accounting, legal, financial, and management

service firms. The relative advantage of large cities also tends to increase as new advances in these services take place, initially linking only major cities. Office functions of firms, including R&D and top-level decision making, are especially dependent on high levels of infrastucture. This maintains a significantly higher level of technological activity and new products and processes in such regions.

Two additional factors are interrelated in their channeling of technological change into regional economic change. These are the regional level of capital availability and the regional history of success among new firms, which are a major source of growth in informal models of urban growth [26, 33]. New firms as a source of employment tend to be involved in the production of new products and services or of existing types of products produced by more competitive methods, although not all new firms (especially in services) are necessarily technologically oriented. The growth of new firms depends in large part on their ability to find capital for expansion. Little rigorous empirical work has addressed regional variations in capital availability. However, a growing literature on venture capital suggests that such funds are regionally biased both toward large cities and toward regions and sectors where new firms have been successful in the past. (See Malecki [15 pp. 323-324] for a review of these studies. This cumulative agglomeration of new businesses has occurred in both microelectronics and biotechnology, especially in California, and seems to be occurring in computer software, a service industry that relies heavily on technical labor.

A final environmental factor affecting regional change is government-sponsored R&D activity. Since it tends to concentrate in a few sectors, in noncommercial applications, and in relatively few locations, the principal effect of such R&D appears to be in its contribution to regional agglomerations of technical workers [16]. In addition, spin-offs are far less common than from commercial R&D [5]. This represents a further enhancement of the input side of technological change, although its usefulness to commercial innovation seems to be limited in many cases.

Conclusions

A formal specification of the model sketched in this paper is premature, due to problems of data availability for variables such as infrastructure, capital availability, and the outcomes of corporate decisions. At a more general level, there appears to be a hierarchy of scales at which technological change is manifested, from the individual plant through the regional economy to the international economy [3, 37]. International competition defines world standards for price levels and product quality, and forces firms to make new product efforts and process improvements. As firms implement these changes in their product and process mixes, they take advantage of existing variations in regional environmental conditions that facilitate their corporate adjustments. Their decisions about what products to produce, and where and how to produce them, in turn generate a modified set of regional conditions for future decisions [19]. Finally, firms allocate product lines and processes

among plants even within a single region as well as among regions. The plants (and regions) that produce the most competitive products, because of either product characteristics or best-practice technology, will be those most able to maintain employment and wage levels in the face of competition from other firms at home and abroad. The challenge for regional science research is to begin to address — qualitatively and quantitatively — the complex regional economies that are the product of corporate decisions.

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