RESEARCH AND PRACTICE

Human Capital-Based Strategy for Regional Economic Development

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Regional policy makers have always wrestled in vain to come up with regional economic development policies that are coherent and uniform and can be defended on economic grounds. However, most policies are either ad hoc or based on political considerations. The relevant literature dealing with regional economic development strategies is fragmented. It also does not provide any guidance to formulate an overall long-term strategy based on an integrated analytical foundation. It incorporates elements like entrepreneurship, human capital, workplace training, capital accumulation, R&D effort, innovations, technology, and technological cycles. This article proposes a human capital accumulation strategy for regional economic development that not only integrates the above diverse elements of the literature into a cohesive analytical framework but also provides the rationale for it to be part of a long-term policy for economic development on efficiency grounds.

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OBJECTIVE AND MOTIVATION

This article attempts to establish that a viable and promising long-term strategy for regional economic development is the accumulation and promotion of human capital. I demonstrate that human capital, which is the source of knowledge (a quasi-public good) and hence technical change, overcomes the limitations imposed on growth by diminishing returns to other inputs like labor and capital. In addition, human capital is shown to promote growth and development through significant externalities of knowledge stock by increasing the productivity of labor and capital, by providing the pool for the emergence of entrepreneurs who implement and diffuse inventions and innovations, and by promoting agglomeration of mature and growth firms and encouraging quality over quantity of children as fertility rates decline.

I also advance the argument that policy intervention for promoting human capital, as opposed to private physical capital, can be defended on efficiency grounds. In fact, it would become obvious that policies that involve the use of public resources to subsidize capital stock are shortsighted and represent misallocation of resources. It is also proposed that such a strategy has a greater chance of success if it is accompanied by the implementation of a complementary strategy to develop

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amenities (location-specific quasi-public goods) in the region. However, because the discussion on the role of amenities is beyond the scope of this article, those who are interested in this line of inquiry may consult Mathur (1998).

The diverse literature on innovations, technology, R&D effort, human capital, and entrepreneurship advances ideas pertaining to economic development, but none of those ideas by themselves provides a uniform and integrated analytical foundation for an overall regional economic development strategy. The proposed development strategy fills this gap, as it tends to integrate different strands of thoughts from the literature and is based on a uniform, cohesive, and analytical framework. There is also a lack of discussion in the literature on the transmission mechanism of human capital on regional growth and development. Barro (1992) does go into some details of the mechanism in his intercountry study. I will elaborate and modify that mechanism to make it relevant in the regional context and explore and emphasize certain mechanisms that are more relevant to regions. A regional economy that is relatively more open than a national economy offers different challenges to researchers and policy makers.

My interest, in this article, is not in the evolutionary theories of growth, in which the region goes through different stages of growth. As Douglas North (1970) appropriately points out, such theories neither describe the process of growth in America nor explain the causes of growth. I also do not wish to pursue the issue of interregional transmission of growth through the "growth poles" of Perroux (1970), the nature of the growth and development process, whether it is balanced growth of Ragnar Nurkse's (1953) variety or the unbalanced growth of Hirschman's (1958) variety.

My plan is to define economic development in Section 2, followed by a discussion of the human capital-based strategy of economic development in Section 3 and policy implications and conclusions in Section 4 of this article.

DEFINING ECONOMIC DEVELOPMENT

In the literature, there does not appear to be consensus among various investigators as to the meaning of economic development. In the literature, growth in per capita income, change in wealth, change in employment, change in both population and employment, and growth in "business" (which is, itself, an ambiguous term) are all considered to be part of the notion of economic development. The lack of precise meaning is reflected in the definition provided by the American Economic Development Council. It defines economic development as the process of creating wealth through the use of all resources (Bingham, Hill, & White, 1990, p. 7). First, this definition is vague and imprecise, because the concept of wealth is not clarified. For example, should it include capital or human capital or monetary assets, or all of them? The imprecision and measurement problems do not provide any guidance for the policy makers to gauge the effectiveness of different policies. Second, if accumulation of wealth implies accumulation of real capital, such a process cannot be sustained in the long run due to the diminishing returns to capital. Third, the focus on wealth creation ignores the distributional aspect of economic development. It sidesteps the issue of economic "well-being" of the people. I recognize that opinions differ in regard to the definition of economic development. However, for my purposes, I define it as a change in employment and/or per capita income that is self-sustained.

[Economic development is] a change in employment and/or per capita income that is self-sustained . . . [and in] the labor market, economic development requires continuous displacement of equilibrium employment.

In the labor market, economic development requires continuous displacement of equilibrium employment. The displacement acquires momentum on its own within the region rather than requiring continuous shocks from outside in subsequent phases of development. This is what Schumpeter has in mind when he states that "by 'development' therefore, we shall understand only such changes in economic life as are not forced upon it from without but rise by its own initiative from within" (quoted in Higgins, 1968, p. 93). This description by Schumpeter does not rule out the conditions and the climate policy makers may create directly or indirectly for economic development to occur. Now the questions are, what drives the process of regional economic development? What strategy makes employment and/or per capita income grow and sustain itself in the region? What role could policy makers play in economic development? I attempt to answer these questions in the subsequent sections of this article.

HUMAN CAPITAL AND REGIONAL DEVELOPMENT

Definition and the Nature of Knowledge Production

The modern theory of endogenous economic growth provides the basis of our new approach to regional employment growth. The central idea is that, for a region to grow in employment and per capita income, it must save and invest in human resources to accumulate human capital. Human capital is an accumulated stock of skills and talents, and it manifests itself in the educated and skilled workforce in the region. It could be measured as person-years of education. The stock of human capital can be increased through formal and informal education and/or on-the-job training of labor. Human capital, although itself produced by human capital and labor, is a significant input in the production of knowledge or ideas. I will use the terms *technology*, *knowledge*, *invention*, *innovation*, and *ideas* interchangeably throughout this article.

Knowledge could be embodied in human beings or capital goods, with one difference—that human beings with knowledge produce more knowledge. It could also be disembodied in the form of general principles. It is the *nonrival* and *nonexcludable* component of knowledge that results in spillover effects. A nonrival good is that good whose use by a firm does not preclude or diminish its use by others. It is nonexcludable when a firm or an economic agent cannot prevent its use by others without incurring substantial cost relative to the value of the good (see Romer, 1990a, pp. 97-99; 1990b, pp. S74-S75 for details). Because the nonrival and nonexcludable portion of knowledge is the source of spillover effects, a discrepancy arises between private and social benefits. Hence, the rewards to economic agents fall short of the social returns, thus providing the disincentive to accumulate the optimum amount of human capital stock. This is the reason the role of policy maker becomes crucial in correcting for the disincentives in the market. Also, if all knowledge is a nonrival good, it can be accumulated on a per capita basis without bounds. Its use with other inputs like capital and labor overcomes the limitations imposed by diminishing returns to these inputs in production. The knowledge does not die with the person who creates the knowledge. However, even though knowledge has significant spillover effects, it is partially excludable and nonrival due to the patent laws and the preventive actions of firms. Therefore, firms that possess knowledge are able to appropriate a significant portion of the rents as a result of increased productivity. This is the reason firms invest in R&D activity. Since 1980 in the United States, industry R&D expenditure as a proportion of gross domestic product (GDP) has surpassed the proportion of the federal government's expenditure (Stephan, 1996, Table 3). In 1993, industry R&D expenditure was 52% of the total R&D expenditure, and in 1991, industry employed 4.7 times more doctoral scientists than did the federal government (Stephan, 1996, pp. 1212-1213).

Neoclassical and Modern Theory of Growth

Before I present human capital's role in regional economic development, it is instructive to discuss briefly the neoclassical and modern theories of growth. Such a discussion will put this strategy of regional development into perspective.

In the neoclassical theory of economic growth, as advanced by Solow (1956), aggregate output of a region or a country is a function of labor, capital, and exogenously given technology. Following the usual assumptions of constant returns to scale, hence diminishing returns to both labor and capital and competitive markets, the growth rate of per capita output will decline as more and more capital is added per worker. In fact, increasing amounts of capital per worker would be giving less and less additional output, unless there is a continuous technological improvement to cause the productivity of labor to rise over time. In such a scenario, the growth rate of output in the long run (steady state) is independent of savings and investment and instead is driven by exogenous technological change.

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The most significant criticism of the neoclassical growth theory is that it provides no explanation for the source of technological change, even though it is the only source of long-run growth. As Plosser (1992) states, technology is not determined by the model: "The theory provides no framework for understanding the economic forces and policies that influence the most important source

of growth" (p. 66). Hence, the model provides no guidance to policy makers. Another implication of the neoclassical model, which is not supported by empirical evidence, is that capital-poor regions will grow faster than capital-rich regions because the returns to capital in the poor regions will be higher than the returns in the rich regions. The intention here is not to focus on the convergence issue but to present the case for a strategy for regional economic development based on the development and promotion of human capital stock.

Evidence on the sources of regional growth or decline in the regions of the United States within the neoclassical framework is mixed. For example, Beeson (1996, pp. 84-85), who does not incorporate human capital in her empirical work, finds that from 1959 through 1978, a lower rate of capital accumulation was the major source of relative decline in the growth rate of manufacturing value added in a sample of large standard metropolitan statistical areas (SMSAs). However, the changes in the relative growth rate of value added are primarily related to the changes in the relative growth rates of labor and productivity (exogenous technological change) as opposed to capital accumulation.

Human Capital and Modern Growth Theory

The modern theory of endogenous growth is built on the ideas first advanced by Theodore Schultz (1961) and later by Gary Becker (1964). However, Becker primarily focuses on firms' and workers' behavior regarding the investment in human capital and the methodology to estimate rates of return and human capital rather than on the role of human capital in economic growth and development. Schultz discusses some fundamental issues relating to the importance of human capital in the U.S. economic growth. Schultz contends that the U.S. economic growth till the 1960s cannot be explained fully by the growth of resources (labor, land, and capital) because the income was growing faster than the growth of the resources. Referring to the residual growth (known as the Solow residual), not accounted for by the growth of the resources, Schultz states that "to call this discrepancy a measure of 'resource productivity' gives a name to our ignorance but does not dispel it" (p. 6). The modern growth theorists, like Lucas (1988) and Romer (1990b, 1990c), have taken up Schultz's challenge and attempt to explain the Solow residual.

There are many endogenous growth models that fit the general rubric of the modern growth theory; however, our focus is on human capital-based theories of the Lucas (1988) and Romer (1990c) variety. In these models, in addition to capital and labor (unskilled), human capital enters as a distinct input in the production function of the economy. In the Lucas model, human capital has "internal productivity effect" as well as "external productivity effect." An individual's human capital increases not only his or her own productivity but also the productivity of other workers with any given skill level. Therefore, in the presence of this externality effect, the growth rate will be higher in those regions that invest more to accumulate human capital. However, as I have alluded earlier, these spillover effects also create disincentives to economic agents to accumulate an optimum amount of stock. Therefore, a region will face slower growth in the absence of policy intervention to restore the incentives.

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The Romer model (1990b, 1990c) is similar to that of Lucas (1988) except with one major difference: In Romer, the source of externality is the stock of knowledge. Growth of knowledge depends on human capital and on the stock of knowledge. Because all knowledge cannot be kept completely secret, productivity of human capital in knowledge production will be greater the larger the stock of knowledge. For example, the current breakthroughs in genetic research are not only the result of dedicated scientists engaged in such research but also are due to the wealth of accumulated information and knowledge since the discovery of the DNA structure in 1953 by James Watson and Francis Crick. Romer (1990c) shows that, in a balanced growth equilibrium (steady state) in which the rate of growth of knowledge is the same as the rate of growth of output, a rise in human capital stock at a given interest rate will increase human capital stock devoted to knowledge production, thus providing the stimulus to growth in output. Therefore, even in the extreme case in which all regions have access to the same stock of knowledge (no secrets at all), regions with a larger stock of human capital will produce a higher growth of knowledge—and, consequently, higher growth rate of output. Moreover, if knowledge is also embodied in capital (which is generally the case),

efficient use of accumulating capital would require increasing amounts of human capital stock. In this framework, endogenous knowledge accumulation also increases the productivity of capital through time and thus sustains investment in capital goods in the steady state. However, as opposed to human capital, rewards to capital can be fully appropriated in the market.

Human capital should not be confused with augmented labor measured in efficiency units. For example, if one unit of (unskilled) labor with one unit of skill is twice as productive as a unit of unskilled labor, we then have two efficiency units of labor, which are equivalent to two units of unskilled labor. However, a larger economy with a larger endowment of unskilled labor may not grow faster than a relatively smaller economy with a larger endowment of skilled labor (see Grossman & Helpman, 1993, pp. 130-135). Because R&D activity is human-capital intensive as compared to non-R&D activity, the well-known Rybczynski (1955) theorem, applicable to two sector models of trade, demonstrates that an economy with relatively abundant human capital as compared to labor would produce more R&D relative to the output of non-R&D activity. Given that technology overcomes the diminishing returns to capital and labor and gives rise to significant externalities, such an economy would be expected to grow faster in the long run than another economy with less human capital. In fact, there is evidence at the industry level (Griliches & Lichtenberg, 1984) and at the firm level (Lichtenberg & Siegal, 1991) regarding the significant positive relationship between R&D intensity and the growth in productivity.

A larger human capital stock also allows more efficiency in knowledge generation; hence, we would expect increasing returns to scale in the R&D production. It is observed (Bartel, 1994, pp. 123-124) that technologically progressive industries (as measured by the mean rate of technological change) are likely to provide more training to the workers than are industries that are not technologically advanced. Bartel (1994) also finds that most workplace training is concentrated among the most educated workers, implying that training resources flow to the most valued uses. Thus, the human capital-based modern growth theory provides a sound basis for a regional economic development strategy. The following discussion explores the transmission mechanism of human capital to regional economic development in more detail.

Transmission Mechanism in a Region

At this time, I assume that there are no interregional spillover effects of human capital accumulation. I relax this assumption in my later discussion. The transmission channels through which human capital affects the regional economy are both direct and indirect. The direct channels are technological change and innovations, entrepreneurship to implement inventions and innovations, and the diffusion of inventions and innovations. The indirect channels are spillover effects of dynamic localization economies and urbanization economies, capital accumulation, lower fertility rate, and a positive feedback loop consisting of human capital, technology, and entrepreneurship.

Direct Channels

As alluded to above, one of the most important ways human capital affects growth and economic development is that it stimulates technological progress (growth of knowledge). Technological progress in the broadest sense not only includes breakthrough technologies, like the invention of a light bulb, a microchip, and a software program such as MS-DOS, but also innovations like just-in-time inventory control, decentralized organizational structure, new products, new uses of existing products, and the Internet. Human capital also facilitates the application of technology, which Schumpeter (see Higgins, 1968, p. 91) calls innovation. Without the application of knowledge, the region cannot realize the benefits of that knowledge. A specific example of innovation is use of the product called Arm and Hammer baking soda (NaHCO3) in a variety of new applications. The Church and Dwight Co. has found new uses for this old product in areas like cleaning printed circuit boards, cleaning municipal water supplies, and blasting of walls and buildings (“No Product,” 1992, p. 95). The highest concentration of innovations is found in the Pacific region (California, Oregon, and Washington) and the Mid-Atlantic region (New York, New Jersey, and

Pennsylvania) (see Audretsch & Feldman, 1996), and these are the same regions that have the highest percentages of college graduates (Heckman, Layne-Farrar, & Todd, 1996).

Human capital creates a body of specific and general knowledge that contributes to productivity directly and indirectly due to spillover effects. The specific knowledge, which is transferable at a positive price, is embodied in individuals; those who possess that specific knowledge or skill are more productive than those who do not possess the specific knowledge. But the general knowledge (explicit or implicit) could be used by one individual or firm without diminishing its use by others. Even though the public nature of knowledge can be found in almost all types of knowledge, some types are more excludable than others in terms of their exclusion costs. The availability of a larger pool of general knowledge stock makes human capital more productive, not only in the production of consumption and capital goods but also in the production of R&D.

Knowledge also goes through the evolutionary process of refinement and enhancement as it is being transferred from one individual to another or one generation to the next. The interactive and cumulative aspects of knowledge accumulation have a duplicative effect on the output of an economy. Lucas (1988) calls the process of human capital accumulation a "social activity" (p. 19). These attributes summarize the reasons for nondiminishing returns to human capital accumulation, hence continual output and employment growth. The magnitude of spillover effects depends on the interaction of various inputs with human capital. For the United States, Lucas provides a rough estimate of productivity effects of spillovers. For each 10% increase in spillover effects of human capital, the U.S. output would rise by 4.17%. Another significant piece of evidence is provided in the simulation study by Bayoumi, Coe, and Helpman (1996). Assume that the United States increases its R&D expenditure by one half of 1% of GDP and maintains the R&D expenditure-to-GDP ratio thereafter. Under certain assumptions, like open trade links and a stable price level, their simulations show that the U.S. potential real output rises by about 9% above the baseline year of 1996 after 80 years. The output increases by more than 3% in other industrial countries (part of the Group of Seven [G-7]) and 4% in developing countries above the baseline due to the increase in the U.S. R&D investment, as outlined above. However, they also find that the growth in potential output in the United States is approximately 14.8% above the baseline after 80 years, when each G-7 country increases R&D investment of the above magnitude under the same assumptions.

The estimates obtained by Rauch (1993) for SMSAs of the United States also confirm the presence of significant spillovers. Rauch shows that an additional year of education beyond the SMSA average increases the total factor productivity (Solow residual) by 2.8%, and the social return is approximately 1.7 times the private return to schooling. At the regional level, the effect is expected to be larger, because in a subnational economy, we expect a greater degree of interaction among regions through trade and migration. In addition, we expect a greater exchange of ideas and knowledge among people with diverse skills and knowledge base in a region. Firms in a region stand to gain in enhanced productivity due to the exchange of ideas and knowledge outside the firms, but also inside the firms, if they are able to harness those ideas. Increasingly, firms are recognizing the potential productivity effects of what many businesses call "knowledge capital" by appointing knowledge officers in charge of coordinating bodies of knowledge within the corporation and developing knowledge databases. For example, Raymond Corporation, a high-tech forklift company, solved the repair problem of its advanced forklifts by creating a knowledge bank, a kind of corporate "Internet," in which employees can participate in an exchange of ideas ("Front Lines," 1996, p. B1). Using national establishment data of private establishments with more than 20 employees, Black and Lynch (1996) found that a 10% increase in average education in an establishment raises business productivity by 8.5% in manufacturing and 12.7% in nonmanufacturing.

At the state level, Ciccone and Hall (1996) estimate that the elasticity of output per worker with respect to education is 1.5, and the elasticity of labor efficiency with respect to education is 1.2 at the county level. In addition, a doubling of employment density (a proxy measure of spillover effect) at the county level increases the labor productivity by 6% and total factor productivity by 4% at the state level (p. 62). It must be noted, however, that the gains in productivity will be larger when the invention or innovation is increasingly diffused as it spreads and is adopted throughout the whole economy. I take up the technology diffusion issue later in this article.

The stock of knowledge, in itself, is not sufficient to generate growth and development. To realize the economic potential of inventions and/or innovations, Schumpeterian entrepreneurs have to emerge in a region. But the emergence of entrepreneurs is closely tied to human capital stock. People with knowledge, ideas, and skills provide the pool from which innovators and entrepreneurs emerge. However, entrepreneurship should not be confused with human capital. An entrepreneur is a risk taker whose reward, following Irving Fisher, cannot be insured. We have examples in Bill Gates and Paul Allen, who not only had knowledge and ideas but took the risk in starting the Microsoft Corporation, which began as a partnership in 1975. Entrepreneurs seize opportunities and apply knowledge. These entrepreneurs provide the link between inventions and innovations and the implementation and diffusion of those inventions and innovations. The transition from access to the stock of inventions and innovations to their adoption in productive use is not as automatic as one is sometimes led to believe in aggregative growth and development models.

For the entrepreneurs to emerge in a region and engage in productive activities that enhance society's well-being, there must exist a reward structure that provides the incentives to such entrepreneurial activities. A reward structure is needed to carry ideas from research labs to manufacturing and/or marketing and eventually to the customers. Otherwise, even bright ideas may face a quiet death in the research labs. Baumol (1990) would argue that, if entrepreneurs are ingenious and creative persons and are interested in pursuing those actions that enhance their wealth and power, it is quite plausible to imagine they may engage in activities that may add nothing to the social product but may even have a negative impact on the economy. Baumol remarks that "at times the entrepreneur may even lead a parasitical existence that is actually damaging to the economy" (p. 894). The prime determinants of entrepreneurial behavior at any time and place are the prevailing "rules of the game" that govern the payoffs for one entrepreneurial activity relative to another. The lack of appropriate reward structure and rules of the game, Baumol argues, was the reason the Romans, who were so inventive, could not make productive successes out of their inventions and innovations. However, in the later part of the Middle Ages, the paucity of innovations and inventions was not a deterrent to a widespread exploitation of innovations and inventions to enhance power and wealth. Similarly, in imperial China, the rules of the game favored Confucian philosophy and calligraphy but were biased against the acquisition of wealth and the promotion of enterprises (see Baumol, 1990).

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Baumol (1990) points out that Schumpeter did not concern himself with the allocation of entrepreneurial resources into productive and unproductive activities, even though this allocation crucially determines the social output, and "It is the set of rules and not the supply of entrepreneurs . . . that undergoes significant changes from one period to another and helps to dictate the ultimate effect on the economy via the allocation of entrepreneurial resources" (p. 894). Schumpeter did realize the importance of social, economic, legal, and political environment in the development of entrepreneurial activity, but he did not visualize the significant role played by the incentive system in the allocation of entrepreneurial resources among different activities so that it promotes growth in social output. Any regulation and/or tax schemes that disrupt the signaling effects of incentives on the formation and location of firms and on productive entrepreneurial activities will be counterproductive.

Mancur Olson (1996) advances an argument similar to that of Baumol (1990) while examining the issue of inequality in the wealth of nations. To Olson, the "only plausible explanation is that great differences in the wealth of nations are mainly due to differences in the quality of their institutions and economic policies" (p. 10). For example, the change from "cost plus" contracts, which guaranteed fixed profit margins, to competitive bidding by the firms in the United Kingdom (initiated by the Ministry of Defense in Great Britain in recent years) has meant that Britain is becoming a place of inventions and innovations outside the defense sector and a place of successful application of those technologies in the private sector ("Sowing a Hightech Crop," 1996). Within the overall institutional framework of property rights and their enforcement in a country, regional variation in human capital formation, inventions, innovations, and, consequently, development activity would be significantly influenced by the structure of economic incentives and policies of the regions.

The process of adoption and implementation of new knowledge (technology diffusion) takes time and is punctuated by a series of related innovations before it has a significant effect on productivity.

The process of adoption and implementation of new knowledge (technology diffusion) takes time and is punctuated by a series of related innovations before it has a significant effect on productivity. For example, converting electricity to practical uses in 1880 did not have much impact till the 1920s, when the factory system was completely reorganized to adapt to the new invention. Once it was adopted in the manufacturing processes, the growth rate of the U.S. economy, which was about 0.3% to 0.5%, jumped to 5% throughout the 1920s ("The Productivity Payoff Arrives," 1994). Similarly, although Charles Goodyear invented vulcanization in 1839—a process that makes natural rubber impermeable to temperature changes—its economic impact is still being felt today. It took 49 years before John Dunlop invented the inflatable tire and another 80 years before Michelin invented radial tires. Radials accounted for 95% of U.S. sales in 1993 ("The Rubber Industry's Biological Nightmare" 1997). An outstanding recent example of the diffusion process can be found in the software invention and the initial licensing of Q-DOS (the PC operating system) to IBM in 1980. It led to the development of MS-DOS (loaded on the first IBM PC in 1981), which has revolutionized the PC software industry and helped spawn other information-based industries, such as the Internet. The effects of this technology are continually being felt, as faster and more powerful microprocessors cause the price-power ratio to fall, and easier, consumer-friendly, sophisticated software continually lowers the technology barriers to individuals and businesses ("Software Struggle," 1995).

The above instances of inventions and their diffusion process point out that the full economic impact of an invention takes a long time and is cumulative. Hence, any commitment of support to basic R&D must take the long view. The long-term nature of the technology diffusion process adds to uncertainty—an added reason for market failure—and provides further justification for policy intervention to ensure optimal levels of R&D.

Indirect Channels

Human capital also contributes indirectly to productivity growth and employment. Among the indirect effects of human capital accumulation are the expanded knowledge base, skills, and talents of other workers. As has been discussed above, the social aspects of human capital accumulation, characterized as spillover effects, generate an expanded knowledge base through time in those regions that have a large initial stock of human capital. Here, I wish to explore the relationship between spillovers and agglomeration of firms in a region. These spillover effects in one sense contribute to the multiple expansion of the initial knowledge base—a kind of knowledge multiplier effect. Some of these spillover effects are industry specific, hence provide incentives to firms to locate near similar firms to realize *dynamic localization economies*, also labeled by some as *MAR* (Marshall-Arrow-Romer) *externalities* (Henderson, Kuncoro, & Turner, 1995). Some are *urbanization economies* or Jane Jacobs externalities, which are generic in nature. Larger areas offer, for example, diverse labor skills, labor supply available at different times of the day, a developed infrastructure of facilities, and public and private services.

The empirical work of Henderson et al. (1995) shows that mature industries tend to be attracted to cities due to MAR externalities. Historical concentration of firms in different industries and the associated knowledge base provide the lure to mature firms in those industries, whereas the location of new firms in growth industries is encouraged by *dynamic urbanization economies*—a result of diversified industry and skill base. Historically, the rise of Detroit as the automobile production center from the initial startup Olds in 1899 is a testimony to the workings of localization and urbanization economies. The shipbuilding industry in Michigan facilitated the conversion of the steam engine to the gasoline-powered boat engine. The boat engine was easily adaptable to the automobile engine. The knowledge base in this technology existed as Olds produced the boat engines, Leland made parts, and the repair work was done by Dodge and Ford. This concentration of skills and firms was supported by skilled workers and venture capitalists, as well as by other industries like steel, machine tools, and carriage production. The combination of reinforcing forces produced the innovation climate for the emergence of the automobile industry, which has dominated not only the region but also the country (for details, see McDonald, 1997, p. 362). The short

history of Silicon Valley in California and the concentration of the software industry is testimony to the operation of similar forces.

It must be emphasized that, because human capital is instrumental in product innovations as well as process innovations, it not only facilitates the emergence of new firms but also sustains the profitability of mature firms that are primarily concerned with cost-cutting (see Klepper, 1996). In addition, firms headed by more educated entrepreneurs survive the longest (Bates, 1990). Thus, the mix of small but high-growth firms and large, mature firms in a region ensures growth with stability.

Lucas (1988) theoretically demonstrates a positive relationship between human capital accumulation and physical capital accumulation. Barro (1992, p. 212) tends to confirm this positive association in his cross-section country study. The complementary nature of capital (physical) and human capital, the idea that diminishing returns to capital can be overcome only by technical change engendered by human capital, and the notion that human capital and not capital is the source of the spillover effects reveal the folly of the often-pursued public policy of subsidization of physical capital. Incentives should be directed at the accumulation of human capital, and the physical capital accumulation would follow through the workings of the market forces. Daly, Gorman, Lenjosek, MacNevin, and Phiriyapreunt (1993) demonstrate that the investment tax credit program in Cape Breton, Canada, adopted to stimulate employment in manufacturing, was not an efficient strategy to create jobs. They calculated that the tax cost of such a subsidy was approximately $477,000 per job, which amounts to a perpetual subsidy of $33,000 at 7% discount rate (p. 571). Tannenwald (1996) also finds no significant relationship between interstate differences in the "business tax" climate and the allocation of capital spending in manufacturing industries, thus further pointing out the misguided efforts of states to subsidize physical capital. A redirection of those resources toward human capital formation and basic R&D holds greater promise in the economic development of a region.

The complementary nature of capital (physical) and human capital, the idea that diminishing returns to capital can be overcome only by technical change engendered by human capital, and the notion that human capital and not capital is the source of the spillover effects reveal the folly of the often-pursued public policy of subsidization of physical capital.

In country studies, human capital accumulation is also linked to lower fertility rates, hence increased productivity (Barro, 1992, p. 212), thus providing another channel for growth and development. A region with higher human capital would have higher income, hence higher opportunity cost of time. Because raising children is a time-intensive activity, one would expect fewer children per family in such regions. In fact, since 1960, women's labor force participation rates and wages are rising, and the birth rate for women ages 15 to 44 is declining. More educated households would devote more time and invest more resources per child for more quality in small families, thereby contributing further to the accumulation of human capital. In addition, human capital accumulation produces an intergenerational externality, in which a higher knowledge base of one generation contributes to furthering the knowledge base of succeeding generations.

The above discussion of different channels of the transmission mechanisms will be incomplete if it is not recognized that they are interlinked—especially with the nexus of human capital, technology, and entrepreneurship—as they feed on each other. For example, it is found that, even after controlling for plant, industry, and location characteristics, proximity to other users of advanced technologies is associated with higher rates of adoption of new technologies by manufacturing establishments (Fuhrer & Little, 1996, p. 18). The proximity effect in technology diffusion is also reflecting the presence of a skilled workforce. These feedback loops are self-reinforcing in the development process. However, the development process, which is a dynamic equilibrium process, is also accompanied by congestion in the generic sense. The congestion effects, as opposed to amenities' effects, are modulating factors in the process of growth and development.

Human Capital Accumulation With Interregional Spillovers

So far, I have argued for a human capital-based developmental strategy in a region, in which all the benefits of investment in human resources stay within the region. However, given that a regional economy is much more open than that of a country, it could be argued that the benefits of such investment may dissipate through the movement of goods and people between regions. This argument acquires significance in the regional context because people with education and skills are

most likely to migrate between regions (Borjas, Bronars, & Terjo, 1992). However, even in the absence of substantial interregional migration of an educated workforce, the advancement of information technology may increase knowledge leaks and thus may diminish the incentive to save and invest in human capital in a region and, consequently, may result in underinvestment in regional human resources. Therefore, the question arises, how significant are the interregional spillovers of human capital that could discourage regions to undertake and commit to such an investment strategy to any significant degree?

There are factors, however, that work against the disincentives created by interregional spillover effects of human capital. Because human capital accumulation is a social activity, the spillover benefits within a region will be greater than between regions, as we expect more intraregional as opposed to interregional interaction between people and firms. Also, people with different and varied knowledge, skills, and talents tend to cluster to benefit from the tacit or implicit knowledge base of a region. All knowledge cannot be made explicit or codified, and even the part that could be put on paper (explicit knowledge) may have many details missing that can be filled only by having face-to-face contact. Hirotaka Takeuchi of Hitotsubashi University, Japan, notes that knowledge creation requires the marriage of implicit and explicit knowledge ("Hot Products," 1996). He highlights the interplay of implicit and explicit knowledge by the example of the automatic bread maker developed by Matsushita Electric Co. of Japan. Before developing the product, the company sent a software engineer and a team of experts to the bakery to observe the baker making the bread with all the twisting motions before writing down complete specifications (creating explicit knowledge) for the machine. The development of the quality bread maker, according to Professor Takeuchi, changed the image of the company from a *maneshita* (a copycat) to an innovator.

In addition to the advantages of face-to-face contact that proximity provides, there are other reasons for knowledge concentration. Because there are economies not only in the generation of specific knowledge and skills but also in the generation of generic but varied knowledge and skills, it is cost-effective to cluster. Grossman and Helpman (1993) also provide a convincing explanation as to why a region's incentive to innovate need not diminish when regions compete in the market for differentiated products. The incentive still remains even when one region innovates and the other imitates. The competition from the firms in the imitating regions may thin out firms in the innovating regions by diminishing their monopoly power, hence profits. However, the profits of the firms that survive in the innovating regions would increase, thus providing incentives to those firms to innovate. Therefore, a strategy to accumulate human capital, even in an open and competitive economy, would have significant payoffs to a region in the long run. In fact, as has already been mentioned, simulations at the country level by Bayoumi, Coe, and Helpman (1996) show that the United States, a highly open economy, tends to retain most of the benefits of its R&D expenditures.

At the regional level, there is another significant piece of evidence that supports my argument. Audretsch and Feldman (1996, pp. 631-633) examine the determinants of innovation concentration across states using innovation data by four-digit standard industrial classification (SIC) industries for the year 1982. They find that commercial innovations occur mostly in California, followed by New York, New Jersey, and Massachusetts. Also, the share of innovations in the most innovative industries (like computers, process control instruments, and semiconductors) is concentrated in the states of California, New York, New Jersey, and Massachusetts. Furthermore, the authors' regression model demonstrates that industry R&D expenditure-to-sales ratio and the ratio of skilled labor to employment are two of the most significant variables in promoting clustering of innovations. Both of these variables are also highly significant in encouraging production concentration. These findings suggest that knowledge spillovers, as proxied by the R&D-to-sales ratio, are primarily internal to the region. Another line of evidence tends to reinforce the above argument. Irwin and Klenow (1994), in their study of knowledge spillovers in the semiconductor industry, find that most of the benefits of "learning by doing" are appropriated by firms. However, there are substantial spillovers from the "rest of the world" to each firm. Hence, we should expect clustering in the industry and the concentration of inventions and innovations in space.

There are other reasons for a region to invest and accumulate human capital. I have stated elsewhere in this article that human capital formation tends to accompany physical capital formation. Physical capital formation in growth industries spawned by inventions and innovations will carry

over to matured industries as well if sufficient labor supply at attractive wages is available and infrastructure is in place to provide support services to those industries. Henderson (1988) shows in his cross-section empirical work on U.S. cities that unskilled labor tends to be attracted to areas with more skilled labor. Therefore, regional growth spearheaded by human capital accumulation would not be thwarted by the lack of labor supply. In addition, a larger human capital stock in a region will tend to generate more Schumpeterian entrepreneurs and thus more "new business" startups, which would have "first mover" advantage in interregional competition. Carlton's (1997) empirical work demonstrates that a larger technical labor force in a sample of U.S. SMSAs significantly increases the births of new firms as well as branch plants in technologically sophisticated industries. Even high wages accompanying human capital formation would not discourage the location of firms because in such regions, productivity would be rising faster than wages, thereby reducing the marginal cost to the firms. Nakosteen and Zimmer (1987) do not find out-migration of firms from high-wage states. In fact, higher wages are associated with more retention of firms, implying that a rise in wages is accompanied by a rise in productivity in those regions. In addition, earlier entrant firms tend to be larger and survive the longest (Klepper, 1996). Such regions would therefore ensure the future propagation of industrial concentration and maintenance of comparative advantage, even in the so-called mature industries. I do not expect the leadership position of California in entertainment, New York in publishing and fashion, and the Midwest in automobile industries to disappear in the foreseeable future.

Finally, because skilled and educated workers are the sources of technological progress and knowledge externalities, clustering of human capital will also tend to attract venture capital and promote venture investment in high-tech growth industries. Florida and Smith (1992) find a significant positive relationship between supply of venture capital, venture capital investment, and concentrations of high-tech firms. In 1995, 70% of the U.S. venture investment went to technology firms ("A Really Big Adventure," 1997). Boosters of regional economic development must recognize that it is the development of human capital stock that attracts venture capital, not the other way around. It is not surprising to find that a select group of about 300 venture capital firms are behind the emergence of some of the biggest high-tech firms like Intel, Microsoft, Cisco Systems, Sun Microsystems, and Netscape ("A Really Big Adventure," 1997).

The above arguments demonstrate that openness of a regional economy is not a deterrent to human capital accumulation, but it may in fact encourage such accumulation by broadening the markets and fostering competition between regions. Regions that embark on a developmental strategy that calls for imitating others' innovations will always be playing catch-up to the leaders in innovation. Perhaps that is the reason why the countries of eastern Asia, which have experienced phenomenal growth during the past two decades partly by imitating Western technology, have embarked on the path of innovation and creation of knowledge ("The Road From Imitation," 1996).

. . . openness of a regional economy is not a deterrent to human capital accumulation, but it may in fact encourage such accumulation by broadening the markets and fostering competition between regions.

SUMMARY, POLICY, AND CONCLUSION

This article has attempted to establish that a successful long-term strategy for regional economic development is the accumulation of human capital. Human capital stimulates growth and development directly as well as indirectly. It directly contributes to knowledge growth and therefore to the knowledge stock of the region. Hence, the productivity of human capital in knowledge growth rises with the accumulation of knowledge stock. Output growth and economic development would be even more pronounced as entrepreneurs apply and diffuse the knowledge in a region. Human capital stock also provides the pool for the emergence of entrepreneurs. Indirectly, to the extent that human capital raises the productivity of other workers and capital, promotes agglomeration economies, and stimulates household investment in children due to lower fertility rates, it further contributes to growth and development.

Because there are increasing returns to human capital in knowledge growth and spillover effects of knowledge stock, competitive market structure breaks down. Increasing returns and imperfect competition in the market provide rewards to human capital, as all inputs are not paid their

marginal product (see Romer, 1990a, p. S87). However, even the monopoly in the market for knowledge cannot appropriate all the benefits as measured by the consumers' surplus. Therefore, there is an incentive for the firms to produce too few inventions and innovations. To a certain extent, the patent system corrects for this suboptimal result as it grants the innovator a degree of monopoly power. On the other hand, given the market distortions created by the monopoly power in the production of innovations and inventions, the policy maker has to weigh the costs monopoly power imposes on the society against the benefits to society from more innovations and inventions. The profit incentives to the firms in the imperfectly competitive market must exist for these firms to innovate. In addition, spillover effects that create a wedge between private rewards and social benefits would also lead to the output level of knowledge below the social optimum. Hence, the role of policy and policy makers is to correct the discrepancy between private rewards and social benefits of human capital and knowledge accumulation. This calls for a subsidy to education and training, as well as a subsidy to R&D. Doeringer (1994) takes an extreme position on the issue of training, although it does need to be addressed. He states that "the crux of the nation's human capital deficiencies does not lie exclusively in its schools, and that improvements in education are not as central to solving the nation's productivity and human capital problems as many have argued. . . . Instead the problem is rooted in the weakening of America's system for building labor productivity" (p. 92).

There is a logical reason for the government to become an active partner in workplace-training programs. In a technologically sophisticated and mobile economy, in which firms must compete in ideas as well as in knowledge-intensive products, a large investment in training may not pay off to individual firms, because highly trained employees would move more often between firms. Hence, the market incentives for training in high-end skills requiring long-term commitment by firms are such that most firms would tend to underinvest in such training programs. Therefore, policy makers have a clear role to play in workplace programs as well if societal needs for skilled people have to be met to ensure continual economic growth and development. However, public efforts to support workplace-training programs should be in addition to, rather than instead of, the investment in schools, colleges, and research institutions to promote and accumulate more generic knowledge with significant spillovers. My purpose here is not to specify a particular policy, as that requires a separate investigation, but to provide an economic argument for policy intervention on efficiency grounds.

As mentioned before, a subsidy to capital is shortsighted. First, a subsidy to capital cannot be justified on efficiency grounds, as there is no clear evidence of market failure in the capital market. In addition, Romer (1990c) shows that a subsidy to capital has no effect on steady-state growth. On the other hand, Romer also shows that interest rate reduction has a positive effect on human capital stock devoted to knowledge production and, hence, on growth. Any public policy that encourages human capital stock and R&D is in the long-term interest of a region, and the threat of interregional spillovers should not distract regional policy makers from initiatives that promote human capital stock of the region.

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