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University-based Economic Growth

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Introduction

Many public policies are based on the popular assumption that investment in university research and infrastructure benefits regional economies. After all, we live in a knowledge economy and universities are seen as a core element of a regional intellectual infrastructure—an essential factor in building technology-based industries and competitive firms. This argument is attractive to many politicians who seek to promote economic growth, and economic development has become the third mission of universities (Etzkowitz, 2003). Still, there are skeptics who doubt the ability of universities to promote economic development (Feller, 1990) and who worry about the effect of this emphasis on the integrity of the academic enterprise (Slaughter and Leslie, 1997). Leaving normative concerns aside, this chapter examines the relations between higher education, industry and economic development. We provide a review of the literature with emphasis on how universities impact economic development and technological change with specific emphasis on the places where they are located.

A body of empirical work concludes that universities are necessary but not sufficient for positive regional economic outcomes. The operative question is under which circumstances universities affect economic growth; specifically, what characteristics of universities promote knowledge transfer and what characteristics of places promote knowledge absorption? While we debate the merits of increased emphasis on commercial activity, universities are moving aggressively into active technology transfer and engagement with commercial activity. The operative question here is how to best manage these relationships to ensure that all of society's goals are met.

This chapter begins by introducing the student of higher education to the theoretical background of university-based growth, including major concepts of increasing returns to scale and institutional economies. The following section looks at the ways universities affect regional economies and addresses the literature that presents the concepts of tacit and codified knowledge and agglomeration economies to explain the mechanisms of knowledge spillovers from universities to companies and industries. The concept of regional innovation systems (RIS) helps to place universities within regional economies and makes a framework to observe the evolution of the universities' role in the regional economy from the concept of *learning regions* to the model of *university products*, where universities are presented as endogenous to the regional systems. The conclusions in the chapter synthesize the thoughts behind the literature on economic development theories and the knowledge spillovers concept, suggesting the major hypothesized systems linking universities with regional growth: mechanisms of knowledge spillovers due to agglomeration economies of scale and specific economic environments where the knowledge spillovers occur.

Framing the Problem

As a field, regional economic development is a complex topic that incorporates theories from different disciplines. The notion of how wealth is generated and distributed has been a topic in economics beginning with Adam Smith's (1776) theory of the market economy. Joseph Schumpeter (1934) was the first economist to study innovation and entrepreneurs as the actors who create innovation in the economy. Olson (1982) and North (1955), in discussing institutional economies, highlighted the importance of public environments and their effect on economic growth. The social capital theory of Putnam *et al.*, (1993) and Granovetter (1985) draw attention to social relationships in the process of creating innovation. Increasingly there is a recognition that geography provides a platform on which to organize economic activity in ways that are more efficient and productive.

Innovation, after all, is a social process. Cities are centres of economic activity that provide externalities that result from the co-location of firms (Audretsch and Feldman, 1996). Externalities are defined by economists as the unintended effects of market transactions that are difficult to capture through the price mechanism. The classic example is the bee keeper and the fruit orchard—both gain from co-location but it would be difficult to imagine how they might compensate one another. Agglomeration economies are the external effects associated with the spatial concentrations of resources. In dense urban environments, linkages between firms, either forwards to the market or backwards to suppliers, work more efficiently, producing more revenue per unit of resources. The concentration of activity in cities allows for increased specialization and a deeper division of labor among firms. The observed benefits of agglomeration not only lowered the costs, but also created better opportunities for innovating and designing new products and services. Moreover, co-location creates greater opportunities for interaction, lowering the costs associated with gathering information. Economists say that agglomeration economies lower transaction costs and thus knowledge-based activity is enhanced. A number of scholars, including Weber (1929), Tiebout (1956), Nelson (1986), Chinitz (1961), and Young (1999), established the positive effect of externalities, characteristics of agglomeration economies, phenomena of the increasing returns to scale, deepened specialization of production, and increased elasticity of supply. These scholars tried to understand the variation of economic performance among regions. Technology is key to this effort.

Robert Solow's Nobel Prize-winning work on the technological residual is credited with emphasizing technology-based economic development. Solow (1957) empirically tested the relationship between economic growth and capital stock, or the presence of physical plant and equipment. The growth that could not be explained by the model was called the residual and is associated with technological change. The presence of the residual implied a contribution of technology advances other than a simple industrialization of economy through the substitution of labour for capital. Solow's residual stood for technology shocks over the business cycle frequencies and was a very important input into the emerging new growth theory.

In the late 1980s, Paul Romer built upon Young's concept of increasing return and Solow's technological residual and formulated a set of principles that established his new growth theory—the main theoretical basis for technology-based regional strategies (Romer, 1986). The new growth theory places its main emphasis on endogenous growth based on industries that generate increasing returns to scale. These industries have a high accumulation of knowledge in the form of new technologies: "the model here can be viewed as an equilibrium model of endogenous technological change in which long-run growth is driven primarily by the accumulation of knowledge by forward-looking, profit-maximizing agents" (Romer, 1986, p. 1003). The model is based on three main elements: externalities of new knowledge, increasing returns in the production of output, and decreasing returns in the production of new knowledge. In his later work, Romer illustrated the historical origins of developing a new growth model into a neoclassical growth model rooted in Marshall's concept of increasing returns that are external to a firm but internal to an industry (Marshall, 1890), and Young's basis of increasing returns through increasing specialization and division of labor. Romer further developed Solow's concept of exogenous technological residual and argued Arrow's (1962) view of knowledge as a purely public good, and he resolved optimization problems by applying a competitive equilibrium with externalities derived from a partially excludable nature of new knowledge to a new dynamic growth model. Romer introduced and analytically evaluated three important premises of the new growth theory: (1) "The first premise . . . implies that growth is driven fundamentally by the accumulation of partially excludable, nonrival inputs"; (2) "The second premise implies that technological change takes place because of the action of self-interested individuals, so improvements in the technology must confer benefits that are at least partially excludable";[1] and (3) "The third premise . . . implies that that technology is a non-rival input" (Romer, 1990, p. S74).

Romer argued that excludability is a function of the technology and the legal system, and therefore prevents anyone other than the owner from using new knowledge to create quasi rents. "The advantage of the interpretation that knowledge is compensated out of quasi rents is that it allows for intentional private investments in research and development. . . . What appeared to be quasi rents are merely competitive returns to rival factors that are in a fixed supply." (pp. S77–S78). He emphasized the importance of human capital in the research process and pointed to agglomeration economies that occur at the intersection of highly specialized firms and a diverse environment that encourages innovations. His theory also states that simple urbanization and specialization itself can only create an economy predisposed to innovation, but what actually creates that economy is the immense investment in research and development combined with a supporting infrastructure of transportation, communication, information, and education.

The concept of increasing returns implies the existence of knowledge spillovers and the benefits of the co-location for innovative activity (Feldman, 1994). Known alternatively as the new industrial geography (Martin and Sunley 1996; Martin, 1999) or the new economic geography (Krugman, 1991, 1995, 1998, 1999; David, 1999), there has been an active intellectual effort to study the relationship of location to economic growth.

The Real Effects of Academic Research

The production function approach suggests that firms that are located in a region with large stocks of private and public research and development (RandD) expenditures are more likely to be innovative than those located a greater distance from such stocks. This advantage is due to benefits from knowledge spillovers and agglomeration effects. Many studies combine geography (distance from the source of knowledge) and innovation (tacit nature of knowledge leakages) within the knowledge production function developed by Griliches (1979). These studies imply that innovative inputs (RandD expenditures) produce innovative outputs (patent or innovation counts) due to localization of RandD spillovers. Moreover, in the early 1980s, a popular hypothesis discussed in the literature relates the spatial distribution of knowledge to its core generator, the university. Jaffe modified the Cobb-Douglas production function to incorporate the influence of technology spillovers on productivity or innovation (Griliches, 1979; Jaffe, 1986, 1989). Using the state as the level of analysis, Jaffe (1989) classified patents in technological areas and showed that the number of patents is positively related to expenditures on university RandD, after controlling for private RandD and the size of the states. He interpreted these positive relationships as localized technological spillovers from academic institutions to local firms. Moreover, his model established the importance of a research university to the location of industrial RandD and inventive activity.

In the mid-1990s the Griliches-Jaffe knowledge production function became a major framework for modelling the impact of universities on separate industries and whole regions (Acs *et al*., 1991, 1994a, 1995; Almedia and Kogut, 1994; Audretsch and Feldman, 1996; Audretsch and Stephan, 1996; Acs, 2002). Feldman (1994) and co-authors, in a series of papers, extended this analysis to consider innovative activity. In 1994, Acs, Audretsch, and Feldman differentiated the production function for large and small firms, finding that geographic proximity to universities is more beneficial for the small firms, as university RandD may play a substitution role for firms' internal RandD, which is too costly for small firms (Acs, Audretsch and Feldman, 1994b). Feldman and Florida (1994) used the knowledge production function to study 13 three-digit SIC industries[2] on a state level and reach conclusions regarding the influence of agglomeration through the network effect: "Concentration of agglomeration of firms in related industries provide a pool of technical knowledge and expertise and a potential base of suppliers and users of information. These networks play an especially important role when technological knowledge is informal or of a tacit nature . . ." (p. 220). Using less aggregated industrial classification (four-digit SIC sectors), Audretsch and Feldman (1996) found that the geographical concentration of the innovation output is positively related to the industrial RandD, which proves the existence of knowledge spillovers within the industrial cluster.

This literature, however, often looks at the single link that channels knowledge created in a university to a specific industry, but never assesses the comprehensive impact of all university products on a regional economy. Jaffe (1989) is very careful in interpreting his research, noting: "It is important to emphasize that spillover mechanisms have not been modeled. Despite the attempt to control for unobserved 'quality' of universities, one cannot really interpret these results structurally, in the sense of predicting the resulting change in patents if research spending were exogenously increased" (p. 968). Varga (1997) confirmed this position in his literature survey "Regional Economic Effects of University Research: A Survey." He reviewed the literature on the impact of university research in four areas: (1) the location choice of high-tech facilities, (2) the spatial distribution of high-tech production, (3) the spatial pattern of industrial research and development activities, and (4) the modeling of knowledge transfers emanating from academic institutions. Varga found that:

> Regarding the effect of technology transfer on local economic development, the evidence is still vague. Its main reason is that no appropriate model of local university knowledge effects has been developed in the literature. Studies either test for a direct university effect on economic conditions or focus on academic technology transfer, but none of them provides an integrated approach (p. 28).

Audretsch (1998) also expressed his caution regarding the interpretation of knowledge spillovers in several empirical studies:

> While a new literature has emerged identifying the important role that knowledge spillovers within a given geographical location plays in stimulating innovative activity, there is little consensus as to how and why this occurs. The contribution of the new wave of studies . . . was simply to shift the unit of observation away from firms to a geographic region (p. 24).

The other major stream of literature (sometimes using the knowledge production function as well) was established by Jaffe, Trajtenberg and Henderson (1993) by using patent citations data as knowledge flows that can reveal the relationships between innovation in terms of geography, time, and sequence. These scholars found that innovative firms more often quote research from local universities, as compared to the universities that conduct similar research in a more distant place. Almedia, Kogut, and Zander in their multiple studies concluded that localized knowledge builds upon cumulative ideas within regional boundaries and depends on the ability of the local labour market to accommodate engineers, scientists, and workers who hold the knowledge (Kogut and Zander, 1992, 1996; Almedia and Kogut, 1994). The Almedia and Kogut (1997) study of the semiconductor industry finds that knowledge spillovers from university research to private companies are highly localized. Other studies draw similar conclusions using different levels of geography and different industries (Maurseth and Verspagen, 1999; Verspagen and Schoenmakers, 2000; Kelly and Hageman, 1999).

Many scholars explored the agglomeration effect of urbanization on the efficiency of university knowledge spillovers. Utilizing Polanyi's concept of tacit knowledge (Polanyi, 1962, 1967) and Innis's concept of encoding personal knowledge (Innis, 1950, 1951), scholars classified knowledge as either tacit or codified and then related them to the process of learning and the spatial distribution of knowledge.

Using these concepts of tacit and codified knowledge, Lucas (1988), Caniels (2000), and Audretsch and Feldman (1996), among others, emphasized that knowledge is neither evenly distributed nor equally accessible in every location. The accumulation of tacit knowledge has regional boundaries while the utilization of codified knowledge depends more on the susceptibility of the recipient to accumulate and employ it. Feldman and those who contributed to the stream of research initiated by Adams and Jaffe (Feldman, 1994; Adams and Jaffe, 1996; Adams *et al.*, 2000; Adams, 2001, 2002, 2004), focused on the localization of university spillovers and found significant evidence that knowledge flows travel a certain geographical distance within regions. While studying commercialized academic research, Agrawal and Cockburn (2002), among others, found strong evidence for the co-location of upstream university research and downstream industrial RandD activity at the level of metropolitan areas.

Agglomeration effects result not only in localized knowledge but also in creative ideas that combine different types of knowledge as a result of urbanization effects or the co-location of a large number of firms in different industries. The line of reasoning is that local diversification stimulates the occurrence of different types of knowledge and their innovative combinations (Harrison *et al.*, 1996; Adams *et al.*, 2000; Adams, 2001; Desrochers, 2001).

Many scholars acknowledged the differences in regional performance and they attributed these differences to the patterns of knowledge spillovers and regional absorption of innovation. Döring and Schnellenbach (2006) surveyed the latest theoretical concepts of knowledge spillovers and concluded that "despite its public good properties, knowledge does not usually diffuse instantaneously to production facilities around the world. Regional patterns of knowledge diffusion, as well as barriers to the diffusion of knowledge, can therefore feature prominently in explaining the differential growth of production and incomes between regions".

There are two major obstacles to knowledge spillovers. The first obstacle arises from the proprietary rights for explicit (codified) knowledge at some phase of its development (patenting innovation). At the same time, exclusive rights for new knowledge cannot ensure its total secrecy—for example, publishing scientific articles and presenting at conferences require disclosing information at the phase prior to patenting. The second obstacle is the cognitive abilities of individuals who can utilize tacit knowledge. Some regions might not have enough scientists with the specific skills or knowledge needed to comprehend and utilize new information. That is, the recipients of knowledge spillover might not be able to absorb the information made available to them. If human capital is sophisticated enough to absorb technical knowledge, then the positive benefits for knowledge spillovers may be realized. Few studies paid attention to path dependencies and the impact of existing industry mix, production culture, and other legacies of a place on current regional economic outcomes.

The University as an Important Regional Player in Regional Innovation Systems

Since the 1980s, studies have analyzed innovation processes within geographical systems (Edquist, 1997; Freeman, 1991; Freeman and Soete, 1997; Lundvall, 1992; Maskell *et al.*, 1998). This stream of research started with identifying national innovation systems (NIS) in Europe, assuming that the occurrence of innovation depends on the structure and organization of industries and companies within a nation, institutions and existing social networks, size of the region, and infrastructure (physical, financial, cultural). The model recognizes universities as institutions supportive to innovation. The role of universities is seen as either direct—through the education of students and production of ideas—or indirect—through knowledge spillovers from research and education.

Over time, the locus of innovative activity changed from the national level to regional economies. Certainly, part of this attention was due to the idea of clusters (Porter, 1990). Yet the literature differentiates between the location of production and the location of innovation (Audretsch and Feldman, 1996). Precise attention of scholars to the regional innovation systems only emphasized the role of universities as regional institutions that matter most to innovative activity.

In the 1990s, through the introduction of the concept of learning regions, social scientists looked at universities as endogenous to the regional systems (Morgan, 1997; Florida, 1995; Lundvall and Johnson, 1994; Hudson, 1999; Keane and Allison, 1999). They concentrated on the creation of knowledge and its absorption by local firms through the social and organizational networks mainly at the regional level. The increased interest in regional information systems (RIS) was triggered by the regionalization of production and the growing importance of a region in global competition. Forced to compete globally, regions were striving for developing regional competitive advantage.

The necessity for continuous innovation with the purpose of developing or retaining a regional competitive advantage changed the whole paradigm of learning. Universities started to see a new client—spatial clusters and relational networks of small and medium-sized firms that substituted for large corporations (Chatterton and Goddard, 2000). The dynamic of learning shifted from a model where learning occurs at universities and knowledge is then applied at the workplace, to a model where interactive learning occurs throughout the lifetime—at the university, workplace, and networking functions.

In late 1990s and early 2000s, the concept of RIS has been widely studied and empirically tested, especially in Europe (Amin and Thrift, 1995; Braczyk and Heidenreich, 1998; de la Monthe and Paquet, 1998; Cooke, 1998; and Hassink, 2001). Scholars have developed a typology to assess structural differences of RISs (Cooke, 1998, p. 19–24) and conducted comparative analyses of regional information systems (Hassink, 2001, p. 224). Iammarino and McCann (2006) classified industrial clusters within four different stages in the evolution of technological innovation systems. Each life-cycle stage of innovation systems has a corresponding knowledge base, a distinctive type of industrial regime, is based on a different phase of knowledge spillovers, and has different requirements in the presence of knowledge-generating institutions within the regional system of innovation.

The concept of differentiating phases of innovation systems within the technological life-cycle is consistent with the stream of research on innovation systems and their spatial and knowledge components by Oinas and Malecki (Oinas and Malecki, 1999, 2002; Malecki, 1997). Analyzing the knowledge component of innovation systems, along with local conventions (e.g. tolerance toward failure, risk-seeking, enthusiasm for change and rapid response to technological change), they emphasize the increasingly important role of regional creativity within the context of regional knowledge.

Acknowledging different types of regional institutions, Etzkowitz (2003) introduced the Triple Helix[3] model that conceptualizes university–industry–government relations. This model describes changes in relationships among three main regional players: academia, business, and government. With the growing importance of knowledge, and as the production of knowledge transforms into economic enterprise, the university is given a more prominent role in the regional economy. The university develops an organizational capacity not only to produce knowledge, but also to deploy knowledge into the regional economy or to sell the products derived from new knowledge outside the region. This process is consistent with an innovation being changed from an internal process of a single firm into one that takes place among many firms and knowledge-producing institutions. These changes trigger a transformation in the relationships among university, industry, and government (Figure 28.1) from a "statist" model of government controlling academia and industry (1),[4] to a "laissez-faire" model, which separates the roles of industry, academia and government, interacting only modestly across strong boundaries (2), and, finally to the Triple Helix model with each institutional sphere maintaining its identity while taking on the role of each of the others (3).

With each of the three players, industry, state, and academia, partially taking on the roles of the others, the established match of an institution to its traditional role and functions is outmoded. The Triple Helix model implies interactions across university, industry, and government; and the interactions are mediated by organizations such as industrial liaisons, university technology transfer offices, university contract offices, and other entities. These mediators have a mission to ease legal and organizational barriers in the interaction of the three players to benefit the deployment of innovation within the region or to benefit the profitable sale of the knowledge products resulting in benefits to the region through a multiplier effect.

According to Pires and Castro, Gulbrandsen, and Leydesdorff and Etzkowitz, as the Triple Helix model evolves, each of the three institutions begin to assume the traditional roles of the others in the technology transfer process (Gulbrandsen, 1997; Pires and Castro, 1997; Leydesdorff and Etzkowitz, 1998). For example, the university performs an entrepreneurial role in marketing knowledge, in creating companies, and also assumes a quasi-governmental role as a regional innovation organizer.

Direct Effects of University Research

In 1980, the United States Congress passed the Bayh-Dole Act and the intellectual property landscape in the U.S. changed dramatically. Universities were allowed to retain intellectual property

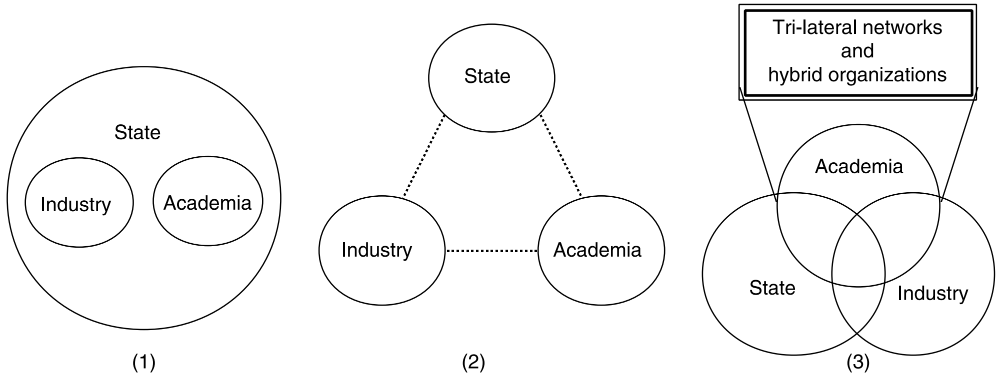

Figure 28.1 "Anthropology" of Triple Helix Model.

Source: Etzkowitz, H. (2003). Innovation in innovation: the Triple Helix of university-industry-government relations. *Social Science Information*, *42*(3), 302.

rights and to pursue commercialization even though the basic research had been funded by the federal government. In the late 1990s, technology transfer activities of research universities began to be recognized as important factors in regional economic growth. Scientists started to look at the different factors and mechanisms stimulating transfer of new technology from university to industry (Cohen *et al.*, 1994; Campbell, 1997; Lowen, 1997; Slaughter and Leslie, 1997; DeVol, 1999). Discussing the benefits of such technology transfer, Rogers, Yin, and Hoffmann (2000) hypothesized that "research universities seek to facilitate technological innovations to private companies in order to: (1) create jobs and contribute to local economic development, and (2) earn additional funding for university research" (p. 48). They illustrated the potential impact of university research expenditures on jobs and wealth creation through the process of simple technology transfer.

Beeson and Montgomery (1993) tested the relationship between research universities and regional labor market performance. They assessed a university's impact on local labour market conditions by measuring quality in terms of RandD funding, the total number of bachelor's degrees awarded in science and engineering, and the number of science and engineering programs rated in the top 20 in the country (p. 755). Beeson and Montgomery identified four ways in which colleges and universities may affect local labor markets: (1) increasing skills of local workers (together with rising employment and earnings opportunities), (2) increasing the ability to develop and implement new technologies, (3) affecting local demand through research funds attracted from outside the area (a standard multiplier effect), and (4) conducting basic research that can lead to technological innovations (p. 753).[5]

Link and Rees (1990) emphasized the important role of graduates to a local labour market, particularly for new start-ups and the local high-tech market, assuming they do not leave the region. Gottlieb (2001) took this idea further in his Ohio "brain-drain" study, emphasizing that exporting graduates is a sign of long-run economic development problems for a region. In their study of 37 American cities, Acs, FitzRoy and Smith (1995) tested university spillover effects on employment, and, like Bania, Eberts and Fogarty (1993), tried to measure business start-ups from the commercialization of university basic research. These studies produced mixed results, showing that university products are statistically significant in their impacts in one case and insignificant in others.

Following Adams' findings about the positive effect on industrial research from the geographical proximity to university research (Adams *et al.*, 2000; Adams, 2001), many studies (Audretsch and Feldman, 1996; Audretsch and Stephan, 1996; Cortright and Mayer, 2002) found that for most industries, activities that lead to innovation and growth take place within only a few regions nationally or globally. Whether it was the impact of universities on regional labor markets or the impact of university RandD and technology transfer on the growth of employment or per capita income, a broader framework was needed to measure the impact of all products created in universities.

Each university interacts with the regional economy as represented by local businesses, government agencies, and the region's social and business infrastructure. The actual interaction is based on its set of products and their value to the region. The university can create sources of regional competitive advantage and can significantly strengthen what Berglund and Clarke (2000) identify as the seven elements of a technology-based economy: (1) regional, university-based intellectual infrastructure—a base that generates new ideas, (2) spillovers of knowledge—commercialization of university-developed technology, (3) competitive physical infrastructure, including the highest quality and technologically advanced telecommunication services, (4) technically skilled workforce—an adequate number of highly skilled technical workers, (5) capital creating adequate information flows around sources of investments, (6) entrepreneurial culture—where people view starting a company as a routine rather than an unusual occurrence, and (7) the quality of life that comes from residential amenities that make a region competitive with others.

The university's influence on these factors is of interest to economic development because each university product can be an asset used by a regional economy or can be sold outside the region, generating regional income. Each university makes a choice about what product will be a priority to produce and sell, assigns its resources, and creates policies to implement its goals.

Many studies are focused solely on showing the impact of university presence using the multiplier effect of university expenditures. These studies are confusing the impact of university products (which we identify as purposefully created outcomes according to a university mission) and the impact of university presence in a region (which depends on university expenditure patterns). In the traditional multiplier-effect studies, the models usually take into account two factors of university impact: (1) the number of university students and employees (which is a non-linear function of university enrollment) and the impact of their income through individual spending patterns and (2) a pattern of university expenditures via a university budget. These two factors (sometimes called university products) are indirect functions of enrollment and endowments and are highly collinear with university size. While normalized to per-capita indicators, they highly correlate with university reputation and, apart from the reputation, are to a large degree uniform across regions.

Morgan (2002) tried to bridge the gap between two concepts of university products and create a conceptual model of the two-tier system of higher education institutions in the United Kingdom. Using Huggins' (1999) and Phelps' (1997) concept of the globalization of innovation and production in regional economies, he discusses two models of direct and indirect employment effects—the elite model and the outreach/diffusion-oriented model (Figure 28.2). Morgan emphasizes the increased role of universities in developing local social capital by acting as "catalysts for civic engagement and collective action and networking" and "widening access to cohorts from lower socio-economic backgrounds" improving local social inclusion (pp. 66–67).

Bringing elements of globalization into understanding the role of universities for the local economy is widely emphasized in the MIT Industrial Performance Center's study led by Richard

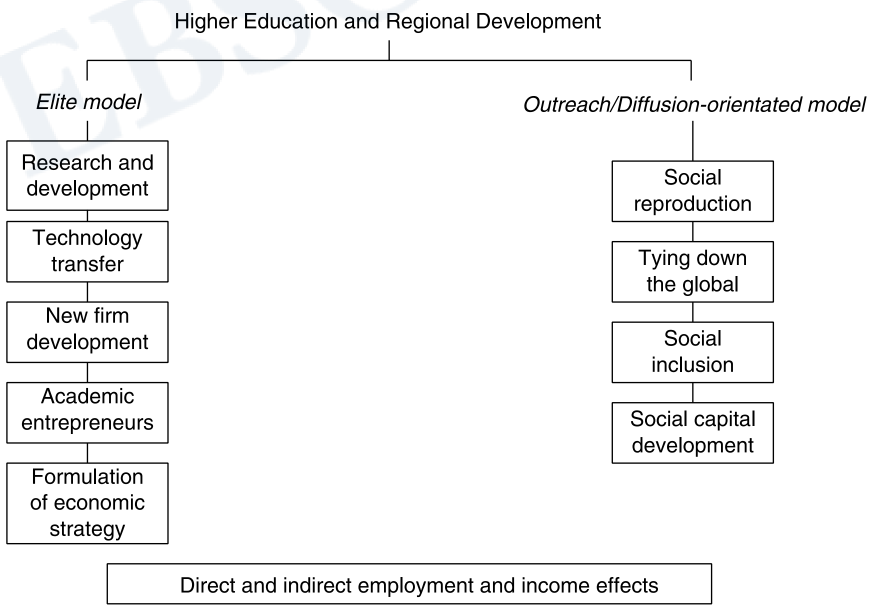

Figure 28.2 Universities and Regional Development: Two Paradigms.

Source: Morgan, B. (2002) Higher education and regional economic department in Wales: an opportunity for demonstrating the efficacy of devolution in economic development, *Regional Studies*, *36*(1), 66.

Lester. The 2005 report "Universities, Innovation, and the Competitiveness of Local Economies" discusses an important alignment of the university mission with the needs of the local economy, emphasizing that this alignment is affected by the globalization of knowledge and production and depends on "the ability of local firms to take up new technologies, and new knowledge more generally, and to apply this knowledge productively".

Through the different roles played by universities, this study acknowledges diverse pathways of transferring knowledge from universities to local industries (Figure 28.3). Some of these pathways are common to economies with different core industries, and some are unique to the regions. For example, *education/manpower development* is as valuable for the economy as *industry transplantation* and *upgrading mature industry economy. Forefront science and engineering research* and *aggressive technology licensing policies* are unique and critical for *creating new industries economies*, and *bridging between disconnected actors* is as distinctive for the economy as *diversifying old industry into related new industry.*

These unique and common pathways for economies with different industrial structures imply existence of universities' products that, besides teaching and research, include faculty consulting, publications, and collaborative research.

The discussion about the role of a university in the regional economy has been enriched by a model created by Louis Tornatzky, Paul Waugman, and Denis Gray (Tornatzky *et al.*, 1995, 1997, 1999, 2002). These researchers advocate the importance of research universities for regional economic development and examine whether the influence of a university on a local economy differs geographically. The authors conclude:

> While we agree with skeptics who argue this [university's impact on a local economy] is not easily accomplished and that some universities and states appear to be looking for a quick fix, we believe that there is enough evidence to demonstrate that universities that are committed

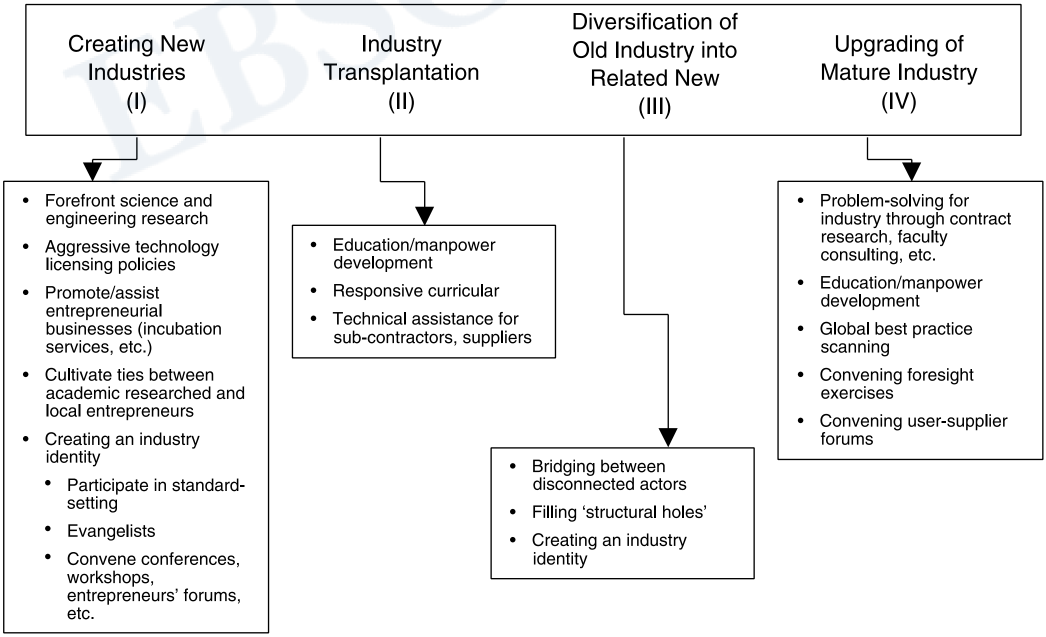

Figure 28.3 University Roles in Alternative Regional Innovation-led Growth Pathways.

Source: Lester, R. (2005) *Universities, Innovation, and the Competitiveness of Local Economies*, Industrial Performance Center, MIT, p. 28.

> and thoughtful can impact their state or local economic environment in a number of ways (Tornatzky *et al.*, 2002, pp. 15–16).

Tornatzky's hypothesis of the ways that universities can affect regional economies is presented in Figure 28.4.

The research team identified 10 "dominants" of institutional behavior that enable the university's external interactions with industry and economic development interests and lie beneath organizational characteristics and functions that facilitate those interactions. Tornatzky *et al.*, (2002) group these dominants, or interactions, characteristics, and functions into the three broad groups depicted in Figure 28.4. The first group (1) represents partnering mechanisms and facilitators identified as "functions, people, or units that are involved in partnership activities that allegedly have an impact on economic development" (Tornatzky *et al.*, 2002, p. 16). The list of programs or activities in this component includes, but is not limited to, industry research partnerships, industry education and training, and other activities.

The second group (2) includes institutional enablers (university mission, vision, and goals, and faculty culture and rewards) that facilitate partnering through the "relevant behavior of faculty, students, and administrators [that] are supported by the values, norms, and reward systems of the institution" (Tornatzky *et al.*, 2002, p. 18). The third group is represented by two boundary-spanning structures and systems: formal partnerships with economic development organizations (labelled (3) in the figure) and industry-university advisory boards and councils (labelled (4)). They are positioned to link the university system to the economic development intermediaries and business community. As a result of communication between all of the components, the framework captures locally generated technological outcomes (5), such as new knowledge and technologies that trigger economic development.

Tornatzky, Waugman and Gray (2002) acknowledged that, while the local economic environment of universities is complex, only universities that are actively involved in extensive industry partnerships can successfully transfer their products into local economies. Such universities will

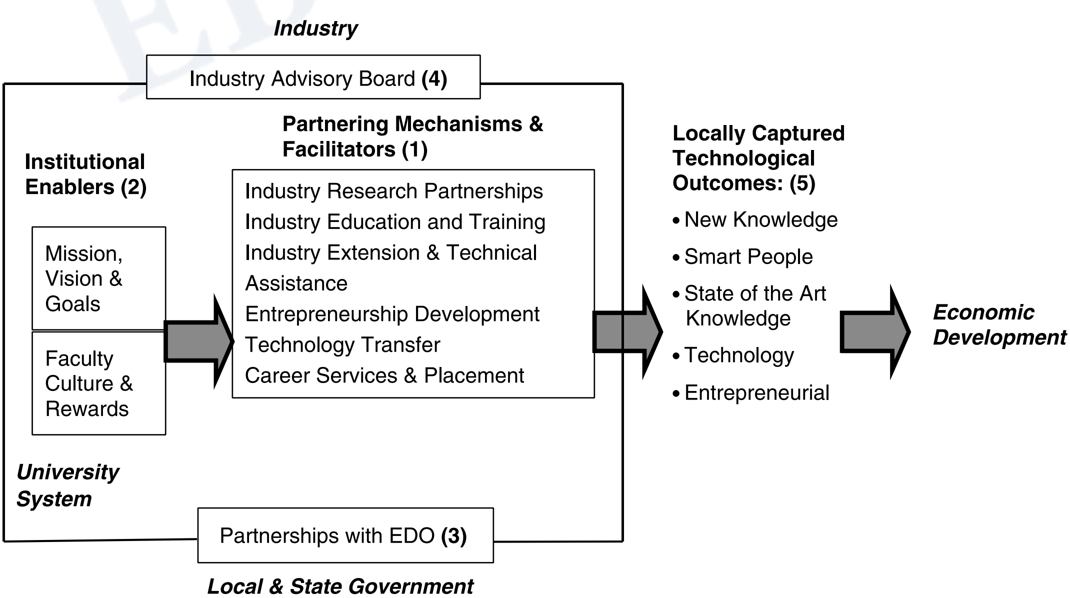

Figure 28.4 Innovation U.: New University Roles in a Knowledge Economy.

"tend to adopt language in mission, vision, and goal statement that reflects that emphasis. They [universities] also tend to incorporate different versions of those statements in reports, publications, press releases, and speeches directed at the external world" (p. 19).

Paytas *et al.*, (2004) tested this hypothesis in their case studies of eight universities by examining the scope of universities' economic engagement in local economies. They assessed the breadth of involvement of universities with their regions and local communities and concluded that, for a university to play an important role in the development of industry clusters, it "must be aligned with regional interests and industry clusters across a broad spectrum, not just in terms of technical knowledge. . . . The characteristics of the clusters are as important, if not more important than the characteristics of the university" (p. 34).

Goldstein *et al.*, (1995) developed a set of university outputs that is also broader than the traditional understanding of university products, which includes only *skilled labor* and *new knowledge*. Their framework identifies eight university products and among them distinguishes between knowledge creation and co-production of knowledge infrastructure, human capital creation, capital investment and technological innovation and technology transfer. This model adds a new and very important understanding of leadership value and regional milieu. According to the framework, these university outputs impact regional productivity and business innovation, enable business start-ups, increase regional capacity for sustained development, and spark off regional creativity. The spending pattern of university reflected in capital investment creates direct and indirect multiplier-type impact regional economy. This framework was operationalized by Goldstein and Renault (2004) and tested with the modified Griliches-Jaffe production function.

A similar approach is used by Porter (2002) in a report for the Initiative for a Competitive Inner City. He studied six primary university products using a multiplier-effect approach. Porter identifies the main impacts on the local economy through the university's (1) employment, by offering employment opportunities to local residents; (2) purchases, redirecting institutional purchasing to local businesses; (3) workforce development, addressing local and regional workforce needs; (4) real estate development, using it as an anchor of local economic growth; (5) advisor/network-builder, channeling university expertise to local businesses; and (6) incubator provider, to support start-up companies and advance research commercialization.

These approaches mix university products—goods and services that are produced by universities according to the university mission—with university impacts—results of university influence on surrounding environments. For example, universities influence appreciation of surrounding real estate value without including this in their mission statement. Lester's study acknowledges that "working ties to the operating sectors of economy are not central to the internal design of the university as an institution, and as universities open themselves up to the marketplace for knowledge and ideas to a greater degree than in the past, confusion over mission has been common" (Lester, 2005, p. 9).

According to Hill and Lendel (2007), higher education is a multi-product industry with seven distinct products: (1) education, (2) contract research, (3) cultural products, (4) trained labor, (5) technology diffusion, (6) new knowledge creation, and (7) new products and industries. These products become marketable commodities that are sold regionally and nationally or they became part of a region's economic development capital base. Growth in the scale, quality, and variety of these products increases the reputation and status of a university. An improved, or superior, reputation allows universities to receive more grants and endowments, attract better students, increase tuition, conduct more RandD, and develop and market more products. This reinforcing mechanism between a university's reputation and university products transforms universities into complex multi-product organizations with a complicated management structure and multiple missions. A university manages its portfolio of products as defined in the university's mission statement and expressed through the university's functions and policies.

Conclusions

The new growth theory and the concepts of increasing returns to scale, knowledge spillovers and knowledge externalities form a basis for creating a framework for technology-based regional economic development. They enable an understanding of the factors that influence regional knowledge creation and implementation of an innovation into regional economic system.

The studies on knowledge spillovers and agglomeration effects apply a variety of approaches and methodologies to studying the impacts of knowledge. Even as they lead to a better understanding of the impact of universities, the results are often fragmented to specific industries and extracts of geographies, primarily due to constraints on data availability. However, even with this fragmentation the empirical results prove the significance of university-based research effects on follow-up industry RandD, increased numbers of intermediate results such as patents, start-up companies, growing employment and wages. It is evident that the positive role of the university in regional economic performance cannot be ignored.

However, the effect of university products on regional economic outcomes is not evident. New knowledge and innovation directly create only intermediate results, such as patents, spin-off companies, graduates, new products and technologies, and new economic, social, and cultural regional environments. Deployed within regional economies, these effects create local competitive advantage. Positive externalities of agglomeration economies of scale allow knowledge spillover and explain the mechanism that enables both, creating the intermediate results of university products and deploying them into regional economies.

Synthesis of thoughts behind the literature on economic development theories and the knowledge spillovers concept suggests that there are two major hypothesized systems linking universities with regional growth: (1) mechanisms of knowledge spillovers due to agglomeration economies of scale, and (2) specific economic environments where the knowledge spillovers occur. The environment of knowledge spillovers and deployment of the results of knowledge spillovers into regional economies can be described by characteristics that reflect the intensity of agglomeration economies and their qualitative characteristics, such as quality of the regional labor force, level of entrepreneurship, intensity of competition in a region, structural composition of regional economic systems and industries, and social characteristics of places, such as leadership and culture.

Notes

1. Paul Samuelson developed the theory of public goods where he assigned all goods to four categories by their two essential characteristics: rivalry and excludability. Knowledge is a public good, which is non-rivalrous and non-excludable. However, developing applications of new knowledge in a form of practical value for the market benefits developers who are earning a profit from selling the applications. The self-interests of developers make the new knowledge of improving technology to become partially excludable goods.
2. Established in the 1930s, the Standard Industrial Classification (SIC) is a United States government system for classifying industries by an up to four-digit code. In 1997, it was replaced by the six-digit North American Industry Classification System (NAICS).
3. The discussion on this model is led by Henry Etzkowitz—associate professor of sociology at Purchase College and Director of the Science Policy Institute at the State University of New York. He is co-convener of the bi-yearly International Conference on University-Industry-Government Relations: "The Triple Helix".
4. This model is more relevant to European systems of education.
5. Also discussed by Nelson (1986).

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