Reconsidering the Regional Economic Development Impacts of Higher Education Institutions in the United States

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Abstract

This study models relationships between United States higher education activities and regional economic performance, 2001 – 2011. Advances include incorporating all degree-granting institutions; estimating spatial spillovers; and comparing multiple economic outcomes, including production and entrepreneurship. Higher education impacts vary by outcome measure but are less influential than in previous studies. Spillovers are substantial up to 60 miles (97 km), reflecting considerable influence across space. More advanced degrees, science and engineering education, and population educational attainment are positively associated with entrepreneurial activity. These findings encourage the traditional university missions of research and teaching, and general policies promoting entrepreneurship, to support economic performance.

1. INTRODUCTION

In the United States, attention to the role of higher education in economic development has broadened substantially since the 1980s. After the Bayh-Dole Act of 1980 and subsequent legislation that granted educational institutions extensive rights to intellectual property produced with federal support, universities became more deeply and intentionally engaged in an expanding assortment of economic development activities (MOWERY et al., 1999). These activities include technology commercialization, cooperative research, consulting, supporting innovation and entrepreneurship, and resource sharing, in addition to the traditional missions of research and teaching (UYARRA, 2010). Liberal arts colleges, community colleges, and other purveyors of higher education exert effects upon regional economies through instruction and varying degrees of commitment to local leadership and advocacy (GOLDSTEIN and DRUCKER, 2006; LENDEL, 2010).

This study investigates the influences of institutions of higher education on U.S. metropolitan economic performance. The purpose is to better understand the role of higher education in supporting economic development and the ways in which distinct educational activities contend or interact. Regressions are calculated with several regional economic outcomes as dependent variables and a variety of indicators of higher education functions as explanatory variables to discern the effects of different educational outputs. The educational data are drawn from the Integrated Post-Secondary Education Data System (IPEDS) of the National Center for Education Statistics and the Computer-Aided Science Policy Analysis and Research (CASPAR) database of the National Science Foundation.

This research advances several objectives related to furthering understanding of the ways in which higher education influences regional economic performance. First, the past decade has witnessed a recession in the United States different in cause and scale from previous downturns and a subsequent recovery that is slow and short on jobs. During this period, the charges placed upon and the budgets of higher education institutions have altered substantially. Now is an appropriate time to update the economic impacts of universities and colleges. Second, production is examined as one measure of regional performance. In comparison with job quality (via earnings), employment, and entrepreneurship, production reflects economic performance without privileging the labor side of the equation. Prior to 2007 production data were not available at the regional scale (PANEK et al., 2007).[1] Third, higher education impacts, particularly the educated workforce attracted or generated, need not stay within geographic or political boundaries, yet spatial proximity may be an important factor still. Most studies have estimated effects restricted to the encompassing spatial unit. This research investigates interregional spillovers directly and tests for remaining spatial dependence to obtain a less constrained perspective of the impacts of higher education. Finally, human capital production at all degree-granting post-secondary institutions is included, to explore the impacts of two-year colleges and four-year teaching institutions together with research universities. Few studies have considered the activities of these types of institutions together. Historically, elements of both cooperation and competition have existed across the institutional categories. Evolution at the institutional and system levels and escalating expectations have altered their respective missions and economic development roles (SKOLNIK, 2011). Evaluating their combined influence is important in providing policy direction, particularly given funding pressures anticipated to persist for some time (CROOKSTON and HOOKS, 2012).

The next section distinguishes among the types of higher education institutions in the United States, categorizes their activities in relation to economic development, and reviews the current state of knowledge regarding their regional impacts. The methods section describes the modeling approach and data utilized, and is followed by a detailed exposition of the empirical results. The paper concludes with a recapitulation of the most important findings and a discussion of implications for education and regional development policy.

2. BACKGROUND AND LITERATURE

2.1. Higher Education in the United States

American higher education is more decentralized than in most other industrialized nations, with systems that differ considerably across jurisdictions (KOEDEL, 2014). Nearly all public institutions are established and controlled by state governments and their instruments.[2] For private institutions, regulation and oversight varies from state to state as well, though some regulation and much of the substantial influence of financial aid allocation and restrictions originate at the federal level.

The majority of high school graduates in the United States pursue at least some further education (BAUM et al., 2013). Higher education enrollment rates have risen more or less continually since the early 1960s, driven by changes in the educational requirements of well-paying jobs and the widely held view of postsecondary education as a crucial mechanism for social and income mobility. In recent years, however, sharply declining levels of public support and the financial insecurity felt by low- and middle-class families have raised concerns about the accessibility of higher education, particularly regarding increasing gaps in affordability, quality, and prestige among types of institutions (BAUM et al., 2013; PERFETTO, 2012).

Several types of institutions can be distinguished. Universities are full-service teaching and research organizations that typically are active in a wide range of academic and professional disciplines and offer graduate as well as four-year undergraduate (bachelor's) degrees. Liberal arts colleges, in contrast, concentrate chiefly on delivering bachelor's-level education in normal academic fields; those offering graduate and professional programs usually do so on a limited basis. Specialized institutions focus on particular subjects (arts, engineering, business, etc.) at either one or both of the undergraduate and graduate levels. There are approximately 2,800 universities and four-year colleges in the United States (Table 1). About one fourth are public, one half are not-for-profit private institutions, and the remainder are for-profit enterprises (NATIONAL SCIENCE FOUNDATION, 2014). Although all types of higher education institutions exist throughout the nation, the northeast portion of the country tends to favor private liberal arts colleges and not-for-profit universities, both in terms of prestige and the share of all degrees awarded.

Community colleges, also termed junior or two-year colleges, first were established early in the twentieth century to provide a transition between high school and four-year higher educational institutions and to serve as 'finishing schools' for women (BAUM et al., 2013). In that capacity, they award mainly degrees that can be earned in two or fewer years of full-time study (associate's and pre-associate's degrees). In the 1960s, individual institutions and systems of public community colleges spread widely across the United States in support of making higher education more broadly geographically and financially accessible (AMERICAN ASSOCIATION OF COMMUNITY COLLEGES, 2014). Whereas their pedigree is less

Table 1. United States Higher Education Institutions, 2011-2012 Academic Year.

Institutions	United States		Midwest		Northeast		South		West	
TOTAL	4,588		1,129		963		1,556		940	
public	1,854	40%	435	39%	291	30%	699	45%	429	46%
not-for-profit	1,627	35%	451	40%	505	52%	446	29%	225	24%
for-profit	1,107	24%	243	22%	167	17%	411	26%	286	30%
community college	1,806	39%	418	37%	305	32%	669	43%	414	44%
liberal arts college	794	17%	226	20%	201	21%	259	17%	108	11%
university	1,022	22%	246	22%	269	28%	322	21%	185	20%
specialized	966	21%	239	21%	188	20%	306	20%	233	25%

Degrees Awarded (thousands)	United States		Midwest		Northeast		South		West	
TOTAL	7,704		1,822		1,482		2,636		1,764	
public	5,088	66%	1,179	65%	709	48%	2,005	76%	1,195	68%
not-for-profit	1,794	23%	454	25%	672	45%	426	16%	242	14%
for-profit	822	11%	188	10%	101	7%	205	8%	327	19%
community college	2,489	32%	543	30%	304	21%	1,018	39%	624	35%
liberal arts college	528	7%	128	7%	157	11%	164	6%	80	5%
university	4,418	57%	1,089	60%	965	65%	1,376	52%	987	56%
specialized	269	3%	61	3%	56	4%	78	3%	72	4%

Note: includes only degree-granting institutions.

Regions: The Northeast includes New England and the Atlantic states south to Pennsylvania and New Jersey; the Midwest comprises the Great Lakes and Plains states; the South includes the Atlantic coastal states south from Maryland and Delaware and stretches west through Oklahoma and Texas; the West contains the Rocky Mountains, the Mexican border states west of Texas, the Pacific coast, and Alaska and Hawaii.

Source: National Center for Education Statistics.

prestigious than four-year institutions, the primary aim of community colleges is well-reflected by their appellation: to serve local communities (ECKEL and KING, 2004). Many community college students are engaged in vocational or technical training, retraining to support career changes, or education for recreational or social purposes, such as English instruction for immigrants. Almost all of the more than 1,000 community colleges nationwide are public institutions, there being only a few non-profit examples. The number of for-profit enterprises that focus on vocational and two-year degree programs, however, has expanded rapidly despite considerable turnover, surpassing 600 distinct institutions.

2.2. Higher Education and Economic Development

The traditional outputs of American universities are new knowledge and educated workers (skilled labor). GOLDSTEIN et al. (1995) describe six additional functions of universities related to economic development: transferring knowledge and know-how, technological innovation, capital investment, regional leadership, contributing to knowledge infrastructure, and influencing the local milieu. Although none represents a uniquely modern activity, the scale of non-traditional outputs has increased markedly over the last thirty years. Importantly, many universities now adopt a proactive, intentional attitude toward regional economic engagement. UYARRA (2010) distinguishes contending models of the regional roles of modern universities, from the relatively detached and conventional 'knowledge factory' to the 'engaged' regional developer and the network-generating, boundary-spanning 'systemic' archetype. Scholars urge research universities to consider purposefully the ways in which their activities impact regional innovation, entrepreneurship, and economic performance, and note that such assessment demands better and more detailed empirical information and understanding (CALZONETTI et al., 2012; CLIFFORD and PETRESCU, 2012; e.g., GUNASEKARA, 2006; HUGGINS et al., 2012; WRIGHT et al., 2012).

Liberal arts colleges and specialized academies focus mainly on the same functions as universities—teaching and research—albeit with a much greater emphasis on teaching (labor force development). They too interact with regional economies through capital investment, regional leadership (at the institutional and individual faculty levels), and contribution to knowledge infrastructure. Public community colleges have evolved from their early origins as transitional institutions into providers of professional certifications, industry-customized training, adult continuing education, entrepreneurship education, and in some cases four-year bachelor's degrees (CALIFORNIA COMMUNITY COLLEGES, 2013; EWING MARION KAUFFMAN FOUNDATION, 2013; GATES, 2013; KOLESNIKOVA and SHIMEK, 2008; ORTMANS, 2012; SKOLNIK, 2011).

The distinction between universities and other higher education institutions is blurring in terms of regional economic development roles. ROSENFELD and SHEAFF (2002) identify development functions of institutions that serve regions lacking a research university: develop workforce skills, diffuse innovation and technology, services broker, information repository, and new business creation. These outputs clearly overlap with those of research universities, especially regarding knowledge infrastructure and information transfer. Universities are less likely to design programs to cater to specific regional needs, though that distinction has been diminishing (SLAPER et al., 2011).

Competition among public higher education institutions and systems historically has centered around budget allocations. Most states allocate resources unevenly, favoring four-year universities and liberal arts colleges over two-year community colleges or adopting the opposite position (ROUSE, 1998). Among public four-year institutions, states may concentrate support on one or a few flagship institutions or distribute attention across more numerous smaller, locally engaged universities and colleges (KOEDEL, 2014). Budget shortfalls engendered or exacerbated by economic recession and fiscal austerity have intensified competition for public funding, and also have reduced access to and eroded the quality of public higher education (CROOKSTON and HOOKS, 2012; JOHNSON, 2011; MILLIGAN, 2013; SMITH, 2013;

WEISS, 2014). Yet enrollment in public institutions is surging, especially near fast-growing minority populations (KATSINAS et al., 2011; ROSCORIA, 2012). The economic implications of these strategies and financial shifts are not yet clear.

Rather than solely funneling students into four-year institutions, community colleges increasingly award terminal technical or vocational associate's degrees, or even bachelor's degrees. Universities and liberal arts colleges generally oppose bachelor's degree offerings by community colleges as detrimental 'mission creep' and rivalry for delivering the most cost-efficient programs in the humanities, social sciences, and general education (KATSINAS et al., 2012; SKOLNIK, 2011; WELDON, 2013). As with public funding, no consensus exists on how these developments affect the economic impacts of higher education. As the involvement of community colleges in regional economic development broadens, the arena for potential overlap and competition will expand further.

2.2. Empirical Research

Most analyses concentrate on the impacts of only one or two higher education functions, due to the difficulty of distinguishing empirically among multiple outputs and the paucity of reliable data. Human capital and knowledge creation receive the most attention, along with capital investment and knowledge transfer. This study similarly focuses on student education and research along with the one newer function of transferring knowledge for which reliable indicators are available.

This section describes three key precursor analyses and empirical results from the last eight years. [DRUCKER and GOLDSTEIN (2007) review comprehensively the theories, research designs, and findings of earlier studies.] Unless otherwise specified, the works examine U.S. educational institutions.

GOLDSTEIN and RENAULT (2004) base a quasi-experimental research design on the embrace of entrepreneurial activities in research universities following the Bayh-Dole Act. By contrasting prior and subsequent regional wage growth (1969–1986 versus 1986–1998), they separate the impacts of the traditional functions from entrepreneurial activities. The university measures have a significant influence only during the latter interval, therefore entrepreneurial activities must be more important for economic development than the traditional functions present in both periods. In addition, only in small regions did wage growth from 1986 to 1998 differ between areas with and without a major research university, suggesting that universities substitute for local agglomeration.

Without a policy discontinuity around which to organize a quasi-experiment, GOLDSTEIN and DRUCKER (2006) apply statistical controls and normalizations to isolate university influences from other effects on earnings growth. The traditional outputs of knowledge and human capital have larger and more statistically significant impacts than technology transfer. Greater concentrations of graduate-level and science and technology degrees are advantageous for earnings growth. Spatial spillovers across neighboring regions indicate a relatively flat spatial gradient of university impacts. Despite the importance of higher education activities, non-university factors—agglomeration economies, industrial composition, educational attainment, and private sector entrepreneurship—generate larger impacts. Small- and medium-sized metropolitan areas demonstrate greater earnings gains from university activities than large regions, confirming that universities can substitute for agglomeration economies in small regions. In large, diverse metropolises, universities are less critical in the economic milieu.

LENDEL (2010) brings the macroeconomic business cycle into prominence, comparing the effects of research universities on employment during an economic expansion from 1998 to 2001 and a contraction from 2002 to 2004. She finds that research university presence positively affects regional employment growth in the expansion period and across the complete macroeconomic cycle, but during the contraction only the most prominent universities exhibit significant (positive) impacts. In signifying research universities solely with dummy variables demarcating research and development activity scale, however, Lendel’s approach disregards substantial information, hiding distinctions among higher education functions and institutional types.

Although the pace of research regarding the economic impacts of universities has slowed recently, scholars continue to investigate subtopics and refine general understandings. Examining metropolitan real wages, WINTERS (2011) finds positive effects from college enrollment and postsecondary educational attainment both separately and together, suggesting both direct and indirect influences of higher education through human capital generation and/or attraction. Research universities seem to support county-level high-technology employment growth solely through human capital creation (FALLAH et al., 2012). Firm births in knowledge-intensive fields benefit from knowledge production and human capital associated with newly established universities in Portugal, but births in other sectors such as low-technology manufacturing are adversely impacted (BAPTISTA et al., 2011; BAPTISTA and MENDONCA, 2010). In the U.S., interactions between university-conducted and government- or industry-led research and development lead to localized firm births and longevity (KIM et al., 2012).

COLOMBO, D'ADDA, and PIVA (2010) report, not surprisingly, that Italian university research boosts employment more for firms started by academic personnel than for other new technology-based firms. University collaborations boost business productivity in the United Kingdom (HARRIS et al., 2011). HUGHES and KITSON (2012) verify for the United Kingdom that commercialization and technology transfer are much less important pathways for knowledge transfer than traditional mechanisms: educating students, academic conferences and publications, and informal contacts. Non-generalizable impact studies of individual universities and programs proliferate (e.g., CLIFFORD and PETRESCU, 2012; GARRIDO-YSERTE and GALLO-RIVERA, 2011; MORRIS et al., 2011; VOGEL and KEEN, 2010).

Recent works advance knowledge of the locational and spatial aspects of university impacts. GOLDSTEIN and DRUCKER's (2006) finding of spatial spillovers across substantial distances is reinforced by several subsequent studies. WOODWARD et al. (2006) find the influence of universities on firm locations peaks at 60 miles (97 km) and is significant as far as 145 miles (233 km) for some industrial sectors. The impact is larger in locations with less initial science and engineering research and development activity. HAUSMAN (2012) demonstrates the beneficial impacts of universities on employment to be greatest in their host counties and substantial in surrounding counties up to 75 miles (121 km) distant. Universities that burden host municipalities with congestion, concentration of students, and tax exemptions, often benefit nearby communities instead (REESE and YE, 2011). Proximity to major sources of venture capital hinders university technology transfer, furthering the idea of universities as substitutes for services and functions found in higher-order population centers; the effect is noticeable within approximately 100 miles (161 km) (WARREN et al., 2008). University technology transfer efforts lose effectiveness with increasing distance from a metropolitan center, though regional-scale industry variables may obscure the relevant distance effects (NAGLE, 2007). HUGGINS and JOHNSTON (2009) verify that universities substitute for agglomeration effects in peripheral regions of the United Kingdom, though not sufficiently to replace the agglomeration-based opportunities of central regions. The impacts of universities on patenting frequency in the United Kingdom depend on migration reallocating human capital among regions (FAGGIAN and MCCANN, 2009). A study of German firm births finds that the importance of spatial distance differs by university function and field of knowledge (AUDRETSCH et al., 2005). Some university links to economic outcomes, such as via direct collaboration on publications and patent applications, depend much more on relational than spatial propinquity (BISHOP et al., 2011; MAGGIONI et al., 2007; PONDS et al., 2010).

There is little systematic empirical research regarding the economic impacts of higher education institutions other than research universities (CROOKSTON and HOOKS, 2012). ROUSE (1998) determines that states focused on public systems of two-year institutions achieve similar attainment as states concentrating on four-year institutions but at half the cost per student. Census data reveal that metropolitan areas have higher proportions of adults possessing bachelor’s (and higher) degrees, whereas rural areas have greater concentrations of adults with associate’s degrees. Two-year institutions are more geographically dispersed, fewer rural residents have the resources to travel to four-year institutions, and two-year colleges usually charge lower tuition and fees and offer more flexible programs and schedules. (KOLESNIKOVA and SHIMEK, 2008; SLAPER et al., 2011). CROOKSTON and HOOKS (2012) find that established community colleges contributed positively to rural employment growth between 1977 and 1997 but negatively from 1998 to 2004, possibly because states with severe fiscal issues cut funding the most. Empirical studies must quantify teaching, vocational, technical, and community college activities with input figures (budget, student counts, faculty size) or the single measurable output obtainable: graduates. As with universities, case studies exist but are not generalizable (PHELPS and PREVOST, 2012; ROSENFELD and SHEAFF, 2002).

3. METHODS

3.1. Research Approach

The research design is based upon the three precursor studies highlighted above, expanding the scope to encompass higher education institutions other than research universities and multiple economic outcomes. Models implementing a cross-sectional approach oriented around the macroeconomic business cycle are estimated using multivariate least squares regression. Although not all university influences can be measured quantitatively, the basic functions of knowledge production and human capital generation are distinguished from the more recent mission of technology development and commercialization. Several indicators of regional higher education institution activities and spatial spillovers arising from educational and other economic activities in proximate regions are included, along with controls for regional characteristics. The explanatory variables precede the outcomes temporally to promote causal interpretations. To help account for path dependence and reduce endogeneity risks, the outcome measures are standardized as changes over time and the base level is included as an independent variable when feasible.

The units of analysis are metropolitan statistical areas (MSAs) of vintage to maximize consistency among data sources (UNITED STATES CENSUS BUREAU, 2009). All variables are reported for MSAs or calculated from county data. The study population of 360 MSAs comprises all but six in the United States, maximizing external validity and statistical power by incorporating as much interregional variation as possible.[3]

To encompass a full national business cycle, the analysis examines the expansion from 2001 to 2007 and the contraction and recovery from 2007 to 2011 separately.[4] This approach is justified by the importance of macroeconomic conditions (LENDEL, 2010) and also means that explanatory variables are measured in reasonably close propinquity to observed outcomes.

The possibility that the independent variables do not fully account for spatial dependence among regions is tested through variable and regression diagnostics and several auxiliary regressions. Because the models explicitly incorporate spatial spillover measures, any remaining spatial autocorrelation cannot be explained substantively; detection of and adjustment for spatial dependence is solely an error-correction procedure. There is evidence of additional spatial dependence in two models, but no significant coefficients differ substantively when they are re-estimated as spatial regression models.[5]

3.2. Dependent Variables

The first regional economic development outcome measure is constructed to match DRUCKER and GOLDSTEIN (2006). The indicator EARNCH starts with average annual earnings per non-farm worker (UNITED STATES BUREAU OF ECONOMIC ANALYSIS, n.d.-b), adjusting for changes in dollar values using the Consumer Price Index[6] (UNITED STATES BUREAU OF LABOR STATISTICS, n.d.) and normalizing as a share of the corresponding national figure. Finally, the dependent variable is the change in the normalized share. The mean regional change in average earnings was negative relative to the United States in the expansion period but (barely) positive from 2007 to 2011 (Table 2). This suggests performance differentials between urban and rural areas (the latter are included in the national figures) or between more and less populous regions (the mean change weights each region equally rather than by population) that flipped across the business cycle.

[Table 2 near here]

Alternative outcomes are considered to evaluate how different aspects of regional economies are influenced by higher education activities and to compare with previous research. Employment change (EMPCH) is the ratio of 2007 to 2001 total nonfarm employment per region, and equivalently 2011 to 2007. The average employment change is positive for both periods, but small standard deviations imply limited interregional variation upon which to base the regression.

Whereas earnings and employment correspond to quality economic opportunities, production signifies output independently of labor conditions. Firms (and higher education institutions) may increase output while reducing or maintaining employment by increasing resource efficiency, labor productivity, substituting inputs, etc. The change in gross metropolitan product per capita (GMPCH) is calculated identically to employment change (UNITED STATES BUREAU OF ECONOMIC ANALYSIS, n.d.-a), and the means and distributions are similar, likewise signifying narrow variation.

Establishment births (BIRTH) and employment in establishment births (BIRTHEMP), each normalized per thousand regional population, indicate regional entrepreneurship. (Births exclude relocations, spinoffs, and new branch plants.) Both derive from Statistics of U.S. Businesses (SUSB), which begins in 2003 and offers its most recent data from 2009 (UNITED STATES SMALL BUSINESS ADMINISTRATION, n.d.).[7] The dependent variables for the expansion period are calculated as the annual average from 2003 to 2007. For 2007 to 2011 the outcomes average the two available years 2008 and 2009. The implicit assumption that entrepreneurship activities held steady between 2009 and 2011 may not be reasonable considering the rapidly changing economic circumstances, and regional time-specific idiosyncrasies may gain prominence in the short interval. Missing data for a handful of MSAs make for slightly fewer observations than in the previous models. Despite these shortcomings, SUSB is a rare high-quality source of entrepreneurship information available at the regional scale nationwide. As might be expected, establishment formation and employment creation declined from the expansion to the contraction portion of the business cycle.

3.3. Higher Education Activities

Three federal sources are utilized to develop measures of the activities of higher education institutions (Table 2). Annual research and development (R&D) expenditures often are employed to indicate university knowledge production because of their accessibility and comparability across regions and over time. They pertain chiefly to research universities. (The data since fiscal year 2004 include all institutions granting bachelor's degrees or higher that perform at least $150,000 of R&D across indicated academic fields. The particular fields have changed several times.) The independent variable UNIVRD sums higher education R&D expenditures in physical science and engineering fields, those that tend to produce knowledge most directly applicable to knowledge-intensive industrial activity (COHEN et al., 2002; VARGA, 2000; WOODWARD et al., 2006), during the five years prior to the analysis period (NATIONAL SCIENCE FOUNDATION, n.d.).[8,9]

To measure the creation of human capital, a series of variables regarding degree awards were derived from IPEDS (NATIONAL CENTER FOR EDUCATION STATISTICS, n.d.). In contrast with earlier studies, associate's and pre-associate's degrees reflect the primary measurable activity of community, vocational, and technical colleges. (Non-degree education, a non-negligible activity for some institutions, is not included.) Despite the expanded coverage in this study, a caution is warranted: degree awards are tracked by institutions rather than individuals, so do not reflect the migration of recipients after graduation.[10] Many permutations were tested to minimize multicolineary and optimize model performance, reflecting three relevant traits: quantity (flow) of academic achievement, distribution of educational outcomes by level, and concentration in science and engineering fields. The three variables included are the share of undergraduate degrees in scientific and engineering fields (UGSCI), the share of pre-bachelor's degrees in scientific and engineering fields (PREBSCI), and the proportion of all degrees at a pre-bachelor's level (PREDEG). Each is averaged across the five preceding years. The first desired trait—achievement quantity—proved highly colinear with R&D expenditures and technology commercialization (described below); therefore, the scale of regional educational activities is included but is not readily distinguishable among university functions.

Technology development is measured by the count of patents granted to universities and university-associated commercialization organizations, PATUNIV (UNITED STATES PATENT AND TRADEMARK OFFICE, n.d.).[11] Patent data have flaws, including that patents do not equate to commercial relevance, yet they reasonably indicate market value of university knowledge and innovation outputs and separate technology transfer and commercialization from traditional basic research (ACS et al., 2002; AGRAWAL and COCKBURN, 2003; SONN and STORPER, 2008). Because the data are not cross-tabulated by organization and region before

2000, the variable for 2001 to 2007 combines patents received in 2000 and 2001. For 2007 to 2011, the variable sums 2002 through 2006.

3.4. Interregional Spillovers

Three variables measure spatial spillovers of educational and other economic activities across regions. ADJMSA, which is the number of MSAs within 60 miles (97 km) (reference region included), indicates basic proximity to other regions, and thus interregional availability of university outputs and agglomeration benefits.[12] Sixty miles is large enough to contain an average metropolitan area commuting shed (ALI et al., 2011), but the particular distance was selected through empirical testing. Smaller and larger distances yield substantively similar though statistically weaker results.

The counts of graduate and undergraduate science and engineering degrees (ADJSCI) and of all degrees awarded at levels beneath a bachelor's degree (ADJPREB), within the same 60 mile radius, together specify improvements to nearby labor forces that may affect the regional economy as well as possible additions to the regional labor market through interregional migration or commuting. They distinguish technically-oriented and low-level degrees from other awards. Various other combinations of proximate degrees demonstrated multicolinearity or failed to provide significant additional explanatory power.

3.5. Control Variables

Many other regional factors may impact economic performance. Non-farm employment (EMPL) broadly proxies the scale of regional agglomeration economies, transformed by natural logarithm to linearize the skewed regional size distribution. The baseline levels of the earnings

(EARN) and production (GMP) dependent variables account for path dependence or cumulative causation (LENDEL, 2010); non-farm employment (EMPL) serves similarly for the employment change models. Regions that start ahead of their competitors may enjoy more opportunities for further economic development and progress. The entrepreneurship models omit starting levels due to the limited years of data available. The regional population growth rate (POPCH) is added as a measure of dynamism to all models except those examining employment change, which is strongly correlated with total population (UNITED STATES CENSUS BUREAU, n.d.-b).

Regional industry structure is incorporated through the earnings shares of manufacturing (MFG and MFGCH) and business and professional services (BSERV and BSERVCH). Both are included as baseline proportions and as share changes over the period.[13] Manufacturing industries are perhaps most able to incorporate technological knowledge directly into commercial practice, and manufacturing earnings helps distinguish long-term declining Rust Belt cities from service-oriented economies. Business and professional services roughly indicates urbanization economies. Commercial entrepreneurial activity is indicated by the earnings share of sole proprietorships (i.e., self-employed individuals), included in level and change forms as PROP and PROPCH, and total patents awarded (PATCOM). The proprietorship variables are omitted from the entrepreneurship models because of the potentially close affiliation with establishment births.

The shares of the adult (25-and-older) population with bachelor's degrees or higher (COLLEGE), and without a bachelor's degree but with at least high school equivalency (HIGHSCH), estimate the education stock of the labor force (UNITED STATES CENSUS

BUREAU, 2012). Because accumulated educational attainment changes very slowly, 2007-2011 data apply to both periods.

Geographic centrality commonly implies travel and transportation accessibility to suppliers, markets, and information, in regional growth and economic development studies. Three dummy variables denote whether each MSA contains an airport classified as a small, medium, or large air hub: HUBSM, HUBMED, and HUBLG (UNITED STATES DEPARTMENT OF TRANSPORTATION, n.d.).[14]

The *Places Rated Almanac* (SAVAGEAU, 2007) offers several measures of regional attractiveness and quality of life. The models include four indices—crime (CRIME), health care access (HEALTH), climate desirability (CLIMATE), and recreation opportunities—each a percentile among regions with zero the least and one the most attractive.[15]

Finally, spatial variation not embodied by the normalized dependent variables or controls may relate to long-term geographic trends, such as out-migration from the industrial Midwest and over-invested Sun Belt housing markets. Major Census Region dummies control for remaining macroregional disparities.[16]

4. EMPIRICAL RESULTS

4.1. Earnings

The earnings (EARNCH) model fit is reasonable but not unusually strong (Table 3). [Lendel (2010) reports coefficients of determination between 0.25 and 0.47]. Some of the statistically significant coefficients have the expected signs but others do not. Tolerance values show overlap but no severe multicolinearity among the independent variables.

[Table 3 near here]

Higher education research and development expenditures (UNIVRD) are insignificant from 2001 to 2007. They are significantly related to regional earnings gains between 2007 to 2011, but the effect is small. R&D is measured in billions of real dollars expended over five years. The estimate translates to a five-year annual average of $176 million in additional expenditures required to raise the earnings index by 0.66, the mean change across all regions. (Currency figures are represented in constant 2012 dollars.) This substantially exceeds the average annual R&D expenditure of $110 million for the 360 study MSAs between 2002 and 2006. Only regions containing the largest research universities or multiple institutions conducting substantial research in engineering and the physical sciences effectively boost earnings through this university activity. The significant, small effect of university R&D corroborates GOLDSTEIN and DRUCKER's (2006) earlier finding.

Of the three regional degree award variables, only the share of pre-bachelor's degrees in science and engineering fields (PREBSCI) significantly influences earnings change at conventional confidence levels, and only in the earlier, expansion period. A greater share of scientific and engineering degrees negatively influences earnings, perhaps indicating that labor demand in those fields is looser than for higher-level education, or that basic skills such as writing and communication are more closely related to earnings growth (a relationship that likely would depend on the composition of the regional economy). The proportion of undergraduate degrees in science and engineering (UGSCI) and the pre-bachelor's share of degrees (PREDEG) are insignificant in both periods. The influence of the degrees earned from regional institutions may be weakened by outflows of graduates to and inflows of graduates from other regions.

Localized human capital creation should be declining in importance over time as both people and information about labor market conditions and opportunities travel more effectively among regions.

Patenting by higher education institutions (PATUNIV) does not exert an effect significant at conventional levels; moreover, the coefficient is positive in the first time period but negative in the second. University patents do not appear to be a consistent influence on regional earnings. Focusing limited institutional resources on technology transfer and commercialization may detract from more effective economic development functions.

The simple tally of neighboring metropolitan regions (ADJMSA) is not influential, but counts of nearby degrees awarded do indicate substantial impacts. Between 2001 and 2007, proximate science and engineering degrees at the undergraduate and graduate levels (ADJSCI) reduce earnings gains, whereas degrees awarded below the bachelor's level (ADJPREB) boost earnings. This might reflect the satisfaction of demand for the type of labor supplied by holders of associate's and other pre-bachelor's degrees, or an influx of higher-level science and engineering degrees suppressing earnings growth in relevant occupations. From 2007 to 2011, the signs of the two degree variables are opposite from the expansion part of the cycle: undergraduate and graduate science and engineering degrees augment and pre-bachelor's degrees suppress earnings gains.[17] Shifting regional economic circumstances following the business cycle, as well as individuals' capacities to relocate, could be affecting the demand (and supply) of labor with divergent effects on the value of undergraduate or graduate science and engineering degrees versus degrees at lower levels and in non-scientific, non-engineering fields. Or perhaps skill accumulation within the labor force, especially in conjunction with slowing growth in labor demand relative to the preceding decade, is altering the relationship between labor supply and demand irrespective of the macroeconomic cycle. Unfortunately, it is not possible to distinguish between these hypotheses within the context of this analysis. The spillover degree variables are measured in units of one hundred thousand degrees over a five-year duration, so the impact scale is modest. Nevertheless, the fact that the influence carries across at least 60 miles adds to the mounting evidence that educational activity impacts diminish slowly with distance and spill across extensive areas.

Addressing potential misrepresentation of the significance of overlapping explanatory variables (LENDEL, 2010, p.215), joint tests of the five intraregional higher education measures and the three spillover variables from 2001 to 2007 demonstrate significance at the 94 percent confidence level. From 2007 to 2011, the regional education variables are jointly significant at 92 percent and the spillover variables are significant with a confidence level exceeding 98 percent.

Higher education activities both within regions and in proximate regions impacts earnings, but other regional factors are more influential. Regions beginning with greater earnings tend to experience larger gains, exhibiting path dependence or cumulative causation. The baseline level of earnings (EARN) wields approximately the same influence, in the same direction, in each phase of the business cycle, so regions that start out ahead maintain and increase their advantage over time. Population change (POPCH) negatively influences average earnings during economic expansion, possibly by spreading income across a greater pool of residents or because of workforce growth pressuring wages downward. In contrast, population growth has a positive impact during the late 2000s recession and recovery, when the causal chain may operate in the reverse direction: areas managing to maintain or grow earnings (or at least avoiding declines) attract more in-migrants.

Educational attainment is a major influence independently of the activities of institutions of higher education in the region and nearby. Especially in the growth years from 2001 to 2007, regions with larger shares of adult residents possessing college degrees (COLLEGE) attain smaller earnings gains, maybe reflecting demand focused on less-skilled, cheaper labor. During the recession and recovery, a greater proportion of the population with a high school but not a college education (HIGHSCH) raises earnings, a finding seemingly in conflict with the effects of pre-bachelor's degrees in proximate regions discussed earlier. The resolution may be related to the distinction between the existing stock of regional workers and the inflow of additional workers from nearby metropolitan areas, noting that degrees awarded at lower than a bachelor's level *within* the region do not significantly alter relative earnings increases. In addition, the result may be a specific characteristic of the recession economy. GOLDSTEIN and DRUCKER (2006) find the opposite in a more typical growth period: greater high-school-and-above education among the non-college-educated population is negatively associated with earnings growth, perhaps from willingness to work in low-wage industries and occupations.

The most influential variables reflect regional economic structure. Areas concentrated in manufacturing (MFG) fare extremely poorly, falling behind in both cycle phases. In addition, MSAs with more rapidly shrinking manufacturing sectors (MFGCH) lag further in earnings gains, as manufacturing is still a high-paying sector. The coefficients of proprietorships' share of earnings (PROP) are negative in both periods. The change in share (PROPCH) switches from negative in the growth phase to positive in the contraction phase. In normal economic times, regional entrepreneurialism may add to job churn while doing little for earnings by substituting for other employment opportunities. During an economic downturn, on the other hand, self-owned enterprises may constitute a fallback economic position and the possibility of at least some earnings as opposed to joblessness. The share of earnings to business and professional services (BSERV) is negatively associated with earnings gains, though significant at conventional levels only between 2007 and 2011. Contrary to expectations of proxying for advantageous regional urbanization economies, the variable, in combination with regional employment and population change, may signify urbanization diseconomies that become more influential during the economic recession and continuing slowdown.

Geographic centrality does not drive earnings changes, with the enigmatic exception of large air transportation hubs (HUBLG) being negatively associated with earnings growth from 2007 to 2011. Higher CRIME scores (i.e., less crime) are related to earnings gains in the earlier period; the relationship fades in the contraction segment of the cycle. Health care access (HEALTH) does not yield significant effects, but CLIMATE and recreation (REC) do. Surprisingly, greater earnings growth is associated with less attractive climates and fewer recreational opportunities. One possible explanation is that the climate and recreation indices effectively proxy formerly rapidly expanding housing and labor markets, which are located primarily in areas featuring mild climates, plentiful sunshine, and suburban amenities. These regions suffered the brunt of the housing market collapse in 2007 and were most strongly affected by the subsequent economic downturn.

Finally, all else being equal, MSAs in the Northeast witnessed slower earnings gains from 2001 to 2007. From 2007 to 2011, Western (and to some extent Southern) regions possessed an advantage. Although the Census Regions differ to some extent in the types of higher education institutions they contain (Section 2.1), that contrast is static; the shifts in differential earnings growth over time suggest that divergent macroregional economic conditions are a more likely cause.

4.2. Alternative Dependent Variables

Table 4 presents the results of the models with the alternative dependent variables. (The tolerance values are omitted as they are very similar to those in Table 3.) The discussion describes the key independent variables indicating higher education activities and compares the results across the different outcomes. Figure 1 summarizes the signs and significance levels of the coefficients of the higher education and spillover measures estimated to be significant influences.

[Table 4 near here]

[Figure 1 near here]

4.2.1. Employment

With employment change (EMPCH) replacing earnings as the dependent variable, the model fit is enhanced for 2001 to 2007 though not for the later time span. A similar number of variables yield significant coefficient estimates. The coefficients are much decreased in magnitude, however, reflecting the smaller absolute variation in the dependent variable.

Educational R&D (UNIVRD) exhibits a similar pattern as for earnings: the coefficient is insignificant for 2001 to 2007, positive and close to significant but substantively small for 2007 to 2011. The other estimates reflecting local educational activities are insignificant. Overall, regional higher education is about as influential as in the earnings model for the expansion phase of the business cycle, but is not influential during the later period, implying that higher education boosts earnings but not employment during a downturn. The earnings effects of educational activities may last longer than the employment impacts, stretching into the contraction portion of the cycle.

Spillovers from neighboring regions are important. As with the earnings models, proximate undergraduate and graduate science and engineering degrees (ADJSCI) diminish employment gains whereas degrees awarded below the bachelor's level (ADJPREB) augment employment from 2001 to 2007, and the relationships are reversed from 2007 to 2011. The count of adjacent regions (ADJMSA) shows a small but significant effect, unlike for the earnings change model, though only in the latter time period. Compared to the mean of slightly fewer than ten neighboring regions, each additional MSA within 60 miles reduces expected employment growth by 0.2 percent, evidence of an adverse influence of greater density at a macroregional scale. Perhaps the net negative interregional spillovers, after accounting for human capital generation, indicate that competition for limited employment opportunities spills across nearby labor markets—an explanation that also might account for the absence of the effect during the less competitive expansion period.

The baseline level of regional employment (included in natural logarithm form as EMPL) indicates a degree of convergence among metropolitan areas. Greater employment in 2001 is associated with slower growth from 2001 to 2007, though the relationship vanishes during the contraction. This is the opposite of the observation from the earnings models that regions with higher average earnings widen their lead.

4.2.2. Production

The production models (GMPCH) are weaker, explaining 29 percent of regional variation for 2001 to 2007 and 35 percent for 2007 to 2011. Items not included in the models, including idiosyncratic factors, may be more important influences on production than on employment or earnings. The five measures of regional higher education activity fail to achieve joint significance in either time period, though together the three spillover effects meet or surpass the significance levels from the previous models.

Individually, higher education activities yield impacts similar to those in the earnings and employment change models. R&D (UNIVRD) has a significant positive impact on production growth only in the latter period, and the effect is small relative to the scale of such expenditures in most regions. Two of the degree award variables—the proportion of undergraduate degrees in science and engineering fields (UGSCI) and the pre-bachelor's share of degrees (PREDEG)—fail to achieve significance, as does patenting activity by educational institutions (PATUNIV). As it does with earnings change, the share of pre-bachelor's degrees in science and engineering fields has a significant negative association with production growth from 2001 to 2007.

The spillover variables also repeat the patterns described earlier. Nearby undergraduate and graduate science and engineering degrees (ADJSCI) hold back production gains between 2001 and 2007 but support increases from 2007 to 2011. Associate's and other pre-bachelor's degrees (ADJPREB) aid productivity in the expansion phase but are associated with smaller production growth during the downturn. The number of adjacent regions (ADJMSA) exhibits a small but significantly negative effect in the contraction period, demonstrating the adverse net impact of spatial spillovers other than human capital noticed earlier with respect to employment change. Although production and employment do not necessarily move together in some industrial sectors (e.g., manufacturing), on an economy-wide basis lagging employment growth may indicate underutilized human capital resources.

The starting level of gross regional product (GMP) produces conflicting implications. The negative association of the 2001 product with growth across the next six years indicates regional convergence, but the equivalent variable yields a positive coefficient between 2007 and 2011. Hard economic times may force controlling actors in regions possessing a greater stock of resources to position those assets in service of raw production, whereas in good economic times more resources and effort are applied to maintaining employment, earnings, and quality of life.

Only one prior model showed a significant effect for college-level educational attainment: a negative influence on earnings change in the expansion period. Interestingly, the college-educated proportion of the population (COLLEGE) contributes positively and significantly to production growth from 2001 to 2007. This may demonstrate the distinction between the application of workforce capabilities to generate efficient production and the allocation of economic returns to those supplying the necessary labor and know-how.

4.2.3. Entrepreneurship

The entrepreneurship variables are not as well explained by the independent variables as are the other aspects of economic performance. The coefficient of determination ranges from over 30 percent for per capita establishment births (BIRTH) from 2008 to 2009 to only 16 percent for employment in new establishments per capita (BIRTHEMP) from 2003 to 2007. The poor fit is not unexpected, given the restricted years of data, slightly fewer observations, and the exclusion of sole proprietorship variables. Moreover, the process of establishing new businesses and generating employment may necessitate intermediate steps and substantial external assistance and time to achieve even when critical stimuli and supports are in place.

Evaluated jointly, higher education institutions do not affect the number of new establishments, but do influence the employment in these new establishments. Examined separately, none of the five measures of the activities of regional educational institutions are significant influences on establishment births in either period or on employment in new establishments from 2003 to 2007. The share of degrees awarded below the bachelor's level (PREDEG) and the fraction of those pre-bachelor's degrees in science and engineering fields (PREBSCI) do exert significant impacts in the 2008 to 2009 period: fewer pre-bachelor's degrees in favor of more advanced awards and greater concentration in science and engineering fields among pre-bachelor's awards encourage entrepreneurial activity.

Spillovers from nearby regions are important to establishment births but have less effect upon employment levels in those establishments. The estimate patterns contrast with the other models. Undergraduate and graduate science and engineering degrees in nearby regions (ADJSCI) detract from establishment creation during the worst of the downturn in 2008 and 2009. Degrees awarded below the bachelor's level (ADJPREB) are associated with more new establishments and greater employment in those establishments, a contrast to the earlier findings of less production, employment growth, and earnings. Neither variable is significant in the expansion period. The count of proximate regions (ADJMSA) has significant negative effects on business creation and employment levels in new businesses during the economic upswing, but with tiny magnitudes. One additional region within 60 miles reduces expected new establishments by only five per hundred thousand residents from 2003 to 2007 (the mean is 273) and diminishes expected employment by seven jobs per hundred thousand residents per year (the mean is about 430). The impact of nearby regions is even smaller in 2008 to 2009. The impact of negative interregional spillovers on entrepreneurship would be expected to be much less direct than for employment growth and gross production.

By far the strongest influences on entrepreneurial outcomes are from population educational attainment. College-level education (COLLEGE) and high-school-equivalency among adults without a bachelor's degree (HIGHSCH) contribute strongly to new business creation and employment in new establishments in both time periods. The airport variables yield the expected influences for the first and only time in this study, with large hubs (HUBLG) powerfully and medium hubs (HUBMED) somewhat less strongly associated with business creation and employment. Southern metropolitan areas generate more new establishments and employment in both periods.

5. CONCLUSIONS

The activities of higher education influence regional economies in the United States less strongly than typically reported in earlier analyses, though several recent studies concur (e.g., CROOKSTON and HOOKS, 2012; FALLAH et al., 2012; REESE and YE, 2011). Research and development buoyed employment, earnings, and production from 2007 to 2011 only modestly, and university patenting largely is unrelated to economic performance. The scale of human capital generation cannot be assessed separately (Section 3.3) but is related closely to the magnitude of research and commercialization activities. For universities, the implications is that concentrating on traditional research and teaching activities is a more effective way of contributing to regional economic performance than technology commercialization. Diminished impacts overall, however, may trouble those who promote higher education as a spur of regional economic development.

Greater shares of bachelor’s and more advanced degrees, and of science and engineering degrees among pre-bachelor’s awards, are associated with more employment in new establishments, particularly in the economic contraction period. In conjunction with the strong relationship measured between local educational attainment and entrepreneurship, this supports policies promoting scientific and engineering degrees and more advanced education as a means toward regional entrepreneurship.

Spatial spillovers of educational activities are substantial. The quantities and types of degrees awarded in proximate regions significantly affect earnings gains, employment growth, and productivity. Establishment births are impacted during the recession and recovery period. Interregional migration likely boosts the importance of spillovers at the expense of the educational activities within the region. This phenomenon may make it more difficult for regions to apply local higher education activities toward economic development goals, but also provides an avenue for regions lacking in higher education activity to capture benefits by attracting recent graduates. The finding also provides a measure of support for the public higher education strategy of concentrating limited resources on select institutions, rather than spreading funding among numerous locally-oriented institutions. In large states, however, the maximum distance across which higher education impacts are influential—60 miles in this research, 100 or even 145 miles in some others—limits the application.

The distribution of regional degrees does not appear to influence economic development outcomes strongly. The share of regional degrees awarded below the bachelor’s level is associated significantly only with one outcome analyzed, (less) employment in new establishments in 2008 and 2009. Earnings and production grew more slowly in regions with a greater concentration of pre-bachelor's degrees in scientific and engineering fields from 2001 to 2007 but not between 2007 and 2011. The impact of the quantity of lower-level degrees awarded in nearby regions is substantial, but varies by period and facet of economic performance. The reported broader engagement of two-year institutions in economic development activities does not seem to be a net positive factor in determining measurable regional economic outcomes. Awarding terminal associate's degrees and technical certificates and readying students for transfer to four-year institutions may remain the dominant missions of community and vocational colleges, allowing policymakers to allocate support among different types of higher education institutions without worrying overly about duplication and competition. Yet it remains unresolved whether the insertion of community colleges into the regional economic development arena is overstated in terms of its influence or just has yet to filter through to economic performance noticeably. The ambiguity offers a constructive area for additional research.

Other regional characteristics tend to be more important than higher educational activities as determinants of economic progress and development. The most influential factors include regional industrial structure; proprietors' earnings (entrepreneurship); educational attainment; population change; macroregional location, including the number of regions located nearby; and regional baseline positions. Most of these characteristics are not subject to direct policy influence, at least in periods shorter than several decades, but entrepreneurship is the exception. Public policies that promote entrepreneurial activity are also likely to improve general economic performance, particularly those supports that enable residents to attempt self-employment initially and to navigate past start-up hurdles to the point of earning positive returns.

Overall, the empirical results appear less straightforward and consistent than in many previous analyses. The study design, however, incorporates numerous explanatory variables, compares disparate economic periods, and examines multiple and plausibly conflicting outcomes. In this light, considerable agreement in fact is reached regarding the influences of higher education activities, especially on earnings, employment, and production growth.

The specific time periods may be critical drivers of the findings. The expansion from 2001 to 2007 was quite weak in historic terms, whereas the succeeding recession and recovery was exceptionally turbulent, with rapidly evolving economic conditions that wreaked havoc upon the assertions of prognosticators and contemporary analysts. Macroeconomic conditions may to some extent overshadow the more subtle distinctions among the different functions of institutions of higher education in this analysis. The relatively weak impacts of higher education activities compared to earlier research may coincide with amplified influences of other factors during the tumultuous periods examined. To understand fully the aggregate and detailed effects of higher educational activities it may be valuable to extend the analysis to a more stable economic period in the near future.

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[1] The author is aware of one other study of university impacts, not yet available publicly at the time of writing, that utilizes regional production. Conversation with one of the authors indicates that their research differs substantially from this effort in that they evaluate a somewhat different set of regional and institutional characteristics, do not include spatial spillovers, and consider only research universities.

[2] The primary exception is the set of national military service academies and graduate institutions.

[3] The cities of Chicago, Los Angeles, and New York are excluded, wherein the exceptional volume of economic activity certainly overwhelms local university contributions and MSA boundaries are less appropriate approximations of functional economic areas. The values are retained in calculating spillover measures. MSAs in Alaska and Hawaii are omitted due to geographic isolation and peculiarities of county boundaries in those states.

[4] The middle of 2001 through the start of 2003 is sometimes considered a brief recessionary period. The unemployment rate rose, but the United States did not experience a two-quarter decline in gross domestic product and the national economic conditions more closely resemble the years immediately following than those preceding.

[5] Diagnostic tests signal spatial dependence in two of the ten models presented. Spatial lag and error regressions were estimated using maximum likelihood techniques. Compared with the ordinary least squares results, only two independent variable coefficients cross a 90 or 95 percent confidence threshold, both by a very small margin, and no

significant coefficient estimates alter sign or otherwise change enough to affect substantive interpretations. The spatial regression outputs are available by request.

[6] The adjustment uses the series best matching each MSA. Some MSAs have their own series; smaller MSAs are classified by Census Region. The 'all urban consumers' series is applied to the national figures.

[7] The data are updated irregularly (author communication with Small Business Administration representatives). The 2009 figures became available in June, 2013.

[8] Physical science and engineering includes aerospace, chemical, civil, electrical, materials, mechanical, other, and unspecified engineering; agricultural, atmospheric, biological, earth, and medical sciences; astronomy, chemistry, computer science, mathematics and statistics, oceanography, and physics; other geosciences, other life sciences, and other physical sciences; and unspecified life and other sciences.

[9] Robustness checks include testing a broader variable including social sciences, and total R&D across all academic fields (available from 2003 onward).

[10] Unfortunately, not only do data tracking graduate locations over time not exist on a national scale, but no such information is publicly available even pertaining to individual institutions. Thus degree awards are commonly used in the literature, and the shortcoming must be considered in evaluating empirical findings. In general, greater interregional mobility of graduates would reduce measured regional impacts as the relationship between degree receipt and participation in the regional labor market diminishes but may increase spillovers across regions.

[11] The United States Patent and Trademark Office does not provide information for institutions with fewer than three patents awarded between 2000 and 2011. It is unlikely that these missing patents, being small in quantity, would substantially affect the quantitative results obtained. Patents listed as being awarded in metropolitan areas in which the university assignee does not operate are excluded from the analysis as likely products of joint or contractual research with unreliable geographic assignment.

[12]Great circle distances between centroids are calculated using county boundaries from the Topologically Integrated Geographic Encoding and Referencing data system UNITED STATES CENSUS BUREAU (n.d.-c) Topologically Integrated Geographic Encoding and Referencing (TIGER), Washington, D.C..

[13] A few MSAs lack manufacturing or business services earnings data in each year. Robustness checks, conducted by estimating a model without manufacturing and/or business services earnings and by substituting the regional mean for the missing areas, confirm the findings presented.

[14] Regions with multiple airports are assigned to the largest applicable category.

[15] The latest edition predates the 2009 MSA definitions, so indices for the few missing MSAs are estimated from nearby regions. For MSAs with multiple divisions, the almanac's rankings are combined into a single MSA value. Details of both procedures are available by request.

[16] The major Census Regions are described in the note to Table 1. United States Census Bureau UNITED STATES CENSUS BUREAU (n.d.-a) Census Regions and Divisions of the United States. provides more detail.

[17] To verify that the significance of the two variables is not an artifact of their joint inclusion, a suspicion raised by their opposite and exchanging signs, supplemental regressions were estimated that alternatingly dropped one of the variables. The results were mixed: the remaining coefficient was sometimes significant with the same sign as in Table 2 and was sometimes insignificant. Although the robustness tests do not aid in the coefficient interpretation, the significances do not appear to be a statistical artifact.

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Table 2. Variable Sources and Descriptive Statistics.

Dependent Variable	*Description*	*Source*	*Period One Year(s)*	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*	*Period Two Year(s)*	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*
EARNCH	Adjusted change in average earnings	BEA, BLS	2001-2007	-2.69	4.86	-19.33	23.86	2007-2011	0.66	4.04	-16.80	20.31
EMPCH	Change in nonfarm employment	BEA	2001-2007	1.10	0.09	0.91	1.54	2007-2011	0.97	0.04	0.84	1.18
GMPCH	Change in real gross metropolitan product per capita	BEA	2001-2007	1.09	0.09	0.86	2.05	2007-2011	0.96	0.07	0.75	1.36
BIRTH	Establishment births per thousand capita	SBA	2003-2007	2.73	1.45	0.54	16.36	2008-2009	1.94	0.73	0.39	7.81
BIRTHEMP	Employment in births per thousand capita	SBA	2003-2007	21.67	11.63	2.53	116.00	2008-2009	14.78	5.70	1.65	60.11

Independent Variable	*Description*	*Source*	*Period One Year(s)*	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*	*Period Two Year(s)*	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*
UNIVRD	University R&D expenditures (billions)	NSF	1996-2000	0.39	0.93	0.00	7.29	2002-2006	0.55	1.29	0	10.37
UGSCI	Science & engineering share of undergraduate degrees	NCES	1996-2000	0.21	0.13	0	1	2002-2006	0.20	0.13	0	1
PREBSCI	Science & engineering share of pre-bachelor's degrees	NCES	1996-2000	0.33	0.15	0	1	2002-2006	0.36	0.15	0	0.89
PREDEG	Pre-bachelor's share of all degrees	NCES	1996-2000	0.48	0.28	0	1	2002-2006	0.47	0.28	0	1
PATUNIV	University patents (hundreds)	USPTO	2000-2001	0.12	0.36	0	4.10	2002-2006	0.29	0.87	0	9.27
ADJMSA	MSAs within 60 miles	Census	-	10.96	6.68	1	29		*same as Period One*			
ADJSCI	Undergrad & grad science deg., 60 miles (hundred thousands)	NCES	1996-2000	60.03	43.10	0	209.67	2002-2006	66.14	47.38	0	241.29
ADJPREB	Pre-bachelor's degrees, 60 miles (hundred thousands)	NCES	1996-2000	126.18	88.15	1.13	497.90	2002-2006	149.48	105.91	0.90	518.60
EMPL	Natural logarithm of nonfarm employment	BEA	2001	11.98	1.05	9.69	15.05	2007	12.07	1.05	10.05	15.17
GMP	Gross metropolitan product per capita (ten thousands)	BEA	2001	3.42	0.94	1.56	7.92	2007	3.72	1.06	1.47	8.62
EARN	Average earnings as pct. of U.S. figure	BEA, BLS	2001	99.59	15.59	70.71	205.31	2007	96.91	15.41	68.58	191.66
POPCH	Pct. change in population	Census	2001-2007	1.04	1.14	-2.75	8.59	2007-2011	0.96	0.81	-0.96	3.59
MFG*	Manufacturing share of earnings	BEA	2000	0.18	0.10	0.02	0.59	2006	0.14	0.09	0.01	0.54
MFGCH*	Change in manufacturing share of earnings	BEA	2000-2007	-0.04	0.03	-0.14	0.03	2006-2011	-0.02	0.02	-0.12	0.05
BSERV*	Business services share of earnings	BEA	2000	0.05	0.03	0.01	0.21	2006	0.10	0.05	0.00	0.32
BSERVCH*	Change in business services share of earnings	BEA	2000-2007	0.05	0.04	-0.04	0.27	2006-2011	0.01	0.02	-0.11	0.09
PROP	Proprietor's share of earnings	BEA	2000	0.11	0.04	0.04	0.35	2006	0.12	0.04	0.02	0.30
PROPCH	Change in proprietor's share of earnings	BEA	2000-2007	-0.01	0.02	-0.08	0.06	2006-2011	-0.01	0.02	-0.08	0.05
PATCOM	Commercial patents (thousands)	USPTO	2000-2001	0.38	1.04	0.00	12.19	2002-2006	0.96	2.80	0.00	34.79
COLLEGE	Pct. 25+ with bachelor's degree or greater	Census	2007-2011	0.26	0.08	0.12	0.58		*same as Period One*			
HIGHSCH	Pct. 25+ with high school but not bachelor's degree	Census	2007-2011	0.60	0.06	0.36	0.73		*same as Period One*			
HUBSM	Small airport hub (dummy)	BTS	2001	0.16	0.37	0	1	2007	0.17	0.37	0	1
HUBMED	Medium airport hub (dummy)	BTS	2001	0.08	0.26	0	1	2007	0.08	0.27	0	1
HUMLG	Large airport hub (dummy)	BTS	2001	0.06	0.24	0	1	2007	0.06	0.23	0	1
CRIME	Crime index	Places	2007	0.50	0.29	0	1		*same as Period One*			
HEALTH	Health care access index	Places	2007	0.50	0.29	0	1		*same as Period One*			
CLIMATE	Climate index	Places	2007	0.49	0.29	0	1		*same as Period One*			
REC	Recreation index	Places	2007	0.49	0.29	0	1		*same as Period One*			
NORTHEAST	Northeast Census Region (dummy)	Census	-	0.12	0.33	0	1		*same as Period One*			
MIDWEST	Midwest Census Region (dummy)	Census	-	0.25	0.44	0	1		*same as Period One*			
SOUTH	South Census Region (dummy)	Census	-	0.41	0.49	0	1		*same as Period One*			
WEST	West Census Region (dummy)	Census	-	0.21	0.41	0	1		*same as Period One*			

Abbreviations: BEA = Bureau of Economic Analysis; BLS = Bureau of Labor Statistics; BTS = Bureau of Transportation Statistics; Census = United States Census Bureau; MSA = Metropolitan Statistical Area; NCES = National Center for Education Statistics; Places = *Places Rated Almanac* (Savageau, 2007); SBA = Small Business Administration; USPTO = United States Patent and Trademark Office.

* Manufacturing share of earnings missing for seven MSAs in 2000 and six MSAs in 2006. Change in manufacturing share of earnings missing for ten MSAs from 2000 to 2007 and 2006 to 2011. Business services share of earnings missing for six MSAs in 2000 and two MSAs in 2006. Change in business services share of earnings missing for seven MSAs from 2000 to 2007 and two MSAs from 2006 to 2011.

Table 3. Model Results: Dependent Variable—Earnings (EARNCH).

	2001 - 2007				2007 - 2011			
Variable	*Coeff.*	*p value*		*Tol.*	*Coeff.*	*p value*		*Tol.*
intercept	8.114	.319		-	-3.926	.542		-
UNIVRD [a]	-0.117	.835		.174	0.747	.013	**	.200
UGSCI [a]	-1.110	.595		.612	2.454	.119		.739
PREBSCI [a]	-4.510	.008	**	.764	-0.924	.485		.755
PREDEG [a]	-0.814	.445		.507	-0.113	.889		.558
PATUNIV [a]	1.760	.187		.193	-0.583	.169		.212
ADJMSA [b]	0.010	.869		.284	0.024	.628		.274
ADJSCI [b]	-3.214	.008	**	.174	1.892	.025	**	.185
ADJPREB [b]	1.016	.058	*	.212	-1.159	.001	**	.206
EMPL	-0.073	.887		.164	-0.310	.442		.169
EARN	0.055	.037	**	.282	0.061	.001	**	.381
POPCH	-0.476	.052	*	.602	1.320	.000	**	.548
MFG	-16.211	.000	**	.335	-10.763	.001	**	.420
MFGCH	23.873	.015	**	.470	35.401	.001	**	.693
BSERV	-17.033	.226		.313	-13.994	.020	**	.366
BSERVCH	-8.139	.307		.615	0.743	.941		.857
PROP	-20.443	.006	**	.477	-16.336	.005	**	.608
PROPCH	-33.234	.009	**	.567	43.140	.000	**	.668
PATCOM	-0.058	.878		.299	0.255	.014	**	.350
COLLEGE	-14.594	.027	**	.180	-3.014	.536		.202
HIGHSCH	-4.865	.447		.282	15.647	.003	**	.266
HUBSM	0.605	.427		.608	0.372	.538		.582
HUBMED	0.301	.805		.453	-1.025	.279		.445
HUMLG	-1.417	.396		.284	-2.271	.085	*	.315
CRIME	2.345	.018	**	.587	-0.036	.962		.592
HEALTH	-1.211	.202		.613	-0.615	.421		.589
CLIMATE	-3.630	.003	**	.390	-3.252	.001	**	.397
REC	-1.479	.155		.527	-2.241	.008	**	.509
MIDWEST	3.425	.000	**	.269	0.508	.509		.260
SOUTH	4.003	.000	**	.199	1.286	.111		.189
WEST	4.232	.000	**	.235	2.177	.010	**	.242
Observations	343				348			
R^2, adjusted R^2	.369	.309			.420	.365		
F-test: university	2.166	.058	*		2.032	.074	*	
F-test: spillovers	2.539	.057	*		3.663	.013	**	

* Significant at 90% confidence level. ** Significant at 95% confidence level.
[a] Included in university F-test. [b] Included in spillovers F-test.

Table 4. Model Results: Alternative Dependent Variables.

	Employment (EMPCH)				Production (GMPCH)				Establishment Births (BIRTH)				Employment in Births (BIRTHEMP)			
	2001 - 2007		2007 - 2011		2001 - 2007		2007 - 2011		2003-2007		2008-2009		2003-2007		2008-2009	
Variable	*Coeff.*	*p value*	*Coeff.*	*p value*	*Coeff.*	*p value*	*Coeff.*	*p value*	*Coeff.*	*p value*	*Coeff.*	*p value*	*Coeff.*	*p value*	*Coeff.*	*p value*
intercept	1.340	.000 **	1.100	.000 **	1.361	.000 **	0.955	.000 **	3.313	.197	0.653	.604	30.875	.156	-0.835	.934
UNIVRD [a]	-0.007	.418	0.005	.140	-0.008	.498	0.011	.062 *	-0.192	.279	0.000	.395	-1.844	.219	-0.001	.274
UGSCI [a]	-0.053	.104	-0.008	.624	0.011	.807	0.046	.127	-0.498	.449	-0.457	.141	-5.817	.321	-3.890	.162
PREBSCI [a]	-0.033	.218	0.008	.580	-0.061	.088 *	-0.002	.947	0.627	.247	0.388	.141	6.637	.151	4.708	.028 **
PREDEG [a]	-0.008	.629	0.006	.516	0.007	.770	-0.001	.939	-0.359	.283	-0.216	.169	-4.351	.137	-2.935	.024 **
PATUNIV [a]	-0.013	.540	-0.006	.184	0.004	.891	-0.013	.117	-0.180	.671	0.000	.766	-1.120	.754	0.001	.839
ADJMSA [b]	0.000	.901	-0.002	.002 **	-0.002	.194	-0.002	.086 *	-0.049	.011 **	-0.031	.001 **	-0.351	.033 **	-0.204	.009 **
ADJSCI [b]	-0.055	.003 **	0.016	.077 *	-0.073	.005 **	0.056	.001 **	0.017	.964	-0.004	.012 **	4.147	.202	-0.015	.257
ADJPREB [b]	0.017	.042 **	-0.008	.053 *	0.035	.002 **	-0.026	.000 **	0.124	.466	0.002	.001 **	-0.584	.688	0.010	.072 *
EMPL	-0.016	.037 **	0.001	.797	-0.013	.218	-0.001	.917	-0.625	.000 **	-0.188	.014 **	-3.688	.007 **	-0.157	.799
GMP					-0.018	.022 **	0.014	.004 **								
POPCH					-0.020	.000 **	-0.002	.711	0.115	.159	0.060	.302	0.241	.728	0.717	.127
MFG	-0.159	.006 **	-0.112	.001 **	0.438	.000 **	-0.098	.112	-1.029	.376	-0.132	.829	-8.406	.393	-0.056	.991
MFGCH	0.404	.009 **	0.228	.039 **	1.137	.000 **	0.564	.005 **	-4.632	.140	-0.793	.695	-25.344	.344	-8.594	.606
BSERV	0.043	.844	0.000	.999	-0.206	.484	-0.199	.084 *	6.420	.155	0.492	.683	60.316	.114	7.927	.418
BSERVCH	0.370	.003 **	0.274	.012 **	-0.017	.918	-0.009	.964	4.119	.103	-0.757	.707	41.903	.050 **	-0.691	.966
PROP	-0.040	.734	0.067	.283	-0.391	.016 **	0.109	.336								
PROPCH	-0.729	.000 **	0.037	.777	-0.813	.003 **	0.665	.004 **								
PATCOM	-0.003	.548	0.001	.271	0.008	.294	0.007	.000 **	0.046	.687	0.000	.742	0.268	.780	0.000	.660
COLLEGE	0.094	.351	0.017	.747	0.250	.081 *	0.012	.907	6.860	.001 **	4.680	.000 **	31.638	.068 *	17.963	.020 **
HIGHSCH	-0.087	.387	-0.152	.006 **	-0.159	.238	0.081	.417	5.997	.002 **	3.469	.001 **	28.821	.084 *	16.914	.035 **
HUBSM	0.005	.690	0.007	.315	0.032	.048 **	-0.012	.320	0.119	.622	0.239	.048 **	1.124	.581	1.316	.177
HUBMED	0.022	.248	0.007	.471	0.050	.053 *	-0.009	.640	0.487	.210	0.401	.035 **	7.363	.026 **	3.540	.021 **
HUMLG	0.054	.040 **	0.001	.919	0.052	.141	-0.046	.075 *	1.227	.022 **	0.918	.001 **	12.902	.004 **	6.317	.003 **
CRIME	0.020	.188	0.024	.004 **	0.002	.907	0.020	.176	-0.264	.402	0.002	.183	-1.497	.575	0.016	.200
HEALTH	-0.038	.010 **	-0.013	.124	0.023	.261	-0.001	.937	0.293	.335	0.001	.498	1.027	.693	0.009	.456
CLIMATE	0.016	.391	-0.045	.000 **	0.016	.536	-0.078	.000 **	0.901	.019 **	-0.001	.749	5.602	.085 *	-0.017	.267
REC	0.018	.249	-0.040	.000 **	-0.003	.877	-0.040	.014 **	0.629	.054 *	0.001	.402	1.259	.649	-0.002	.894
MIDWEST	0.009	.559	0.003	.762	-0.014	.499	-0.009	.524	0.465	.128	0.006	.971	4.171	.112	1.134	.359
SOUTH	0.071	.000 **	0.021	.012 **	0.028	.190	0.023	.134	0.728	.022 **	0.416	.010 **	6.001	.027 **	4.158	.001 **
WEST	0.040	.017 **	-0.019	.038 **	0.054	.020 **	-0.002	.926	0.193	.579	0.226	.166	-0.072	.981	0.920	.483
Observations	343		348		343		348		339		345		333		340	
R^2, adjusted R^2	.534	.492	.404	.351	.287	.219	.353	.291	.245	.179	.309	.251	.158	.084	.266	.203
F-test: university	2.520	.030 **	0.768	.573	0.717	.611	1.251	.285	1.424	.215	1.563	.170	1.876	.098 *	2.422	.036 **
F-test: spillovers	2.007	.113	8.150	.000 **	4.263	.006 **	7.133	.000 **	2.355	.072 *	6.878	.000 **	1.720	.163	3.225	.023 **

* Significant at 90% confidence level. ** Significant at 95% confidence level. [a] Included in university F-test. [b] Included in spillovers F-test.

Figure 1. Summary of Model Estimates for Key Explanatory Variables.

Regional	Earnings		Employment		Production		Births		Empl. in Births	
Higher Educ.	'01-'07	'07-'11	'01-'07	'07-'11	'01-'07	'07-'11	'01-'07	'07-'11	'01-'07	'07-'11
UNIVRD		+ +				+				
UGSCI										
PREBSCI	− −				−					+ +
PREDEG										− −
PATUNIV										
joint	X	X	X X						X	X X
Spillovers										
ADJMSA				− −		−	− −	− −	− −	− −
ADJSCI	− −	− −	− −	+	− −	+ +		− −		
ADJPREB	+	− −	+ +	−	+ +	− −		+ +		+
joint	X	X X		X X	X X	X X	X	X X		X X

Note: 1 symbol = significant at 90% confidence level, 2 symbols = significant at 95% confidence level.