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AN EXPLORATORY ASSESSMENT OF REGIONAL KNOWLEDGE-BUILDING CAPACITY

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Abstract

The knowledge economy has been argued to be a characteristic of leading economies today, following the development of an information economy. However, scholars have differed markedly in their approaches to study the concept. Reviewing the breadth of literature, this paper explores the concept of continuous innovation to study knowledge-building capacities among regions. Using three industry measures related to innovation at a regional level – employment base, productivity, and productivity growth of research and development workers – the author compares the knowledge-building capacities of all metropolitan regions in the U.S. This exploratory method captures the dynamism in continuous innovation in a knowledge economy. The results show plausible findings based on experiences of leading metropolitan regions. These lead to three theoretical and policy implications. First, they show how government support is an important ingredient to create knowledge-building capacities. Second, knowledge industries are not restricted to high-tech industries. And third, it is important to create both quality and quantity of innovation through collaborations and entrepreneurship. The study concludes with limitations and proposed future research directions.

Keywords

Knowledge, knowledge worker, knowledge economy, innovation, human capital

Introduction

Scholars have long touted the importance of the growth in physical and human capital as well as technical progress as principle sources of economic growth [11] [12] [21] [22] [23] [34]. Tied to this phenomenon is the emphasis on knowledge, whose value is reflected by the demand for knowledge goods and the salaries of knowledge workers [14]. Today, the technologically advanced economies have created a competitive edge where knowledge has become yet another critical factor, beyond land capital and labor, in determining the standard of living [37]. Gaps in innovation capabilities increasingly determine income disparities [33].

The knowledge economy therefore, highlights an important economic shift as the dynamics of production change. Among regions, economic development initiatives are therefore increasingly implemented to manage this shift [3]. These initiatives include value-oriented processes that emphasize innovation, learning, and technology commercialization. However, underlying these mechanisms is the foundation of human capital. Research has shown that the availability of talents in a region forms the basis for innovation, which is fundamental to the knowledge economy.

However, the concept of a knowledge economy is abstract. It follows that the means to gauge the level of regional knowledge-building capacity is challenging. This refers to the ability of a region to create continuous innovation in its economic production for sustainable growth. As the arguments in this paper will show, the mechanism for continuous innovation is a critical component of the knowledge economy.

This exploratory paper proposes the use of industry level data to gauge the knowledge capacity of a region. By comparing the relative employment base of workers engaged in research and development (R&D) and the productivity of the R&D industry among metropolitan regions in the U.S., the author draws preliminary conclusions about the exploratory measurement of knowledge-building capacities. The paper includes a discussion of theoretical and policy implications.

The study is structured as follows. The subsequent section (Section 2) comprises a review of literature on the knowledge economy to derive a working definition for purposes of this research. It includes a discussion of the theoretical importance of human capital in the knowledge economy to establish the grounds for using employment as an important construct in the proposed method. Section 3 comprises a description of the research method used to construct the means of comparison across U.S. metropolitan regions. Section 4 contains a summary of findings. Finally, in Section 5, the author discusses the theoretical and policy implications and concludes with limitations and future research directions.

Review of Literature

The review of literature comprises two main sub-sections. The first includes a discussion of the knowledge economy to derive a working definition using innovation as a proxy to understand the abstract concept. The second elaborates the discussion to include human capital as it is tied closely to innovation from an industry point of view.

Defining the knowledge economy

There are wide variations of the term knowledge economy [9]. It is therefore, useful to review trends in the literature to derive a working definition of the knowledge economy. Among its characteristics, the knowledge economy involves the development and utilization of information and communication technologies (ICTs), emphasizes education, and focuses on innovation [14] [15] [19]. In the broadest sense, the knowledge economy is not entirely based on material inputs. Rather, its productive and distributive processes are oriented around knowledge-based inputs [36]. Bell postulated that knowledge represents the source of innovation [7]. According to Bell, knowledge is "a set of organized statements of facts or ideas, presenting a reasoned judgment or an experimental result, which is transmitted to others through some communication medium in some systematic form" [7]. Thus, knowledge can be perceived as value-added information.

Scholars have taken three different approaches to study the knowledge economy [9] [32]. The first is characterized by the growth of science-based industries and how they trigger societal change. Here, researchers studied knowledge as a factor in facilitating production [5] [20] [24] [25] [31]. While useful in creating a theoretical framework, the knowledge economy is very broadly defined in this approach. The publishing industry for instance, can be seen as a science-based industry but may not be entirely be knowledge-based [32].

Researchers taking the second approach focus on specific IT industries that make particular use of scientific and professional knowledge [9], such as the semi-conductor industry. Here, researchers analyze new market opportunities, product development, and production processes amidst rapidly changing production requirements [1]. In this second approach, although knowledge is more clearly defined, the forms of knowledge which deserve emphasis are, however, not agreed upon [9]. These include highly trained managers, engineers, and planners [16], high technology industries [8], health, education and government services [7], and finance and accounting services [35].

The third approach in the knowledge economy is characterized by learning and continuous innovation. This narrower definition focuses on the less tangible aspects of human capital such as learning and adaptability [14] [15]. Studies taking this approach focus on social conditions that facilitate or impede knowledge creation and transference [10]. It follows that competence building is a critical ingredient for the knowledge economy [2]. This approach accounts for the dynamism involved in the concept and allows researchers to focus on the human capital element that is critical to innovation, and hence knowledge creation

Innovation and the knowledge economy

Innovation is emphasized directly and indirectly in all three approaches to the knowledge economy. However, only the third approach directly uses continuous innovation as a key characteristic of knowledge production. According to Gates, knowledge-intensive firms can systematically adapt to new technological applications [17]. It follows that an ability to create continuous innovation is a key facet of the knowledge economy. Baark emphasized the importance of innovation in a study of the knowledge economy, in which continuous innovation will facilitate to a continuous cycle of knowledge creation [4]. According to Yeo, knowledge is cumulative. Hence, a continuous learning process becomes a key to a sustainable knowledge economy [38].

Scholars utilizing the third approach perceive the knowledge economy as a continuously evolving entity instead of a fixed configuration. This can be applied to any industry that employs innovative practices and devotes efforts to create more productive processes.

In today’s world, many industries utilize IT in their production processes. It is therefore, less meaningful to use technology penetration statistics to gauge the level of knowledge-orientation. As discussed, information differs markedly from knowledge.

Therefore, using information technology related statistics alone to represent the knowledge economy may be a microscopic view. It may be more useful to assess the basis for innovation instead. The underlying mechanism of innovation however, resides in an effective leverage of human capital. Therefore, knowledge workers can be seen as those who are constantly producing and contributing to the innovation cycle.

Taken together, innovation is recognized by researchers as a key characteristic of the knowledge economy. Therefore, continuous innovation can be used as a proxy to study the knowledge building capacity of a region. Since human capital is a key resource of innovation, the next section discusses the importance of human capital in a knowledge economy.

The importance of human capital

Human capital has been touted by scholars and practitioners alike to be critical in the knowledge economy. Being intangible and dynamic, economic well-being in the knowledge economy is dependent on technology dynamism and results. Successful regions are able to transfer innovation from creation to commercialization effectively and efficiently. In this process, human capital, in the form of talented professionals, can be leveraged to facilitate the production of innovation.

With their capacity to create and transfer knowledge, talented professionals are transformed to critical human capital that is integral to innovation. In view of this, training programs, including educational systems, are designed and promoted to grow human capital. Indeed, according to DeVol, investments in education and work-based learning procedures are important ingredients for economic growth [13].

Nobel laureate Gary Becker has also explained the importance of human capital: "The continuing growth in per capita incomes of many countries during the nineteenth and twentieth centuries is partly due to the expansion of scientific and technical knowledge that raises the productivity of labor and other inputs in production. The increasing reliance of industry on sophisticated knowledge greatly enhances the value of education, technical schooling, on-the-job training, and other human capital" [6].

Method

The importance of innovation and how it stems from human capital point to the relevance of knowledge workers in a knowledge economy. It follows that the research and development (R&D) industry may be a key to gauge the innovation building mechanism in a region. According to the North American Industry Classification System NAICS), code 5417 depicts the industry engaged in Scientific Research and Development Services. This includes various forms of R&D and goes beyond the conventionally understood high-tech or information technology industries.

From the review of literature, two terms have been crucial to the assessment of knowledge-building capacities: continuous innovation and human capital. These translate into three constructs that can be measured quantitatively: the employment base of R&D workers, productivity of the R&D industry, and growth in its productivity.

The study utilizes annual industry level data over a span of five years (2004 to 2008) by metropolitan statistical areas (MSAs) in the U.S. to construct a composite measure of knowledge-building capacity for each region. Metropolitan statistical areas are used instead of cities because they can capture a broader scope of collaborations across states. For purposes of this study, these are referred to as metropolitan regions or MSAs.

Since each of the three constructs (the employment base of R&D workers, productivity of the R&D industry, and five-year growth in its productivity) are theoretically related to knowledge-building capacity, the product of the three constructs can possibly reflect this capacity.

The employment base of the R&D industry by region refers to the location quotient of the industry relative to the U.S. average. This technique can ascertain the degree in which a region's products exceed the local demand and hence move beyond its local markets. Taken to the U.S. average, a score of 1.0 will mean that the base is equivalent to the U.S. average. A region with a higher score has a stronger the base in that industry.

The formula to calculate the employment base, or location quotient, is given as follows, where X denotes the R&D industry.

Formula 1. Font sizes of headings

$$\frac{\text{Regional Employment in Industry X / Region's Total Employment}}{\text{U.S. Total Employment in industry X / U.S. Total Employment}}$$

Productivity is related to economic output. A region with a higher level of productivity is one that achieves a higher level of output per unit worker. Applying this concept to the R&D industry, it becomes possible to assess the productivity of the industry in each of the regions under investigation.

In this paper, this concept of productivity is measured over a period of five years to gauge provide the continuity element. A region whose R&D industry is continuously productive will be one that has a stronger base for continuous innovation. For purposes of comparison, the relative growth in productivity will be used, whereby the productivity growth in the R&D industry is divided by the same growth for the U.S. in the same period. Similar to the calculation of location quotients, a relative productivity growth of 1.0 suggests that the R&D industry in a region is growing at the same rate as the national average.

The data for each metropolitan region were collected and compared for analysis. While this approach is theoretically possible, it is highly exploratory and does not constitute the only method to measure the knowledge-building capacity of a region. This is discussed further in the final section on limitations and future research directions.

Findings

The findings for each of the three constructs will be presented consecutively. For purposes of this paper, the top 10 regions will be shown. This will facilitate the discussion of key highlights in the regions' respective performances.

In Section 4.4, the composite scores will be shown and discussed. Since this represents a more detailed discussion, the top 20 metropolitan regions will be shown. This is followed by the implications of the proposed method in assessing regional knowledge-building capacities.

Employment base

The location quotients (LQ), a measurement for R&D employment base, for the respective R&D industries in each metropolitan region were calculated and ranked. The following table shows the results of the rankings in 2008.

Table 1. Top 10 regions in R&D Location Quotients, 2008

Rank	Metropolitan Area	Location Quotient
1	Kennewick-Pasco-Richland, WA	10.15
2	Cambridge-Newton-Framingham, MA	7.54
3	Durham, NC	7.30
4	Boulder, CO	7.23
5	Bethesda-Frederick-Gaithersburg, MD	6.13
6	Albuquerque, NM	5.99
7	Trenton-Ewing, NJ	5.62
8	San Jose-Sunnyvale-Santa Clara, CA	4.84
9	Huntsville, AL	4.41
10	San Diego-Carlsbad-San Marcos, CA	4.30

Source: Moody's Economy.com

Based on the results, Kennewick in Washington was the top ranked metropolitan region. This is followed by Cambridge in Massachusetts and then Durham in North Carolina. These findings show that these 10 metropolitan regions have the highest employment base of R&D workers. In other words, they have a higher concentration of R&D workers relative to the U.S.

Productivity

The productivity levels of the R&D industry in each metropolitan region, given as thousands of dollars per worker, were calculated and ranked. The results for 2008 are given in the following table.

Table 2. Top 10 regions in R&D productivity, 2008.

Rank	Metropolitan Area	Productivity (Ths. Per worker)
1	Vineland-Millville-Bridgeton, NJ	1461.01
2	Pocatello, ID	817.96
3	Rochester, MN	709.89
4	Harrisonburg, VA	585.52
5	Rochester, NY	566.01
6	Coeur d'Alene, ID	549.82
7	Lubbock, TX	545.29
8	Greenville, NC	523.60
9	Midland, TX	517.22
10	Roanoke, VA	516.71

Source: Moody's Economy.com

Based on the R&D industry alone, these metropolitan regions, led by Vineland in New Jersey, have produced the highest amount per worker. It is important to note that these top regions are markedly different from the top 10 in employment base pertaining to the R&D industry. Incidentally, none of the top 10 in this measure appeared in the measure on location quotients.

Growth in productivity

Measuring a five-year growth in productivity relative to the same growth in the U.S., the following table shows the top 10 metropolitan regions that have performed best in this regard. Again, this pertains specifically to the R&D industry of these regions.

Table 3. Top 10 regions in R&D productivity growth, 2003-2008

Rank	Metropolitan Area	Relative Productivity Growth (2003-2008)
1	Vineland-Millville-Bridgeton, NJ	8.15
2	Greenville, NC	4.46
3	Midland, TX	4.00
4	Lubbock, TX	3.96
5	Idaho Falls, ID	3.58
6	Tyler, TX	3.43
7	Rochester, NY	3.01
8	Roanoke, VA	2.69
9	Columbia, MO	2.64
10	Pocatello, ID	2.52

Source: Moody's Economy.com

Some of the top 10 regions here appear in the top 10 in the measure on productivity. Vineland in New Jersey and Rochester in New York have shown high growth in productivity and had one of the most productivity R&D industries in 2008. However, again, the lists of top 10 regions are markedly different.

Composite measure

Using all three measures, a composite score was obtained by multiplying raw values in each measure. This score was then rebased to show the relative position of each metropolitan region with a maximum score of 100 points. The following table shows the composite scores of the top 20 metropolitan regions.

Table 4. Top 20 knowledge-building capacity, 2008

Rank	Metropolitan Area	Composite Score
1	Idaho Falls, ID	100.00
2	Albuquerque, NM	84.73
3	Kennewick-Pasco-Richland, WA	72.00
4	Boulder, CO	64.83
5	Cambridge-Newton-Framingham, MA	60.18
6	Ann Arbor, MI	52.49
7	Bethesda-Frederick-Gaithersburg, MD	51.79
8	Trenton-Ewing, NJ	50.77
9	San Diego-Carlsbad-San Marcos, CA	43.83
10	San Jose-Sunnyvale-Santa Clara, CA	42.28
11	Midland, TX	39.19
12	Durham, NC	38.09
13	Detroit-Livonia-Dearborn, MI	37.44
14	Albany-Schenectady-Troy, NY	32.72
15	Norwich-New London, CT	31.76
16	Washington-Arlington-Alexandria, DC-VA-MD-WV	31.06
17	San Francisco-San Mateo-Redwood City, CA	29.69
18	Fort Collins-Loveland, CO	29.54
19	Barnstable Town, MA	28.70
20	Edison-New Brunswick, NJ	28.60

Interestingly, some of the well-known tech leaders such as Cambridge in Massachusetts and San Jose in California did not come within the top three in terms of the composite score. Cambridge and San Jose are known for their world class universities such as Harvard and Stanford. Yet in terms of their knowledge-building capacities, measured using the concentration and productivity of R&D workers, did not enable them to lead the regions.

Idaho Falls' leadership in its knowledge-building capacity stems largely from the Idaho National Laboratory (INL) that focuses on energy research in support of the U.S. Department of Energy. It is the largest local employer in the region and, with its strong R&D base it attracts high-value workers and federal research funding. The presence of other R&D facilities also supports the region's growth [28]. This explains its high capacity for innovation.

At the second position, Albuquerque in New Mexico hosts a dominant presence of Kirtland Air Force base and two national laboratories. With its strong technological infrastructure and ties to government-sponsored research, the region boasts a large capacity for knowledge building [26].

Kennewick in Washington occupied the third position overall and was the leading metropolitan region in terms of R&D employment base in 2008. Similar to Idaho Falls and Albuquerque, Kennewick is a recipient of large pools of federal funding for the construction of a vitrification plant. Its level of productivity is boosted by its highly educated engineering employment landscape [29].

The experiences of more commonly known regions such as Cambridge, San Jose, Durham, Washington, and Edison are substantially different from the top three regions. They include more dominant private industry players and renowned research universities in the R&D industry mix. For example, San Jose has the presence of Stanford University [30], a leading private university in the world, and one of the largest employers in the region. Edison hosts Bristol-Myers Squibb and Merrill Lynch & Company, Inc. as leading employers in the region [27].

Overall, the findings suggest that high tech industry leaders may not always have the largest knowledge-building capacities, according to the method used in this paper. Furthermore, while some regions have attained high productivity levels in a single year, enhancing and sustaining productivity is different altogether.

Discussion and Conclusion

Implications

This paper presented an exploratory method to assess and study knowledge-building capacities at a regional level. Based on the literature review, the knowledge economy can be best studied using the level of innovation. The roots of innovation lie in talented professionals, and hence, human capital development is a key facet of in the knowledge economy. Furthermore, knowledge involves creation. Hence, continuous innovation is a better indicator compared to innovation per se. Together they represent the knowledge-building capacity of a region.

To study the knowledge economy at a regional level, industry data were used. Three measurements on the R&D industry were used to measure knowledge-building capacities: employment base, productivity, and productivity growth. A composite measure for each region was obtained by the product of these measurements.

Within limitations of the exploratory method, the findings lead to three major implications that can be applied to theoretical and policy research. These are discussed in turn.

First, the levels of knowledge-building capacity are more strongly determined by government support. The leading regions in the overall score were leveraging their respective government support for R&D projects. While they may not have the advantage of leveraging world renowned research universities, they came out stronger in their knowledge-building capacities through government support.

This does not mean that research universities are not important. Metropolitan regions with leading research universities appeared in the top 20 regions in the overall composite score rankings. However, only the top three metropolitan regions scored more than 70 points overall. This suggests that government support may play a substantially stronger role in developing knowledge-building capacities in regions.

Taken at a higher level, it may suggest that developing a knowledge economy is not entirely industry-driven. The government has an important role to play in pushing for this shift. It is therefore not surprising to see many government-led initiatives that attempt to create a knowledge base in different regions regardless of their economic makeup. For example, San Joaquin Valley in California is an agriculture-based economy. But it was targeted by the state government to develop tech-based industries [38]. The strategy appears to replicate the development of Silicon Valley in San Jose, a region that had an agricultural industry base prior to its status as a coalition of high-tech clusters today.

This discussion leads to the second implication that leans more towards the theoretical domain. The knowledge economy differs from the information economy. While studies have used high-tech data to study knowledge industries, the arguments and findings in this paper suggest that knowledge industries go beyond the high-tech industry. For example, the dynamic pharmaceutical and biotech industries also involve continuous innovation and heavy use of technologies. Knowledge-building can also be applied to manufacturing and agriculture where innovative practices are developed to support the production processes.

Innovation is not restricted to high-tech alone. It can be applied to any industry. Therefore, a plausible approach to define a knowledge industry is the extent of R&D. In this paper, three industry level measures related to R&D were used to measure the knowledge-building capacities of regions. The results show that the method has achieved valid results, within exploratory limits and constraints of methodological limitations. The latter will be discussed in the next sub-section.

Finally, a third implication stemming from the findings is that a high concentration of R&D workers does not imply high levels of productivity. As shown, the top metropolitan regions in the measures of employment base and productivity differed sharply. Regions that performed well in terms of productivity achieved a higher level of output from a smaller number of workers.

The importance of this implication could be extended to show that the knowledge economy is based on innovation. Idea generation is not entirely dependent on sheer numbers. Therefore, while regions initiative efforts in an attempt to encourage higher education among its population, it is also important to develop an environment conducive to entrepreneurship.

Since knowledge transcends industry boundaries and hence, academic field boundaries, inter-disciplinary collaborations may be encouraged to nurture the seeds of innovation, so as to create a virtuous cycle of continuous innovation in a region. Indeed, inter-disciplinary trends can be seen in the emergence of new knowledge-driven fields such a biotechnology, that involves biology, information technologies, and nanotechnologies.

Future research directions

The study proposes a different method to assess the knowledge-building capacity of a region. Gault argued that using data on research and development activities and intellectual property commercialization as indicators of knowledge creation are static and may not be useful in capturing the dynamism of the knowledge economy [18]. These indicators measure the output of innovation but neglect the other dimension that looks at the capacity for innovation, which suggests the continuous nature of innovation [38].

Although this study addressed the gap by proposing a method to ascertain the knowledge-building capacity at a regional level, the study was limited in its use of a data set spanning five years (2003 to 2008). Furthermore, discussions were limited to the top 10 and 20 metropolitan regions in the U.S. While the findings appeared plausible and reasonable, the method can be further enhanced if applied at a more detailed and wider level. For example, 10 years worth of data can be used to add breadth to the analysis. Furthermore, a systematic method such as correlations can be used to determine the statistical relationships among the three measures used in this study.

Future research could combine both methods to look at the output of innovation over time, and the knowledge-building capacities of regions to develop a more rigorous measure of the knowledge economy. Other external measures such as research funding may also be useful. As shown in the results, government support can play an important role in determining the level of productivity and hence, the level of innovation in a region. Given the dynamic nature of the knowledge economy, which involves continuous innovation, a comprehensive measure that includes the growth element of various innovation-related constructs could be developed to enhance this research.

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