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Analysing Knowledge-Based Growth: Going Beyond Innovation

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ABSTRACT

Today, the most technologically advanced economies have utilised knowledge as a key factor in production by developing initiatives that encourage continuous innovation for sustainable growth. However, the fruits of innovation are dependent on regional contextual factors that go beyond innovation per se. Regions that have successfully created and leveraged their innovation capacities have leveraged their favourable social contexts to support their growth. In this exploratory study, the author reviewed literature to define the knowledge economy for empirical analysis. He further analysed economic data on U.S. metropolitan regions from 2003 to 2008 to provide evidence in support of this argument. The findings suggest that industry innovation measures alone are not significant predictors of economic growth. The author discusses these findings theoretically and proposes policy implications.

Keywords (Required)

Knowledge, research and development, knowledge economy, innovation, productivity, economic growth

INTRODUCTION

With the global transition to the intangible knowledge economy, knowledge-based inputs have become key productive forces that drive economic growth (Stehr, 2002). These knowledge-based inputs define the notion of knowledge work, and hence knowledge industries today. Knowledge work can be defined as innovation-oriented production knowledge workers are consistently engaged in activities resulting in innovation (Yeo, 2009). Indeed, innovation is an increasingly important factor of market development at a societal level of analysis (Baark, 2005).

Therefore, it is not surprising that the most technologically advanced economies today are innovation-oriented, and hence, knowledge-based. The analysis of knowledge-based production however, is not as straightforward. Unlike the information economy that can be measured by the presence of information technology industries, the knowledge economy is characterised by innovation that spills across different industries (Yeo, 2009). It follows that innovation measures can be used to study the impact of knowledge-based production on economic growth.

In this study, the author investigates the ability of innovation measures at the industry level to explain economic growth among regions. This paper comprises three main sections. The first includes a discussion of the knowledge economy to establish a working definition for empirical analysis. In the subsequent section, the author analyses economic data on U.S. metropolitan regions to show the economic impact of innovation measures at the industry level on economic growth. Finally, the author puts the findings together to discuss future research directions.

WHAT IS THE KNOWLEDGE ECONOMY

In a knowledge economy, products and services are generated by knowledge work (Powell and Snellman, 2004). These knowledge inputs to the economy are less material than physical inputs such as capital and land in the industrial economy. They are also less tangible than information, the engine of the information economy. Knowledge is value-added information. It is what an individual knows and is harder to disseminate compared to information. According to Godin, the knowledge economy is based on information technologies and that innovation is a key element among its abstract characteristics (Godin, 2003).

Research on the knowledge economy can be categorised into three main veins. Using the first approach, scholars studied science-based industries that rely on knowledge. Knowledge facilitates production, leading to economic growth (Basalla, 1988; Machlup, 1962; Gotzfried, 2004). However, this approach is too broad-based to account for the differences between knowledge-work and non-knowledge-based industries (Yeo, 2009). Today, most industries are science-based to various degrees and this definition does not distinguish them from each other in terms of knowledge orientation. The publishing industry for instance, is science-based but may or may not be conventionally deemed as a knowledge-based industry (Power and Snellman, 2004).

The second approach takes a more focused view on these science-based industries (Brint, 2001). These include technology-based industries such as the semi-conductor industry that apply specific professional knowledge. However, knowledge can be applied in any industry. Using this approach does not sufficiently allow researchers to define knowledge empirically for investigations and analyses. Researchers using this approach have studied specific industries but without a consensus on which industries are knowledge-based, given the wide variations in application (Brint, 2001).

The third approach uses continuous innovation as a key indicator for knowledge work. Romer argued that innovation is a key factor of growth in advanced economies today (Romer, 1986; Romer, 1990). According to Romer's New Growth Theory, innovation is a key endogenous factor of production in the knowledge economy (Hulten, 2000). This argument can be dated back to Schumpeter's work in the early 20th century (Schumpeter, 1927; Schumpeter, 1962). Scholars have since acknowledged the role of innovation in generating economic growth (Drucker, 2004; Godin, 2003). Along these lines, Yeo argued that this approach accounts for the abstract and dynamic nature of knowledge, as innovation should not be understood as an isolated incident (Yeo, 2009). Therefore, innovation measures must be taken as a continuous process that generates economic growth for a region.

METHOD

Adopting this third approach, the author used economic data on metropolitan regions in the U.S. from 2003 to 2008 to study the impact of innovation measures on economic growth. The knowledge economy can be characterised by continuous innovation, which is its key driver of economic growth (Yeo, 2009). While this is easily understood in qualitative terms, in quantitative terms, it remains a challenge to operationalise continuous innovation.

Taking an industry approach, innovation can be seen as the direct consequence of research and development (R&D) activities (Bell, 1973). These activities create knowledge and develop new applications (Russo, 2004). Hence, it follows that the R&D industry can be used as a direct indicator of innovation activities in a region. Based on the North American Industry Classification System (NAICS), the R&D industry is clearly defined by NAICS code 5417. Using this quantitative definition as a proxy for the knowledge-based industry, three main independent variables were used in this study: Innovation base, innovation-based output, and innovation-based productivity. These are given in Table 1. For purposes of this paper, innovation and R&D are synonymous since they are both key characteristics of a knowledge economy, as discussed in the preceding Literature Review.

Independent Variables	Operationalisations
Innovation base	The location quotient of the R&D industry
Innovation-based economy growth	The economic output generated by the R&D industry
Innovation-based economic productivity	The economic output per worker in the R&D industry

Table 1. Operationalisations of variables

The innovation base of a region, as measured by the location quotient (LQ) refers to the relative share of the industry's employment to the U.S. The formula is given as follows. A score of 1.0 will indicate that the R&D base of a region is equivalent to the U.S. It follows that a score of more than 1.0 will suggest the region has a stronger concentration, and hence base for innovation, than the U.S. The converse applies.

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

Equation 1. Location quotient formula for calculating R&D base

These data were obtained from 2003 to 2008 for each metropolitan region in the U.S. Metropolitan regions, or metropolitan statistical areas (MSAs) are regions comprising several counties. Economic activities can spread across different counties and even state boundaries. Therefore, using MSAs as units of analysis is appropriate as they can capture the spread of these activities for analysis.

The concept of continuous innovation requires these quantitative data to be analysed over time rather than a cross-sectional static representation. Therefore, growth measures for each independent variable were taken over the five-year period. A regression model was run to show the impact of these variables on economic growth. The results are given in the following section.

ANALYSIS OF U.S. METROPOLITAN REGIONS

4.1. Descriptive Analysis

Table 2 shows that Kennewick, Cambridge and Durham are the top three regions in terms of their innovation base. It comes as no surprise in view of the top knowledge-based establishments in these regions. For example, in Kennewick, Lockheed Martin Corporation and Amazon.com, Inc. are two of the large employers. The region boasts a highly educated and technical workforce. Its low costs of living and doing business also make it an ideal location for knowledge work (Moody's Economy.com, 2009).

Rank	Metropolitan Region	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		

Table 2. Top 10 metropolitan regions in R&D location quotient

Looking at the growth in innovation base from 2003 to 2008 among the same regions, the top 10 regions are markedly different from the preceding table. These regions that have the largest growth in LQ from 2003 to 2008 are given below in Table 3. These top 10 regions are those that have grown their R&D base considerably since 2003, while the top 10 regions in Table 6 are those that already have a strong innovation base.

Rank	Metropolitan Region	Location Quotient Growth (2003-2008)
1	Goldsboro, NC	2387.50%
2	Gainesville, GA	883.33%
3	Naples-Marco Island, FL	516.00%
4	Jacksonville, NC	325.49%
5	Bloomington, IN	323.60%
6	Greenville-Mauldin-Easley, SC	312.61%
7	Fort Collins-Loveland, CO	307.90%
8	Olympia, WA	302.41%
9	Sioux Falls, SD	279.75%
10	Columbus, GA-AL	264.00%
Source: Moody's Economy.com		

Table 3. Top 10 metropolitan regions in R&D base growth

Table 4 shows the top 10 regions in innovation-based economic output in 2008. In this measure, the GDP of the R&D industry (NAICS code 5417) was obtained for each metropolitan region. These top 10 regions are regions with a strong R&D base by virtue of their long history of universities and high-tech anchors companies. For example, Philadelphia and San Jose house the University of Pennsylvania and Stanford University respectively. Incidentally, Philadelphia has a strong life science cluster (DeVol, Yeo, Chatterjee, Wong, & Bedroussian, 2009), a knowledge-based conglomerate of life science anchor companies (DeVol et. al., 2009).

Rank	Metropolitan Region	R&D Output ($Millions)
1	Washington-Arlington-Alexandria, DC-VA-MD-WV	5,472.71
2	San Diego-Carlsbad-San Marcos, CA	4,383.12
3	Chicago-Naperville-Joliet, IL	4,373.91
4	Cambridge-Newton-Framingham, MA	4,310.00
5	New York-White Plains-Wayne, NY-NJ	3,840.79
6	Los Angeles-Long Beach-Glendale, CA	3,508.21
7	Philadelphia, PA	3,075.26
8	San Jose-Sunnyvale-Santa Clara, CA	2,876.31
9	San Francisco-San Mateo-Redwood City, CA	2,279.61
10	Bethesda-Frederick-Gaithersburg, MD	2,196.98
Source: Moody's Economy.com		

Table 4. Top 10 metropolitan regions in innovation-based economic output

Table 5 shows the top 10 regions with the highest innovation-based economic output growth between 2003 and 2008. Similar to the findings from the innovation base analysis, these 10 regions are totally different from those in Table 4. It can also be inferred that the 10 regions in Table 4 are those that have a matured and well-developed R&D base. They have the capacity to attract anchor companies and grow their deeply rooted R&D assets, while those in Table 5 are currently growing.

Rank	Metropolitan Region	R&D Output Growth (2003-2008)
1	Gainesville, GA	1218.12%
2	Naples-Marco Island, FL	935.83%
3	Greenville, NC	515.88%
4	Greenville-Mauldin-Easley, SC	469.85%
5	Fort Collins-Loveland, CO	459.50%
6	Allentown-Bethlehem-Easton, PA-NJ	434.99%
7	Olympia, WA	420.84%
8	Akron, OH	379.94%
9	Sioux Falls, SD	360.77%
10	Punta Gorda, FL	296.77%
Source: Moody's Economy.com		

Table 5. Top 10 metropolitan regions in innovation-based economic output growth

As shown in Table 6, the top 10 metropolitan regions in innovation-based economic productivity in 2008 are not the same as the ones with the highest innovation-based economic output. These 10 regions in Table 6 are relatively smaller regions that have achieved a high level of innovation-based economic output from a smaller pool of R&D workers.

Rank	Metropolitan Region	R&D Productivity ($Thousands per worker)
1	Vineland-Millville-Bridgeton, NJ	1,461.01
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		

Table 6. Top 10 metropolitan regions in innovation-based economic productivity

Interestingly, some of the regions in Table 10 appear in Table 7, which depicts the top 10 metropolitan regions in terms of innovation-based economic productivity growth. These include Vineland, Rochester, and Midland. This finding suggests that innovation involves the creation of more efficient production processes. These three regions have developed new mechanisms that enabled them to generate a higher level of output per worker in R&D. It also suggests that innovation in the knowledge economy is a continuous concept.

Rank	Metropolitan Region	R&D Productivity Growth
1	Vineland-Millville-Bridgeton, NJ	843.15%
2	Greenville, NC	415.95%
3	Midland, TX	363.44%
4	Lubbock, TX	358.23%
5	Idaho Falls, ID	314.48%
6	Tyler, TX	296.98%
7	Rochester, NY	248.04%
8	Roanoke, VA	211.71%
9	Columbia, MO	205.50%
10	Pocatello, ID	192.01%
Source: Moody's Economy.com		

Table 7. Top 10 metropolitan regions in innovation-based economic productivity growth

Regression

A regression model was run to analyse the impact of the three independent variables – innovation base, innovation-based economic output, and innovation-based economic productivity – on overall economic output. The aim of the analysis is to show the economic relevance of innovation on a region's economic performance. The results are given in Tables 8.

The regression model suggests that there were no significant direct relationships between the three independent variables and overall economic output at 95 percent confidence interval (R^2 = .004, n=373). Following these results, the innovation base growth, innovation-based economic output growth and innovation-based economic productivity growth are not significant factors that determine the overall economic performance growth of a region.

Variable	t-statistic
547 Productivity Growth	.163
5417 GDP Growth 2003-2008	1.012
5417 LQ Growth 2003-2008	-.655
R^2 = .004 Standard Error = .071 N = 373	

Table 8. Regression model on overall economic output growth

DISCUSSION

The analysis on U.S. metropolitan regions shows that innovation alone, as operationalised by R&D, is insufficient to create regional economic growth and productivity. Furthermore, the regions with strong overall economic output and total productivity growth were not the same regions with strong innovation-based growth. Indeed, the regions that performed well economically have established innovation bases that do not show large amounts of growth between 2003 and 2008.

At the same time, smaller regions with fast growing innovation bases did not show high levels of economic performance. Therefore, it follows that while the innovation capacity of a region is a critical component in the knowledge economy, growth requires more than innovation per se. The lack of statistical significance from the industry innovation measures suggests that the answer to economic growth in the knowledge economy resides within unique regional contexts. This argument echoes Yeo's findings that contextual factors are important in driving knowledge-based growth (Yeo, 2009).

The findings also imply that regions with strong economic performance levels have established strengths in industries that are less knowledge-based. Skills and learning competencies are critical elements in the knowledge economy (Houghton and Sheehan, 2000). The culture of entrepreneurship is also an important facet in its development (Branscomb and Florida, 1997).

While top performing regions have deeply rooted economic assets, they face challenges posed by smaller regions that are capitalizing on knowledge-based production for building learning competencies and entrepreneurship. These, among other knowledge-based activities, are especially critical in an era characterised by and increasingly dependent on innovation.

From context to policy

Continuous innovation takes into account the conditions that create the basis of innovation continuously. The use of growth measures in the independent variables captured the continuous element of innovation in a knowledge economy. However, it may not have captured the contextual element that is necessary. Since knowledge, as opposed to information, is contextual, it follows therefore, that an empirical definition of knowledge must be contextual. The findings suggest that contextual factors may be a reason for the lack of a significant relationship between innovation and economic growth.

The contrast between Boston's Route 128 and San Jose's Silicon Valley's experiences is evidence supporting this argument. Although both regions are high tech clusters grown from agricultural roots, the latter showed sustained economic growth while the former experienced a decline in economic performance. Both clusters have contrasting regional contexts. Route 128 is characterised by independent and self-sufficient businesses, while Silicon Valley is made up of companies that have formal and informal social linkages among each other, resulting in a culture or cooperation. In Silicon Valley, business, universities, and research institutions in the vicinity are organised around this cooperative relationship. Their different cultures were influential to their present economic performance (Saxenian, 1997).

Knowledge is cumulative and therefore, requires a strong value chain made up of knowledge-based establishments. Knowledge is contextual and not easily disseminated. It resides within the individual. In contrast, information can be owned by a collective of individual (Foskett, 1982). Therefore, knowledge requires special linkages among individuals to be shared and accumulated for knowledge generation. At the regional level, establishments such as institutions, businesses, universities and other knowledge-based organizations contribute to the cumulative knowledge capacity of a region by virtue of their linkages among each other. These linkages are dependent on the regional contexts that influence the type of linkages and the extent to which they are leveraged.

This has important policy implications as well. Effective policy making involves the development of policies that fit the local contexts (Houghton and Sheehan, 2000). These contexts include the history, geography, political characteristics, and institutions (Mukand and Rodrik, 2002).

As regions strive to develop a strong knowledge base to compete in the age of knowledge economies, strategies are implemented not only to create technology-based industries but also a viable innovation-orientation. It is no longer sufficient to use technologies as in the information economy. It is more important to create useful technologies on a continuous basis.

Policy making in the knowledge economy therefore, becomes complex. While it may be one thing to build R&D industries, it is much more difficult to build an R&D cluster, which is characterised by a sustainable culture of innovation.

Acknowledging differences among regional contexts, Yeo and Trauth advocate the importance of transformational governance in the creation of a knowledge economy. Using this approach, governments must develop evaluation mechanisms to continuously investigate local conditions to develop adaptable policies that reflect the needs of the regions (Yeo and Trauth, 2009). Institutions behave differently in different contexts (Rodrik, 2000). In contrast to the information economy where the application of e-governance involves the utilization of information technologies to facilitate public and as government processes, transformational governance acknowledges and addresses the dependence on regional contexts in the knowledge economy.

Trauth's study of the information economy in Ireland showed that policies have intended and unintended consequences (Trauth, 1996). She argued that the evaluation mechanisms are aimed at adapting to local conditions rather than replicating the experiences of other regions. It becomes important for policy making to take into consideration unique local contexts so as to leverage them for building knowledge work capacities.

Conclusion

The development of a knowledge economy involves the creation of a viable context that is conducive to innovation growth. The analysis of U.S. metropolitan regions shows that industry measures of innovation were not significant predictors of economic performance and productivity growth. Therefore, the development of R&D industries alone is a necessary but not a sufficient condition. This process involves consideration given to complex local conditions, using a transformational approach to governance.

This exploratory study serves as an impetus for further studies in the same vein to establish the importance of regional contexts in the knowledge economy. This is especially critical given the complex context-dependent nature of knowledge. The findings are useful to scholars studying the knowledge economy as well as policy makers in the era of knowledge.

Although growth measures were used in the statistical analyses, they were restricted to one growth period: between 2003 and 2008. A more rigorous analysis could be executed on a series of five-year growth measures, such as between 2002 and 2007, 2001 and 2006, and so forth. This would help investigate the relationships further.

Also, researchers can design case studies to investigate contextual elements depicting regional cultural facets to provide rich, in-depth qualitative evidence. Qualitative findings enable researchers to understand the research problem and induce variables that may be tested subsequently via quantitative methods. The inclusion of these additional variables in future studies can enhance the rigor of the statistical analyses and yield more in-depth results.

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