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Technological innovation in BRIC

In a knowledge-based economy, innovation is far more important than land, physical capital, or labor as the primary factor affecting a nation's economic growth and development. Technological innovation can circumvent entry barriers and help a country maintain technological competitiveness. Similarly, a country failing to innovate may be outpaced economically as competitors devise more advanced and more marketable products. Effective innovation management is thus a key to corporate success, technological prowess and national economic development. With reference to the research study "technological innovation in the BRIC Economies, this article investigates three main issues related to BRIC technological innovation: 1) different indicators of technological innovation are examined to compare technological innovation capability in the four countries; 2) innovation configurations in the BRIC are compared; 3) absolute and relative innovation strengths of BRIC in different technological fields are compared.

Several indicators of technological innovation have been proposed and used. The most common measures can be categorized as measures of R&D, patents and new products. The present study analyzes patents as a major measure to elucidate technological innovation: First, patent data are accurately recorded, readily accessible, quantifiable, and easily manipulated for more detailed analysis by technological field, product or patent holder. Second, analysis of patent grants within a single country provides an objective and consistent measure of technological innovation, because patents are examined and eventually granted by a single national patent office. Finally, in comparison with other sources, patents are often the only timely measure of rapid technological change, particularly in the context of global competition.

Comparing Technological Innovation Capability

Early studies typically examined patent count as a measure of innovation capability; however, more sophisticated analyses have been made by examining patent citation statistics. The quantity of patents issued to a company in a given year is far less significant than patent quality. The patent and citation data set used in this study consists of all patents granted by the U.S. Patent and Trademark Office (USPTO) to BRIC inventors from 1976 to 2006. This study investigated only utility patents, and not design or plant patents. The following two indicators are often used to measure technological innovation, as well as to compare innovation capability in BRIC countries.

1. Patent count

Patents actually granted are assigned a higher value than mere patent applications because patents are only granted when they contain technological innovations that exceed a certain level of newness. Patent count is a simple proxy for the summed value of those patents. Patent count defines the number of patents granted to a country during a particular year.

Between 1976 and 1995, the patent counts for the four BRIC countries were low and did not differ significantly. From 1995 to 2001, however, Russian patents increased markedly, while the other three countries exhibited moderate increases in the number of patents. In both China and India, patents granted increased significantly after 2001 and peaked in 2006, while Russia and Brazil showed a slight decrease after 2001.

Patents granted to China from 1976 to 2006 totaled 4,745. India had the second highest number in patent count, and Russia and Brazil received 3,029 and 2,134 patents, respectively. However, the gap between the four countries in terms of patent count has increased. The patent count for China approximated that of Brazil during 1995, but since then has increased to seven times that of Brazil.

2. Citation ratio

Patent quality is extremely heterogeneous, with a few patents being of high quality and most being of low quality. The underlying assumption in using patent citations to measure patent quality is that frequently cited patents likely involve more significant technological advances. In 2002, Bloom and Reenen proposed the use of citation ratio as a proxy for accurately assessing patent quality. Citation ratio is defined as the average number of a country's patents cited by later patents. The citation ratios for Russia, Brazil, India, and China in 2006 were 5.3, 4.7, 3.6, and 3.6, respectively.

Comparing Innovation Configurations

1. Fundamental vs. applied innovation

Distinguishing between fundamental and applied innovation is vital. Technology invention is often termed fundamental innovation, and technology adoption is termed applied innovation. The present study employed the Science Linkage measure to distinguish between fundamental and applied innovation. Science Linkage indicates the extent to which innovation builds upon cutting-edge scientific research. A patent citation may come from three sources: 1) patents of other firms, 2) the applicant's own previous patents, and 3) the academic literature (scientific journal papers and conferences).

Science Linkage is calculated from the average number of citations that a country's patents cite from scientific journal papers and conferences. The underlying concept is that the number of citations an organization lists on its patents increases with the number of inventions incorporating recent scientific discoveries from outside the organization and linked to basic science or fundamental research. Organizations whose patents cite many scientific papers are assumed to be partial to fundamental innovation. Conversely, organizations with lower scientific linkage ratios are assumed to focus more on applied innovation. In 1999, Deng et al. reported that Science Linkage is positively and significantly associated with market performance.

The indicators of Science Linkage show that Russia ranks higher than other countries in scientific research. Technological innovation in Russia is expected to reflect the latest scientific developments. Restated, Russia is partial to fundamental innovation. In comparison, Brazil and China have relatively lower Science Linkage ratios and are assumed to be focused more on applied innovation.

2. Incremental vs. radical innovation

The overall impact of innovation is usually defined as incremental or radical. In radical innovation, the properties of a product suddenly change and significantly alter market dominance, competitiveness and the overall industrial landscape. Incremental innovation impacts the existing capabilities of organizations and the existing knowledge and demand structures in the environment. This study employed a self-citing ratio to distinguish between incremental and radical innovation.

A self-citing ratio is measured by the percentage of citations of its own previous patents given by a country's inventor. All of those utility patents in which the country's own previous patents are cited can be viewed as incremental innovation. A country exhibiting a higher self-citing ratio is presumed to favor incremental innovation, whereas a country with lower self-citing ratio is assumed to be undergoing radical innovation.

The self-citing ratios of Russia, India, Brazil & China are 17.1%, 15.4%, 9.5% and 8.5% respectively. Russia and India tend to favor incremental innovation, while Brazil and China tend to engage in radical innovation. That is, Brazil and China are mostly building on other countries' technologies.

Obvious differences in innovation configuration are apparent in the BRIC countries. Russia appears to be highly focused on both fundamental and incremental innovation; India is working closely with applied and incremental innovation, while Brazil and China tend to focus on applied and radical innovation.

Innovation Strength in BRIC Economies

Analysis of innovation strength includes both absolute and relative innovation strength. Absolute innovation strength is measured by the number of patents invented by a country relative to BRIC countries in a specific technological field. Relative innovation strength is measured by the number of patents in a specific technological field relative to all patents in a country. The historical data indicate electrical engineering, audiovisual technology, telecommunications, and information technology are the top four technological fields of innovation strength in BRIC countries during 1976-2006.

Brazil exhibits absolute innovation strength in surface technology, materials processing, thermal processes, engines, mechanical elements, food processing, space technology, and consumer goods. Russia demonstrates absolute innovation strength in organic chemistry, drugs, materials, basic materials chemistry, and civil engineering. India shows absolute innovation strength in audiovisual technology, telecommunications, information technology, semiconductors, polymers, biotechnology, food chemistry, and nuclear engineering. China displays absolute innovation strength in electrical engineering, optics, control technology, medical technology, chemical engineering, environmental technology, machine tools, handling, and transport.

Thermal processing, control technology, organic chemistry, and surface technology are the top four technological fields of relative innovation strength in Brazil. Russia has relative innovation strength in audiovisual technology, optics, electrical engineering, and materials. The top four technological fields of relative innovation strength in India are telecommunications, audiovisual technology, information technology and semi-conductors. China shows relative innovation strength in electrical engineering, audiovisual technology, control technology, and semiconductors. In conclusion, BRIC countries differ markedly in the technological fields in which they exhibit innovative strength.

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