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The relationship between technology, business model, and market in autonomous car and intelligent robot industries☆,☆☆

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ABSTRACT

This study develops a new innovation diagram based on three elements — technology–business model (BM)–market — for characterizing the knowledge-based economy and open innovation. It identifies the relationship between technology, business model, and market through analysis of in-depth interviews with Korean firms that belong to the autonomous car and intelligent robot industries at first.

It develops the Casual Loop Diagram based on the dynamic relationships between technology–BM–market. In developing this diagram, regulations, standards, and leading firm effects were considered which were caught at the interviews. The technology–BM–market system causal loop diagram was proven through the analysis of technology, and business model patent statistics, and the reference and citation networks among these patents from worldwide in 2 industries.

It identifies the importance of the business model in addition to 3 factors identified in this research, the leading firm effect, standardization, and regulation. The research suggests new market increase strategies and policies which are based on technology–BM–market diagram in technology intensive industries such as autonomous car and intelligent robot industries.

1. Research questions

1.1. Research questions

Many IT-related industries are emerging in the second information revolution based on mobile information technology, sometimes called the third industrial revolution (Rifkin, 2011, p. 14). In particular, IT-based autonomous vehicles and intelligent robots are the most prominent areas of the newly emerging sector. In these newly emerging industries, the relationship between technology and market as well as their combination are expected to become the key drivers for establishing future corporate strategies and industrial policies.

This study attempts to obtain answers to the following research questions with respect to the autonomous vehicle and intelligent robot areas: What are the relationships between technologies, business models and markets? Additional questions to be answered include: 1.) During the growth process of the two industries, what is the driving force of the growth, technology, business model, and market? 2.) Where are the bottlenecks of growth in the two industries? 3.) As the determining factor for the growth process of the two industries, where is the delay phenomenon taking place? 4.) How is the growth process being developed in the short, medium, and long term?

1.2. Scope and methods of research

The technology sectors that serve as the research subject of this study are the autonomous vehicle (or car) and intelligent (autonomous) robot industries. The two industries have not yet fully matured, and so come under the category of emerging industry or growing industry. At present, there are no definitions of the two industries that the main industry, academic world, and research communities can agree on. The autonomous car, also known as a driverless car, self-driving

☆ This paper looks into the relationship between technology, business model, and market in autonomous car and intelligent robot industries.

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car, or robot car, is an autonomous vehicle capable of fulfilling the human transportation capabilities of a traditional car (Göhring et al., 2013; Milanés et al., 2010). Also according to the Wikipedia (2014), an autonomous (intelligent) robot performs behaviors or tasks with a high degree of autonomy, and is particularly desirable in fields such as space exploration, floor cleaning, lawn mowing, and waste water treatment (Hsu and Fu, 2000; Schöner et al., 1995).

As a research method, this study first establishes the Dynamic Innovation Model, which is used in analyzing the dynamic technology-innovation process of specific industries through the analysis of research papers. This is used to establish a conceptual model of the relationships of the technology and the market of the two industries.

Second, this study randomly selected five firms, each from Korea's autonomous car and intelligent robot industries. An examination was conducted of the manufacturing of their representative mass-produced products (products that are being manufactured now or will be in the not so distant future) and the relationships between relevant technology, market, and business model. This was accomplished through an analysis of interviews in both industries, analysis of media materials, and analysis of Web sites. The interviews were conducted for 1–1.5 h using the half-structured questionnaire, with firms in Taegu and Seoul between February and March, 2014. The findings of the interviews are posted on the Google blog, Korea Open Innovation Center <Appendix 1>. In addition to these, we did brainstorming about findings from interviews at 2 industries with focus group. These groups included experts, researchers, and developers from relevant industries, and many others.

Third, we developed the causal loop model of the two industries.

Fourth, The SD model was validated by the analysis of the technology and business model patents of major countries in the two industries (the U.S., Europe, International, Japan, France, Germany, Canada, China, and Korea). The validation of the two industries' causal model was secured by analyzing technology patents and business model patents pertaining to G06Q, and search results using the names of the two industries as keywords, namely, autonomous vehicle (or car) and intelligent (autonomous) robot.

Lastly, we add implications which were caught by interviews, confirmed by causal loop model, and validated by patent analysis.

2. Review of existing research and establishing the research model

2.1. Review of existing research: Technology push, demand pull, and business model

Lotti and Santarelli analyzed the industry dynamics and the distribution of firm sizes, trying to assess the empirical implications of different models of industry dynamics. These included the model of passive learning, the model of active learning, and the evolutionary model (Lotti and Santarelli, 2001). In the model of industry evolution, the dynamics are driven by the process of endogenous innovations followed by subsequent embodiments in physical capital (Lach and Rob, 1996). The field of innovation studies finally came to the conclusion that both were important for the innovation and development of product (Dosi, 1988; Mowery and Rosenberg, 1979; Van den Ende and Dolfsma, 2005).

However, the field of innovation studies has gained renewed attention with the emergence of the solar industry, wind power generation industry, the electric car industry, home intelligent robot industry and many others. Such industries have not yet been able to develop their business models or mature because of market factors, but are attracting the attention of the market despite their technological immaturity.

One of the traditional theories on technological innovation is the Technology Push Theory (Nemet, 2009). The core of the science and technology push argument is that advances in scientific understanding determine the rate and direction of innovation (Nemet, 2009). The theory focuses on technology as the source of innovation, or as the motivation for innovators. Thus, this theory, as the starting point of technology innovation is an enterprise had been the main logic of the closed innovation until the 1990s during which the importance of enterprises' own technological developments were emphasized (Almirall and Casadesus-Masanell, 2010; Chesbrough, 2004; Chesbrough, 2006).

Another traditional technological innovation theory is the Demand Pull Theory. The concept of the theory can be illustrated by what happened during the Middle East Energy Crisis of the 1970s: the price changes of the traditional energy sources triggered technology innovations in new energy sources, which are today's alternative energy sectors (Popp, 2001). The theory stipulates that demand steers firms to work on certain problems (Rosenberg, 1969). However, while the Demand Pull Theory is adequate when explaining incremental innovation, it has limitations when explaining destructive and radical innovation (Abernathy and Utterback, 1978; Dewar and Dutton, 1986).

The traditional innovation theories above have been developed into an integrated technology innovation theory that takes both technology and market into consideration like Fig. 1 (Pinch and Bijker, 1987; Williams and Edge, 1996). In this model, technology directly gives effects to market, and market also directly gives effects to technology. But recently, in addition to that integrated technology innovation theory, numerous further discussions and analyses have been appearing which also take the integration of technology and market into consideration. Such is the case with biosensors, which have been expected to play a significant analytical role in medicine, agriculture, food safety, homeland security, and environmental and industrial monitoring. The technology's commercialization has significantly lagged behind research output because of rising costs and some key technical barriers (Luong et al., 2008). In other words, a significant portion of biosensor technology commercialization is being delayed by both technology and market factors.

In another example, a case study on one of Germany's biggest and most successful software development and information technology service providers revealed how market pull and technology push activities within the corporate technology and innovation management can be integrated (Brem and Voigt, 2009). That particular case demonstrated how technological innovation and the commercialization of enterprises can succeed through the integration of technology and market.

Another study (Nemet, 2009), investigated how a strong government policy that stimulates demand pull can fail if non-incremental technological changes don't accompany it. It was determined that such failure can occur for the following reasons: (1) when the rapid convergence on a single dominant design limits the market opportunity for non-incremental technical improvements; (2) when implemented policies stimulate demand, but uncertainty in their longevity dampens the incentives for inventions that were likely to take several years to pay off; and (3) as a result of declining R&D funding, weakening presidential engagement on energy, and other circumstantial reasons. In other words, even a government policy based on demand pull cannot succeed unless sufficient consideration is paid to the technology push aspect. Policies that maximize the effects of both technology and market integration are required.

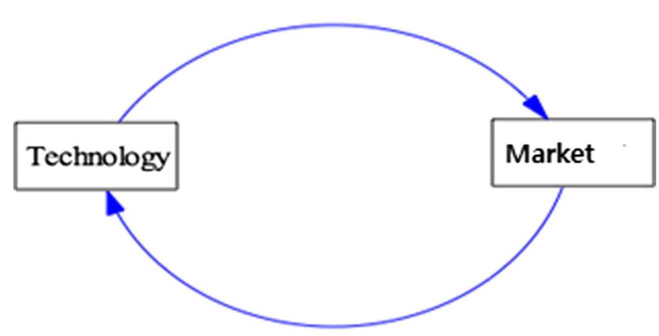

Fig. 1. Technology–Market relation in traditional innovation theory.