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Identification of the technology life cycle of telematics: A patent-based analytical perspective

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ABSTRACT

Identifying technology life cycles (TLCs), particularly TLCs that relate to promising technology, is crucial to managers, technological product investors, and inventors. Telematics technology has gained prevalence in the information and communication technology fields and been increasingly applied. This study determined the current TLC of telematics and investigated using a mainstream technology and development focus at each TLC stage. A supervised assessment method and the indicator pattern of current anchoring technology were employed, and a significance test of the results generated from a curve matching analysis was used to identify the TLC stages of telematics. The results revealed that telematics is in the maturity stage, and the technological focus of each of its TLC stages is distinct. At the maturity stage, telematics emphasizes wireless communication networks and diversified market applications. We assessed the development stage of telematics; governments can refer to this assessment to facilitate strategic development in technological industries.

1. Introduction

Because of the development of the Internet of things (IoT) and popularity of vehicles, transportation is no longer solely focused on transporting people and goods. People's need for transportation safety and efficiency, as well as entertainment experiences for avoiding boredom, have affected technological development. Telematics technology has driven digitalization in the automotive industry and been used to improve driving conditions and enhance road safety. The integration of telematics technology and global positioning system services has shifted the orientation of the automotive industry from production to the provision of knowledge economy services. This study aimed at preliminarily determining the technology life cycle (TLC) of telematics technology as well as the activities and development trends in the field of telematics. The results are expected to serve as a reference for technology portfolio development in the future and subsequent studies.

The investment appeal of technology is determined by its current TLC stage. Typical methods of identifying the TLC stages of technology involve observing the quantitative growth of relevant patent applications and grants. Several empirical studies have indicated that typical patent quantitative growth patterns follow S-shaped curves (also referred to as S-shaped evolutionary paths) or even double S-shaped curves (Andersen, 1999; Chiu and Ying, 2012; Ernst, 1997; Liu et al., 2011; Trappey et al., 2011). Although identifying the TLC of a product or technology by observing an S-shaped curve is feasible, this approach creates a technical problem because it requires statistics regarding all applications in the field of the product or technology (Haupt et al., 2007). Moreover, despite the extremely high data integrity of contemporary patent databases, searching all patents related to particular types of technology in patent databases is difficult or impossible. This problem arises because no definite terms can be used to define and search most types of technology and to collect all patents related to these types of technology from patent databases. Furthermore, patents cannot be precisely matched to particular product technologies even by using the International Patent Classification (IPC) or cooperative patent classification systems.

Moreover, using patent quantity alone to identify TLCs by observing S-shaped curves is an oversimplified method. Therefore, some studies have used multiple patent indicators to determine TLC stages (Alencar et al., 2007; Haupt et al., 2007; Lizin et al., 2013). However, determining TLCs according to multiple indicators sometimes generates subjective assessments. Additionally, defining the time points of TLC stages is difficult and requires a detailed literature review, in-depth case studies, or expert opinions to reinforce the robustness of research data and conclusions.

Therefore, Gao et al. (2013) employed an analogical method and multiple patent-based indicators to estimate the TLC of emerging technologies. Specifically, researchers can anticipate the growth patterns of emerging technologies by using the analogical method to observe those of related technologies. If a strong correlation is found between the two types of technology, then the growth pattern of the emerging type of technology is more likely to be identified. The indicator-based analogical method emphasizes the accuracy of the collected patent data rather than the data quantity, thereby eliminating

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the necessity of a comprehensive investigation of all technology-related patents. Moreover, the study by Gao et al. (2013) aimed to provide a prototype that can be used to determine the technological development patterns of subsequent TLC stages. However, their analogical method requires improvement. Gao et al. (2013) employed the cathode ray tube (CRT) and thin film transistor-liquid crystal display (TFT-LCD) as training technology. However, they did not use a specific method to determine the optimal training technology. Therefore, the present study proposed a novel assessment method. Moreover, Gao et al. (2013) used a nearest neighbor classifier method to analyze TLC by calculating the shortest distance from the test to training points and comparing the test and training technology. However, this method cannot be used to compare two types of technology at particular TLC stages. The present study proposed a more precise classification system.

Based on the limitations identified in the aforementioned studies, this study proposes the following solutions. First, in contrast with previous studies that used a single indicator to determine TLCs (Ernst, 1997; Liu et al., 2011; Trappey et al., 2011), this study predicts the TLCs of emerging technologies by using analogy, which describes the respective patterns of multiple indicators at different TLC stages. Second, although multiple indicators have been employed to measure the life cycles of such technologies – for example, Haupt et al. (2007) proposed hypotheses and conducted a literature review to extrapolate the changes in indicator patterns at different TLC stages – this method is not efficient in delineating the TLC stages unless complemented by a solid theoretical framework. This study aims to address this limitation. In addition, Gao et al. (2013) adopted analogy to predict the TLCs of emerging technologies, eliminating the need for all patent data related to the technologies because the distribution patterns of the patent indicators for an anchoring technology are used to determine the TLC stages of a test technology. Moreover, researchers can prioritize quality over quantity in selecting patent data. This method is also used in the present study. However, Gao et al. neither specified their method for selecting training technologies nor clearly described the similarities at specific TLC stages between training and test technologies (thus, whether comparing these similarities by analogy achieved significance remains unknown). This paper presents empirical approaches to both limitations in the research of Gao et al. (2013).

2. Development of telematics

2.1. Definition of telematics

The development of the intelligent transport system (ITS) resulted in the integration of mobile communications, data transmission, and positioning systems. ITSs have been applied to managing and controlling road and transportation systems, with ITS applications becoming a traffic improvement trend among developed countries. Telematics combines the systems of wireless communications, information management, and in-vehicle computing to allow car owners to use wireless communication functions to exchange and convey information as well as provide drivers and passengers with personalized information services. In recent years, telematics has been a crucial development in ITS fields. “Telematics” is a portmanteau of the words “telecommunications” and “informatics” (Cho et al., 2006). Telematics resulted from the rapid development of wireless communication technology, global positioning systems, and e-commerce. Through the application of onboard units (OBUs) in vehicles, telematics systems facilitate in-vehicle communication and information services. The most crucial features of telematics systems are that they assist people in driving, integrate services, and are service-oriented. Telematics system services are provided by various vendors, such as content providers, content coordinators, software developers, hardware vendors, telecommunication service providers, telematics service providers (TSPs), and telematics system coordinators (i.e., vehicle manufacturers). Through the collaboration of these vendors, telematics systems can be used to provide services (e.g., communication, entertainment, safety, medical, and navigational services) to satisfy user needs. Fig. 1 presents the conceptual framework of a telematics system.

2.2. Future and trends of telematics development

In response to the saturation of the global vehicle market, vehicle manufacturers have explored new markets and developed new products to expand their business scope. In seeking high-value-added products, vehicle manufacturers have transformed vehicles into diversified service platforms. Therefore, vehicles are not only used for transportation but also for providing drivers with additional features to promote driver and vehicle safety as well as mobile communication. Because customers expect vehicles to be equipped with telematics systems, many vehicle manufacturers provide telematics services. As wireless communication technology and information and communication technology (ICT) have evolved, telematics technology has been developed. In addition to some TSPs, which cooperate with vehicle manufacturers, independent TSP vendors also provide telematics services. The cooperation of both types of TSPs as well as telematics technology innovations is the key factor influencing the development of telematics-related industries. This cooperation and innovation drives healthy competition among TSPs and telematics-related industries to develop innovative user-oriented telematics services.

The global telematics market continues to expand and is projected to have a compound annual growth rate (CAGR) of approximately 23% for 2014–2020. Currently, the market penetration is 15% (i.e., of all the vehicle units produced globally, approximately 12% include installed telematics systems [embedded, integrated, or tethered]; according to market trends, this figure is likely to increase by up to 50% by 2020 [IndustryARC, 2014]). The global telematics market is focused on many countries in North America (e.g., Canada and the United States), Europe (e.g., the United Kingdom, France, Germany, and Italy), and Asia–Oceania (e.g., Japan, Korea, and Australia) (Markets and Markets, 2014). Moreover, North America leads the global telematics market, but growth in the telematics market in Europe and Asia-Oceania has been substantial. Therefore, the global telematics market possesses high growth potential.

Telematics systems combine technology from many industries. Therefore, developing telematics systems requires applying and integrating technology from many industries. Because end consumers primarily use telematics systems while driving, these systems should be designed to provide consumers with needed information in a safe and practical manner. Therefore, the key technologies used to develop telematics systems are ICTs, in-vehicle computing technology, human–machine interfaces, and software platforms. Particularly, the rapid evolution of ICTs has produced diverse applications of telematics technology in recent years. For example, although wireless networking environments are highly developed, a new generation of onboard computers was designed, thus connecting driver and passenger smartphones and tablet computers by using wired or wireless high-speed connection interfaces (e.g., Bluetooth, universal serial buses, MirrorLink, mobile high-definition links, and MiraCast devices). Therefore, these onboard devices allow drivers and passengers to access the Internet and operate vehicles, thereby providing additional navigational, media, and networking services. Because of the advances in telematics technology, this study analyzed not only the current TLC stage of telematics technology but also its other TLC stages and the key technologies of each stage, thereby assessing telematics technology development.

3. Methodology

3.1. Determining technology life cycles

3.1.1. By patent data

Since the theory of product life cycle (PLC) was proposed in 1966 (Raymond, 1966), TLCs have been investigated extensively (Andersen,