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A mixed spectrum management framework for the future wireless service based on techno-economic analysis: The Korean spectrum policy study

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ABSTRACT

The evolution of radio technology and various services has increased the world's dependence on wireless communications. The demand for and value of spectrum resources therefore are also increasing. Spectrum efficiency is the most important factor in managing spectrum scarcity. However, under the current spectrum management approach, it is difficult to adopt innovative technologies that improve spectrum efficiency and flexible usage in the current dynamic wireless market. Recently, there have been several approaches to improve efficient use of spectrum resources, and each approach has its own advantages and disadvantages. Therefore, this research first discusses current issues and analyzes relative social welfare based on the different characteristics of technology and market conditions to compare various attributes of each approach. Based on the techno-economic simulation results, this paper introduces a mixed spectrum management framework for the future wireless service and support policy makers' decision making. Furthermore, the mixed spectrum policy to spectrum management in Korea is proposed to find a more realistic and efficient spectrum management policy.

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1. Introduction

Recent development of new technologies and services has made wireless communication more important in people's lives, with the dawning of the age of broadband and of flexible and agile systems. Therefore, the demand for and value of spectrum resources will significantly increase. According to the International Telecommunications Union (ITU) report, the estimated total spectrum bandwidth requirement for the year 2020 ranges from 1280 to 1720 MHz² and in the case of Korea, researchers estimate 2520 MHz as the total spectrum bandwidth requirement in the year 2020 (Chung, Lim, Yook, & Park, 2007). Although those results do not include Local Area Network (LAN) and broadcasting systems,³ it forces spectrum

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² The Radio Communication Assembly 2003 adopted Recommendation ITU-R M.1645 on the "Framework and overall objectives for the future development of IMT-2000 and systems beyond IMT-2000"; Recommendation ITU-R M.1768 suggests a methodology for the spectrum requirement estimation based on M.1645. The empirical results are presented in Recommendation ITU-R M.2078. With higher market setting, the total spectrum requirement for the IMT2000 and evolution of IMT2000 systems is expected to be 840 MHz in the year 2010, 1300 MHz in the year 2015, and 1720 MHz in the year 2020. With lower market setting, total spectrum requirement is expected to be 760, 1300, and 1280 MHz, respectively.

³ only included pre-IMT systems and IMT-2000 and its enhancements and IMT-advanced systems.

access users to use a limited spectrum resource as efficiently as possible because the spectrum resource is scarce and limited.

Coase (1959) suggested a spectrum auction through the spectrum property concept as an efficient spectrum allocation method. Thirty years later, New Zealand introduced the world's first spectrum auction, and many countries have introduced auctions since Personal Communications Service (PCS) allocation by auction in the USA was successful. Furthermore, several countries have recently allowed spectrum trading and leases besides auctions, and liberalization of spectrum usage right is actively down for discussion. Both auction and trading are a market-based management regime in terms of spectrum management policy, and it is becoming popular in many countries.

In Korea, government policy has generally been based on "Command and Control" with little concept of a market-based regime. The Korean government did not adopt auctions for the spectrum allocation but stated clearly in the Spectrum Act (2000) a concept of allocation based on fees, which introduces a market concept. The International Mobile Telecommunications (IMT)-2000 licenses were first granted through this allocation method. Moreover, government is trying to change the spectrum management policy to use spectrum flexibly and efficiently.

The traditional spectrum is mostly managed by an exclusive licensing "Command and Control" method. In this method, a license is given to a regulator, which grants the licensee exclusive use of a specific service for an extended period of time and also cannot be transferred to another party. It has also been realized that static long-term licensing of spectrum use by a single technology hinders fast innovation cycles because developments of new technologies generally move faster than regulations. In recent years, there has been a growing trend toward deregulation and a great reliance on market forces in spectrum management. Thus, new perspectives on spectrum policy have emerged.

There are many and long-standing discussions on efficient use of the spectrum. Farquhar and Fitzgerald (2003), Rosston (2003), and Hazlett (2003) recommended a number of regulatory and statutory changes, such as eliminating use restrictions for new wireless allocations, replacing existing use restrictions with power limits, and enhancing rules about interference limits. Furthermore, Baumol and Robyn (2006), Hazlett and Bazelon (2007), Benjamin (2007), Werbach (2004), and Cave (2006) suggested adaptive and flexible spectrum management regimes. The Ofcom (2005, 2007) reports also suggested that spectrum trading, liberalization, and unlicensed use should be implemented.

Meanwhile, significant strides have been made in radio technology including wideband radio, such as spread spectrum and ultra wideband (UWB), software-defined radio (SDR), cognitive radio (CR), ad-hoc networks, and other forms of peer-to-peer infrastructure architectures. The developers of these technologies ensure that the products based on these technologies undermine the current system of administrative allocation of exclusive-use licenses, and they request an open or shared approach to the spectrum that would do away with exclusive use. Lehr and Crowcroft (2005), Cooper (2005), and Peha (2005) discussed spectrum common and sharing approaches.

The literature to this point has pointed out the pros and cons of each regime, and some researchers have compared each regime. For example, Faulhaber (2006) compared the property right regime and the common regime. However, the analyses have only provided a rationale for each regime, and there have not been enough comparative analyses and verifications required for an overall evaluation and comparison of different regimes to make a decision with the complexity of industry. Ting, Wildman, and Bauer (2005) tried to make a model for the welfare characteristics of several possible governance regimes and used the model to evaluate the static welfare performance of each. In this model, the regimes differ according to whether the number of competitors is determined by the government or by open entry and whether the interference robustness of devices is set by regulators or determined by market forces alone. Tonmukayakul and Weiss (2006) showed a trade-off between the market mechanism of secondary spectrum use and the nonmarket mechanism of unlicensed spectrum access, and compared welfare based on the signal to interference and noise ratio (SINR) utility values. This study also focuses on transaction cost effects in the secondary spectrum use using welfare analysis. However, there have been very few researches by applying computational methodology. Even if computational methodology was considered, it is based on the market and regulation factors and not based on technology and service characteristics. Since a suitable frequency band and required bandwidth are different according to technology and service characteristics, the analysis considering these factors is required. In additions, despite the fact that the way of spectrum sharing has been progressing due to the development of technology, previous researches have mainly focused on market-based mechanism. Therefore, research on the spectrum sharing management as well as market-based and unlicensed regime is required.

This research analyzes different spectrum management regimes to investigate various attributes depending on technology and service characteristics and the wireless communication market conditions by comparing the social welfare values. Based on the simulation results, this study can examine the welfare consequences of policy makers' choices regarding controls on entry and the engineering specifications of wireless devices with new innovative technologies. Furthermore, this paper proposes a mixed spectrum management framework for the future wireless service. This framework supports more flexible spectrum use for the service providers and promotes intense competition as well. Moreover, it is suitable for the converged services as paradigm changes and encourages adopting innovative technology. For policy implications, the mixed spectrum policy is applied to spectrum management in Korea.

The remainder of this paper is organized into several sections. In the following section, the alternative spectrum management regimes are analyzed. Section 3 introduces the welfare analysis model with premises and simulation assumptions. Section 4 shows a simulation scenario and parameters. Section 5 shows the simulation results and suggests the mixed spectrum management framework. Section 6 concludes the paper and addresses policy implications.

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