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## A new institutional perspective on shared spectrum access issues

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## **A new Institutional perspective on shared spectrum access issues**

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### **Abstract**

This paper analyzes the evolution of the Radio Spectrum Management (RSM) institution in Europe in the light of the New Institutional Economics. The paper uses the “four levels of institutional analysis” framework developed by Williamson to analyze and shed light on limits of the current RSM system. In this paper we focus particularly on the impact of technological change represented by the emergence of Cognitive Radio (CR) on level 2 and 3. The second level of institutional analysis refers to the “formal rules of the games” (institutional environment). We argue that the shift from exclusive and static to shared and dynamic use of spectrum is an institutional change fostered by the use of CR and the desire to meet spectrum-specific policy objectives. The third level of institutional analysis refers to “the play of the game” between actors with different objectives and strategies. Here, the reaction of incumbents and potential new entrants are discussed. It is shown that actors who want the change are trying to shape the rules of the game in order to get a competitive advantage whereas incumbents resist to the change. We conclude with main themes discussions and issues for future research.

## 1. Introduction

In the latest years, the limits of the current approach to spectrum management were demonstrated. Current management system is based on static and long term allocations which lead to the inefficient use of spectrum resource (Bae, 2008). The recent literature has shown some limits to the current system (Crocioni, 2009) (Cave, 2010) (Valenta et al., 2011). For example, several measurements have revealed the underuse of radio spectrum (FCC, 2002; Valenta et al., 2010; McHenri et al., 2006). The inefficiencies under the current RSM system originate from exclusive rights of use, spectrum fragmentation, and the reluctance of spectrum right holders to exchange use state-allocated rights. On the other hand, existing technologies could render a better use of frequency bands, and in particular, the new cognitive radio paradigm. Cognitive Radio (CR) is the technology which adds intelligence to radio components and facilitates opportunistic secondary use of TV White Spaces (TVWS) (Ballon, Lehr and Delaere, 2013). This new paradigm seems the most valuable for a dynamic and flexible radio environment (Mitola and Maguire, 1999). In fact, when considering recent attention in “cognitive radio” use scenarios (Barrie, Delaere and Ballon (2011); Peha, 2009; Durantini and Martino, 2013) and other technologies such as Software Defined Radios (SDR), Ultra-Wide Band (UWB), cognitive radio technology appears like the most promising solution to face up to the limits of current system (Taparia, Basaure, et Casey, 2012). With this technological change, spectrum access models are shifting from static and individual access to dynamic and shared access. As a consequence of this, several spectrum market design scenarios have been developed such as: pooling access model, private commons model, hierarchical access model, or dynamic secondary spectrum market model (Durantini and Martino, 2013; Barrie and al., 2012; Caceido and Weiss, 2011; Weiss and Lerh, 2009). These various design represent a new institutional environment which will imply the development of new institutional arrangements (Williamson, 2000). They represent a change of the formal rules of the game, which may influence, in the near future, the play of the game.

The objective of this paper is to analyze the evolution of the spectrum management institution in Europe and the current trend of deregulating wireless resource in the light of the “New Institutional Economics”. This paper is twofold. First it analyzes the impact of the technological change, i.e. Cognitive Radio emergence, over the basic institutional environment. CR influences the formal rules of the game. We are aiming to show particularly how they impact the existing property right and their allocation. Second, this paper analyzes the impact of the institutional change on the behaviors of firms, and we are arguing that it is during the changing environment that the actors need to rethink their strategies (Jacobides, 2010a).

The rest of the paper is organized as follows. Section 2 briefly reviews Williamson’s framework and presents information on the field study. Section 3 discusses the formal institutional environment (level

2), based on an analysis of the evolution of property rights under RSM since the emergence of CRs. Sections 4 analyzes the new institutional arrangement “shared spectrum access” described in the literature and sets out the behavioral response of stakeholders and new firms face to this institutional change. Section 5 concludes the paper by summarizing the main themes.

## 2. Background

### 2.1. Technological change as a determinant of institutional change

The Cognitive Radio (CR) is a novel concept which constitutes a new technological change. This new concept fosters new opportunities to the evolution of the institutional framework. The Cognitive Radio System (CRS) was first introduced as a concept in 1999 (Mitola & Maguire, 1999) and it was recently described by ITU (2009) as:

*“A radio system employing technology that allows the system to obtain knowledge of its operational and geographical environment, established policies and its internal state; to dynamically and autonomously adjust its operational parameters and protocols according to its obtained knowledge in order to achieve predefined objectives; and to learn from the results obtained.”*

In the panel of main enabling technologies such as ultra wideband (UWB) devices, mesh networks, software defined radio (SDR), smart antennae, Cognitive Radio is considered as the technological development which could lead to a “*new disruptive development cycle in wireless communications industry*” (Fomin et al. 2011).

Thus, the CR can be seen as a disruptive innovation allowing the improvement of the initial institutional arrangement. Indeed, spectrum system management is based on the licensing regime which delivers long term and individual right of use, leading to some inefficiency. For example, underuse of resource is becoming an increasingly concern anywhere in the world and appears as a central issue in Europe. Underuse of frequency bands, e.g. “white spaces”, “spectrum holes”, means that some parts of spectrum are unused during sometimes or in some geographical areas (McHenry, McCloskey, Roberson, & Macdonald, 2006). However, CR represents a technological change and a solution to face the limits of current system by fostering a Dynamic Spectrum Access (DSA). CR and DSA concept allow increasing use and access to radio frequency (Baldani et al., 2013). IEEE (2008) defines DSA as:

*“the real-time adjustment of spectrum utilization in response to changing circumstances and objectives, where, changing circumstances and objectives include (and are not limited to) energy conservation, change’s of the radio state (operational mode, battery life, location, etc.), interference-avoidance (either suffered or inflicted), changes in environmental/external constraints (spectrum,*

*propagation, operational policies, etc.), spectrum usage efficiency targets, quality of service (QoS), graceful degradation guidelines, and maximization of radio lifetime.”*

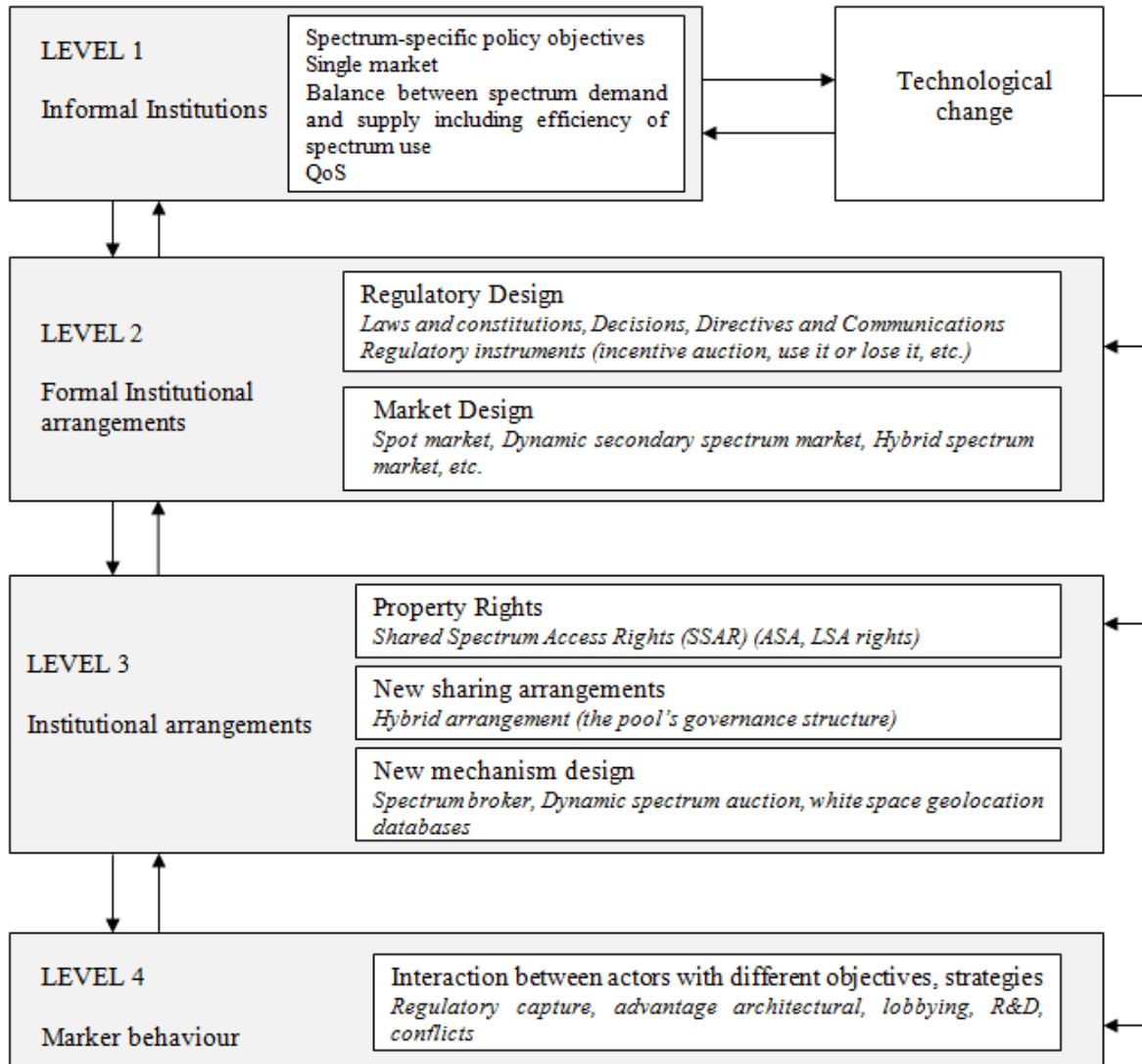
The deployment of CRs in the TV White Spaces (TVWS) has already been tested. However the potential of this technology could be applied to more frequency bands such as allocated band in order to remove constraints for industries which are limited by the current spectrum management approach. Particularly, the evolution of the demand for wireless networks capacity (Cisco, 2011) and the inefficient use of the allocated spectrum (D'Itri & McHenry, 2008, FCC-02-135, 2002, Valenta et al., 2009) could be resolved with the use of dynamic spectrum access technologies.

Hence, European commission calls to a shared spectrum access and the deployment of dynamic spectrum access technologies. The following section seeks to make observations about the current change toward a collective use of spectrum and applied the four-layer model (Williamson, 2000) to the spectrum market.

## 2.2. Four levels of institutional analysis

In this section we consider the literature that adopts the point of view of these agents who consider cognitive technologies like the promising solution to improve current spectrum management. We employ the New Institutional Economics literature to analyze the impact of the cognitive radio on the institutional framework. Institutions are designed as “rules of the game” (North, 1990; Williamson, 2000). By allowing a shared and dynamic use of frequency bands, cognitive radio implies to define new rules of the game.

We use the most useful framework proposed by Williamson (2000) to analyze the new institutional spectrum management since the emergence of cognitive radio technology. Williamson (2000) distinguishes four stages in which an institution functions. The following sections 3 and 4 focus on level 2 and 3 of the institutional analysis. Here, we discuss the first level which deals with spectrum-specific objectives that the institution is embedded in. The general objectives of a single market and spectrum market reforms for a shared and dynamic access, on the one hand, and, competition and innovation, on the other, impose constraints on lower level. The spectrum-specific policy objectives are the efficiency use of spectrum resource, the respect of the QoS and the balance between spectrum supply and demand. As CR concept appears as a solution to improve these objectives more attention has been paid for this technology. To limit the scope of this paper, we focus on the impact of technological change on the levels 2 and 3 applied to the spectrum market. The second level relates to regulatory design and market design which are the two main institutions of the market economy (Glachant, 2005). The third level provides analysis of new institutional arrangements and these consequences in terms of organisations and behavior on the wireless services market.



Source: Adapted from Williamson (2000), Groenewegen (2005)

**Fig.1. Economics of institutions**

It should be stressed that level 1 is important in shaping the evolution of institutions in general, and so, spectrum management in particular. Informal constraints such as norms, culture, beliefs (level 1) evolve and influence formal rules over time. Here we consider specific wireless services sector informal constraints at the level 1.

The wireless services industry is experiencing a period of rapid change. Tomorrow, billions of devices connected to internet will be able to communicate with each other and with minimal human intervention to deliver new services. This interconnected world will enable new business models in transport systems, health (such as medical appliances, phone, digital health, Body Area Networks),

research, civil protection, and in environment and energy (including smart energy grids and smart metering systems). Increases in world population and wireless services demand in the next few decades are expected to cause a substantial rise in world spectrum use. Global mobile data traffic will increase 26 % annually by 2015 (CE, 2012). By then, there will be 50 billion of intelligent connected devices in 2020 according to the European Commission<sup>1</sup>, or 100 billion, according to economist Richard Thanki (2012). These intelligent connected devices will make up Internet of Things (IoT)<sup>2</sup>.

Growing spectrum needs for wireless connectivity is becoming increasingly important in the economy. The manner of allocation and regulation of radio spectrum is a key issue for the development of the Internet of Things. The Europe 2020 Strategy sets environmental objectives for a sustainable, energy-efficient and competitive economy. Wireless technologies can play a key role in meeting these objectives. The interconnectedness of different spectrum functions reflects the increasing complexity of our modern society. Economic functions (navigation, transport and energy wireless applications), ecological functions (smart grids and smart cities applications) and social functions (safety and security) are of critical importance to our modern society. Reinforcing number of frequencies allocation for one particular function may have adverse effects on others under an individual use regime. Policy-makers, as well as spectrum managers cannot afford to be ignorant about one of these functions; for this, the consideration of a collective use of spectrum is appeared more and more useful.

Moreover, radio spectrum is a key resource which today supports 3.5 million jobs and more than €250 billion of economic activity each year in Europe (CE, 2012). Finding additional spectrum could create more job and considerable economic gains. That is why politics are studying varied ways to maximize spectrum value. But spectrum is a complex resource; each of the four dimensions (political, economic, institutional and physical dimension) interacts with implementation of new measures, policies or architectures. Thus, RSM can benefit from knowledge of NIE analytical tools.

In this paper, informal institutions in the sense of the Williamson's conceptual framework are the broad spectrum policy objectives (such as spectrum demand for wireless broadband, convergence of services, cross-border coordination, digital dividend, etc.), the single market, and the balance between spectrum demand and spectrum supply including efficiency of spectrum use. We consider that

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<sup>1</sup> Digital Agenda: Commission consults on rules for wirelessly connected devices - the "Internet of Things"  
Cisco (2012) Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2011-2016  
OECD (2012) Machine to Machine Communications: Connecting Billions of Devices. OECD Digital Economy Papers, no.192

<sup>2</sup> Internet of Thing refers to future communication between a wide variety of sensors and control mechanisms supporting a variety of applications for people, for cars, or for cities. It is a collection of inanimate objects that can communicate with each other electronically. They can exchange information at any time (day, night, on the move), anywhere (traveling, inside and outside, with PC or not PC) and in different and varied way (PC to PC, person to person (without PC), person to object, object to object). The Internet of Things is the connection between the real and virtual world. This concept gathered steam since the development of new technologies, such as RFID, wireless sensors, nanotechnology, etc., which enable to extend the use of the Internet to real objects.

informal institutional changes lead to a new trend in the UE institutional framework consolidated by the emergence of cognitive radio.

### **3. The emergence of a new institutional environment**

The property rights govern the manner in which actors use and accede to frequency bands. Property rights structure and determine the final outcome of RSM. According to [Demsetz \(1967\)](#) an efficient use and allocation can be reaching through the privatization of natural resources and market forces. However, in the case where the costs of exclusion are high the efficient use and allocation is compromised. This is true particularly in the case of the spectrum resource where “*essential sectors and services, including mobile, wireless broadband and satellite communications, television and radio broadcasting, transport, radiolocation, and applications such as alarms, remote controls, hearing aids, microphones, and medical equipment. It supports public services, such as security and safety services including civil protection, and scientific activities, such as meteorology, Earth observation, radio astronomy and space research*” depend on this resource. More recently, the benefice of the shared spectrum access regime, where both the licensed and unlicensed users have access to the frequency bands, are increasingly realized. In this section, we first describe and assess the shift from a static and exclusive property regime to a dynamic and shared property regime that has driven in Europe.

#### **3.1. From static to dynamic management**

Currently the institutional structure in spectrum sector in Europe is changing. This change originates from the technological change represented by the emergence of CR and implies a redefinition of initial property right. Change may take place on all institutional levels. The legal framework is changing and regulators propose new forms of property rights to match spectrum supply and demand under these new conditions. The previous section introduces the technological change represented by CR technologies and raises the question about this impact on level 2 and 3 of institutional analysis. Here we analyze the institutional change resulting of the emergence of dynamic spectrum access technologies by looking new formal rules of the game and property rights.

By proposing to create market by auctioning off property right for radio bandwidth, [Ronald Coase \(1959\)](#) appears as one of the important pioneers of New Institutional Economy. Hence, static and exclusive spectrum property rights have been created establishing competitive mechanism and market institution like the new institution behind the Command and Control model. Moreover, in the late 1990s, secondary spectrum market has been built to allow adjusting supply and demand. However, at



this day spectrum scarcity remains a big concern. Two supply-side flaws explain why the market couldn't operate in reasonably close accord with economic principles. The first supply-side flaw is due to the current duration of spectrum access and causes a lack of supply reactivity to short-time access need of frequency bands (PCAST, 2012; Holland et al., 2012). Indeed, today two extreme durations of authorized spectrum access are possible, e.g. longer-term licenses which give exclusive use rights to the license or unlicensed access without QoS. The second supply-side flaw comes from the license term which provides strong expectation of renewal following expiration (Mardsen, 2011). In this sense, competition through auctions is only one-shot. If short-time supply could be enforced by a dynamic access, the market could function almost in alignment with the theory of competitive markets. License auctions have allowed granting a license from 10 years to 35 years, which means that licenses are similar, for carriers, to monopoly rights allowing individual exploitation of a frequency band during this long-term period. Moreover, the high degree of complementarities among spectrum licenses creates entry barriers to the market for wireless services (Bae et al., 2008). These problems lead to the need to rethink initial institutional arrangements.

In the light of actual property rights appearing incompatible with future wireless-connected world, competitive mobile market, and innovation, the Europe policy is driving toward shared spectrum access. Since the CR concept many studies have explored the benefits of a shared and dynamic use of spectrum (PCAST, 2012; Holland, 2012, Peha, 2009, Doyle et Forde, 2007; Olafsson et al., 2007). Most politicians, researchers, engineers, and economists agree that a shared spectrum access will be better than the current individual use of spectrum.

Shared spectrum access appears like the best solution to meet an efficient spectrum management system. Growing concern over growing need in frequency band have revived interest in sharing and collective use of spectrum for some time now. In 2002, the Spectrum Policy Task Force report recommends spectrum sharing and introduces white space sharing concept. In 2008, the Radio Spectrum Policy Group (RSPG) adopted in this report<sup>3</sup> a transition approach aiming at shared access. It claimed that a “*coherent approach to Collective Use of Spectrum (CUS) can stimulate the development of sharing technologies in Europe, resulting in more sophisticated sharing possibilities and more efficient use of spectrum*”. Collective use of spectrum is based on the principle of a shared access of frequency bands between two or more users. Requirements to meet spectrum sharing are not well explicit in the literature. In 2006, Collective use of spectrum is defined, in a study for the European Commission, as “*one of three main approaches to management of radio spectrum, the other two being the administrative model, (...), and the market based...*” (p.9) that means CUS is referring to commons approach. But, later in the document, (p.22), CUS is defined as “*all spectrum management approaches allowing more than one user to occupy the same range of frequencies at the*

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<sup>3</sup> «Aspects of a European Approach to “Collective Use of Spectrum”»

*same time, without the need for individual (exclusive) licensing*". So, this second definition opens the way to new institutional arrangements (level 3).

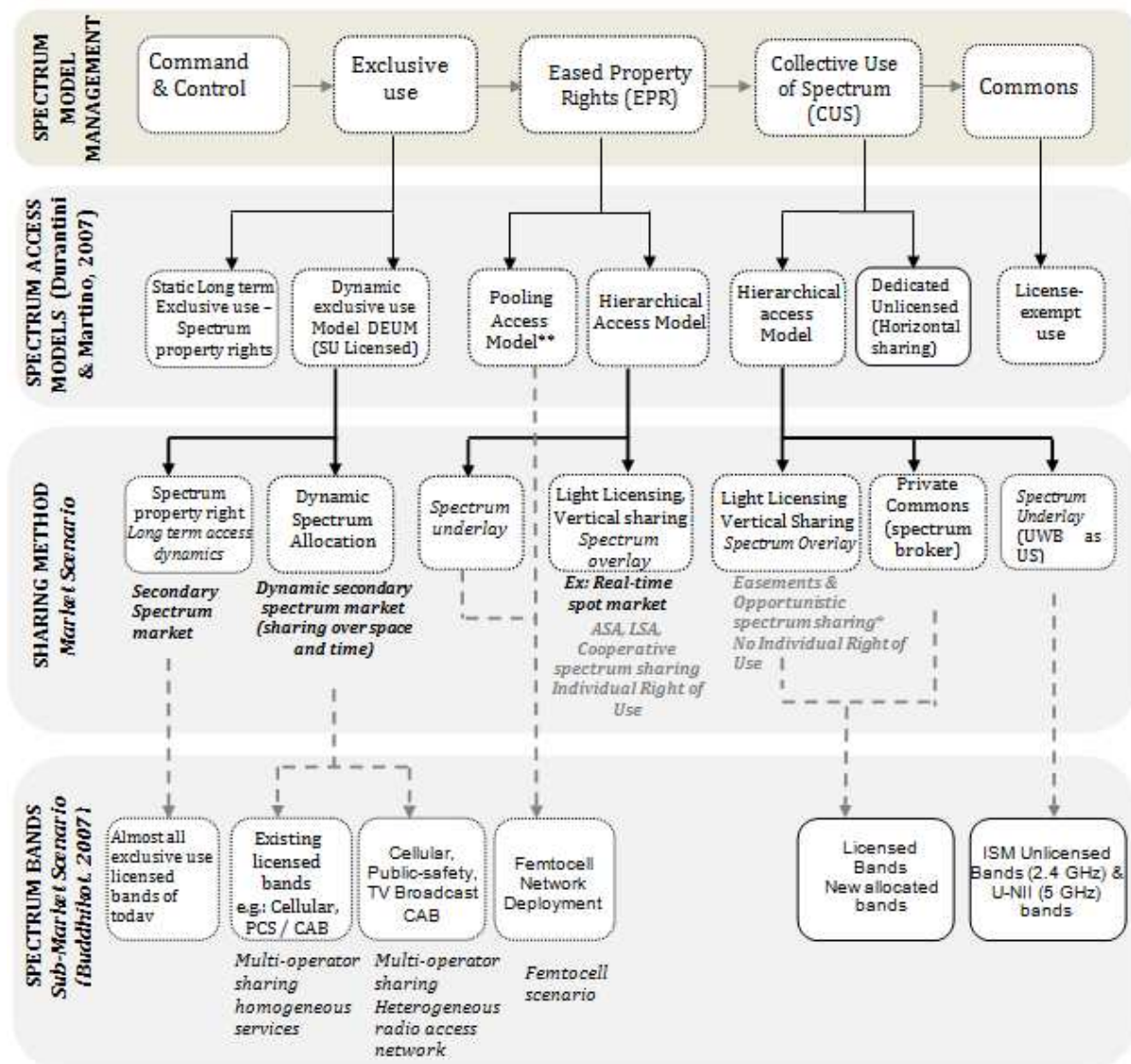
### 3.2. Shared Spectrum Access Right

In this way, Shared Spectrum Access Rights (SSAR) have been recognized by regulators leading to various sharing scenarios. In 2011, Qualcomm and Nokia, in a joint response to the RSPG consultation on cognitive technologies, proposed a new institutional arrangement, Authorised Shared Access (ASA), which is a specific property rights model, including in this scheme cognitive radio techniques. ASA propose a shared access to spectrum under a licensing regime in order to offer services with a certain quality of service. Another similar concept developed by RSPG in the same time is the Licensed Shared Access concept (LSA). These two authorization schemes are in line with the current approaches for spectrum sharing. LSA and ASA are new regulatory-based modes and show the political desire to map a transition pathway. They constitute a new institutional arrangement because they differ from traditional band sharing seeing that they are not a static arrangement set by the regulator (SCF, 2012).

Moreover, CUS concept, DSA concept and SSAR lead to new sharing arrangement such as the pool's structure governance, or new mechanism design such as real-time auction (Gandhi et al., 2008). Each of these concepts shall constitute some institutional evolution which implies new reforms to the radio spectrum management and use. Hence, the technological change has an impact on formal institutions and institutional arrangements. Shared Spectrum Access represents a new institutional arrangement which should lead to the implementation of institutional reforms and new property rights to access spectrum such as ASA rights. NIE is also useful to analyze how the reforms will emerge and which kind of arrangement will be chosen and influenced by actors. It will be necessary to analyze the reform in the light of three following criteria: the attractiveness, the feasibility, and the credibility of the reform (Perez, 2002).

### 3.3. Diversity of the "Shared Spectrum Access" reform

As we can see in the Figure 1 the trend toward a shared and dynamic spectrum access will necessitate the implementation of reform. At this time, except the trial use of TVWS none reform has been implemented. However we can consider the extent of the possible reform. The dynamic and shared spectrum play a part in modifying first the spectrum management model, second the spectrum access model and third the spectrum shared model as it is shown in the Figure 2.



Source: Adapted from Buddhikot (2007), Zhao and Swami (2007), Hwang and Yoon (2008) and Durantini and Martino (2013)

Fig. 2. “Shared Spectrum Access” reform diversity

These various models will lead to various business models scenarios. [Baldani et al. \(2013\)](#) identify eight main use cases which could emerge under the application of CR concept. These use cases are the following: (1) ad-hoc CR in White Spaces frequency bands, (2) Mid/long range wireless access over White Space frequency bands, (3) Short range wireless access over White Spaces frequency bands, (4) Short range with spectrum underlay, (5) Dynamic Exclusive-Use, (6) Uncontrolled commons, (7) Managed commons, and (8) Private commons. Each case makes reference to a specific authorization model for spectrum usage. [Durantini and Martino \(2013\)](#) describe three authorization models for spectrum usage: (a) dynamic exclusive use model (DEUM), (b) collective use of Spectrum (CUS), and

(c) Eased property right (EPR). These models lead to different spectrum access approaches as suggested in [Durantini and Martino \(2013\)](#), and the regulatory decision concerning the choice of the spectrum access approach will have different impact on the wireless industrial organisation. For example, at this time, only CR in white spaces frequency bands is allowed. For others use cases the debate is underway. However, in the near future cognitive radio should improve the actual system by creating a new spectrum market design, surely more complex, with the respect to the incumbents. This one will require specific regulation.

#### **4. Institutional evolution and game of actors in the shifting landscape**

The fourth level is represented by market behavior shaped by interaction between actors with different objectives and strategies. In this section we analyze the emerging behavior response of actors face to the emerging concept of shared access spectrum and the use of cognitive radio. We make the distinction between organizations and institutions according to North's theory.

##### **4.1. A spectrum policy reform altering the balance between stakeholders**

Since the emergence of CRs, technological, institutional and political elements constitute a socio-technical transition. The architecture of wireless industry is expected to change under this socio-technical transition and the associated results. Thus the impact of cognitive radio on the institutional environment seems to lead to new regulatory reforms which will constitute an occasion for existing firms or new entrants to build an architectural advantage and to shape rules of the game.

In the actual RSM evolution, the real challenge to firms is to redefine the different rules and roles in the sector ([Jacobides, 2008](#)). Actors are expecting important structural change in the wireless industry. Research on mobile communication industry has considered the development of a multi-sided platform due to the entry of new stakeholders in existing market ([Taparia, Casey & Hämmäinen, 2012](#); [Casey and Töyli, 2012](#)). More recently, a potential TV white spaces exploitation value chain has been developed, and one of the next promising actors in this value chain seems to be intermediary spectrum managers who includes geo-location database managers, Brokers, Band Managers, etc. ([Mwangoka and al., 2013](#)). Those scenarios and new intermediary spectrum actors will affect the current spectrum market design. The pool's governance structure, spectrum broker's governance structure, or dynamic auctions represent new arrangement and market design. The aim of this section is not to detail the various market designs which are possible under the Shared Spectrum Access regime but to understand that changes in an upstream spectrum market influence the play of the game in the downstream wireless services market. Moreover, we argue that it is during the change that incumbents

and new actors need to shape the new rules of the game. Thus, as none reform has been implemented at this time, it is the good time for actors to intervene shaping the future rules of the game in order to get a competitive advantage and to create a bottleneck in the new value chain.

#### 4.2. Looking for the architectural advantage

This section describes the industry architecture that allows understanding how firms try to shape their competitive environment to create and capture value. According to [Jacobides et al. \(2006\)](#) industry architecture “*provides two templates, each comprising a set of rules: (1) a template defining value creation and the division of labor, i.e. who can do what and (2) a template defining value appropriation and the division of surplus, or revenue, i.e. who gets what.*”

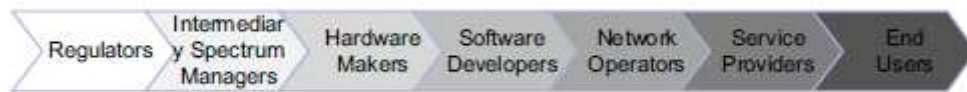
Google is an interesting case to study how actors try to gain an architectural advantage in the new value chain of TV white space exploitation. Moreover, the case of Google has already been mentioned by Jacobides like a firm particularly successful to reshape all sort of sector ([Jacobides, 2008](#)). The Google interest for TV White Spaces shows one more time the capacity to the firm to understand that “never-ending” dimension of the battle in the redefinition of the sectors. According to [Jacobides’ concept \(2008\)](#), it seems that Google not want to own the sector but the firm seeks to control it by creating an TVWS ecosystem of interdependent firms, where he could capture the critical parts.

CR influences the architecture of the spectrum market and various institutional ways have been considered by researcher. However, a modification in the formal institution “spectrum market” may affect the formal institution “industry architecture”. Thus, it exists for incumbent a true challenge in the design of new formal institutions for spectrum market. Considering the new institutional economics, actors try to shape the rules of games and this is very important in a changing environment if they don’t want to lose their profit ([Jacobides, 2006](#)). These new designs of market will not emerge autonomously but will be create by regulatory bodies. That’s why, certain actors have already started the running to the architectural advantage by tempting to influence regulator in these decisions.

This section points out how certain actors are trying to capture value in the new white spaces value chain while other are being to block the deployment of CR. It attempts to identify strategies of some actors and their key stages in the “architectural advantage” running process. It also notes that regulators are already implied in the introduction of the radio cognitive on the market and that this consideration should motivate mobile operators to look how they can build and capturing value in the changing competitive landscape.

Like opportunities for changing the architecture thus emerge in new sectors, for new technologies ([Jacobides et al. 2006](#)), the new TV White Spaces sector enabled with the use of CR represents an

important opportunity for actors to capture an amount of benefits created by this new spectrum use. Recently, [Mwangoka et al. \(2013\)](#) have analyzed a potential TV white spaces exploitation value chain which includes new actors such as intermediary spectrum managers. These new actors will be in the top of value chain, just behind the regulator. When we look this value chain the extreme interest shown by Google for the white space is clearer. Indeed, the Google's core of competence is to be service provider. Google is a web search engine and computer software company. However, in 2005, Google bought the mobile software Android, and in 2011, the company bought Motorola, the mobile device manufacturer.



**Fig. 2. A potential TV white spaces exploitation value chain ([Mwangoka et al. 2013](#))**

The growing interest of Google for the white space shows that it has understood that the structure of the sector is changing and that the profits are migrating from one part of the value chain to another. Hence, Google seeks to introduce itself in the new TV White Space value chain by developing strategies and new instruments such as geo-location database, web site spectrum database, etc.

The case of Google is one of the most interesting to illustrate this desire to build a competitive advantage. The Google's initiative to create a spectrum database<sup>4</sup> shows the interest of the actor for the growing need for spectrum availability. Through his database, Google is working with regulator and industry to reach a consensus allowing a dynamic spectrum sharing. So, as [Anker et Lemstra \(2012\)](#) have highlighted, the government and the firm are highly interdependent in the realization of their objectives.

However, while potential new entrant may shape the new rules of the game, incumbents show a resistance to the change (North, 1990). In the existing literature this resistance to the change has been mentioned several times for example as following:

- [In Baldani et al. \(2013\)](#): "*Incumbents are usually against spectrum sharing approaches because they do not want to lose or share their rights on spectral bands, based on considerable economic investment (for example, UMTS auctions) or needed for operational reasons (for example, public safety and military bands).*" (p.100) and "*In some case, there was a clear opposition to spectrum sharing from incumbents*" (p.103)

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<sup>4</sup> <https://www.google.org/spectrum/whitespace/index.html>

- In [Medeisis et Minervini \(2013\)](#): *“Incumbents systems and standards are likely to pose a substantial barrier to the technology-push of CR”* (p.109), and, *“The main factors that appear to lock CR development into the R&D phase are the onerous regulatory requirements for the protection of incumbent technologies, which are further compounded by the wary attitude of existing stakeholders.”* (p.112)
- In Taparia, Casey, and Hammainen (2012): *“Win win situation is considered important because the potentially losing spectrum owners have many powerful means to slow down the evolution towards increasing spectrum dynamics”*.

The list of citation is not exhaust. Thus, the technological change has an influence on industrial organization. The shift toward a collective use of the spectrum resource is going against the interest groups that have traditionally benefited from the current system (Stigler, 1971; North, 1990;

The continual effort to deregulate wireless spectrum resource and promote dynamic spectrum access can be seen as a deregulation policy. [Glachant and Perez \(2008\)](#) made an institutional analysis of the reforms in networks industries, particularly deregulation policy, and discussed four steps that could be relevant in our future research. First step concerns the issue of the attractiveness of the reform is introduced the issues concerning the status quo that some of the interest groups can benefit. Second step of the institutional analysis consist to evaluate the revise of industry structure while the third one consists to recast industries that are constrained by the initial configuration of their right. Then, it is necessary finally to adapt the governance structures to the new nature of the transaction. Hence, the aim of this fourth step institutional analysis will be to identify various forms of governance structures induced by the current trend of deregulating wireless resources.

## **5. Conclusion**

This paper suggests that the new institutional economics can provide powerful tools and useful insights in analyzing shared spectrum access issues and assessing potentials evolution of the regulatory framework. Property rights and transaction costs are two main concepts developed by NIE which are relevant to understand the shift from a static and exclusive use of spectrum to a dynamic and shared use, because this one might require dramatic changes in the allocation of rights, in policy makers' actions and in coordination among parties.

In this paper we have brought the beginnings of NEI applied to the spectrum market by structuring the analysis according to Williamson's four levels of institutional analysis and focusing particularly on levels 2 and 3.

The current institutional design of spectrum policies is unable to ensure that spectrum supply adequately meets demand. Although the move towards a collective use of spectrum is certainly a step in the right direction, it constitutes a challenge for policy makers and calls them to make choice. The analysis of the future “rules of the games” (level 2) under the use of dynamic spectrum technologies has highlighted the fact that this trend implies a diversity of new institutional arrangements and new spectrum market. Spectrum policies and rules in general lead for new forms of sharing of underutilized spectrum. However, as arguing by [Nicita and Rossi \(2013\)](#), *“none of the mentioned theoretical models has gathered sufficient attention to translate into a concrete policy proposal.”*

The third level analysis is exposed to severe problems in the “play of the game”, including serious enforcement and price problems. It seems that the move toward a dynamic use will need to set and enforce new mechanism design such as dynamic auction and new spectrum price. The sharing of spectrum between primary and secondary users leads to define a new payment system for unlicensed actors who are not contributed to the auction and infrastructure payment.

ASA and LSA shared spectrum access right seem the most promising because they are based on coordinated and not opportunistic sharing, allowing a guaranteed quality of service (QoS) for both incumbent and prospective users. The following works will discuss the role of the regulator in the establishment of new “rules of the game”. Particularly, we are agreeing with that fact that a government cannot change all the rules. Thus, deregulate entirely the spectrum resource and authorize an open spectrum, as recommended by certain actors, we appear unrealistic because basically we cannot do all what you want with rights. The government need to be credible on the long term and stable, that why LSA and ASA appear at this moment as the best institutional arrangement because they defend incumbents interests.

Because individual levels are inter-connected, the technological change has an impact on the four levels. By influencing one level, a change or a problem have repercussions on the other levels. In this paper the player’s incentives are briefly analyzed, however, they are very important for understanding the evolution of the radio spectrum management in the near future. A detailed analysis of each of these levels is an important venue for our future research.



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