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Analysing standardisation processes as technology trajectories in the mobile ecosystem: Implications for competition and innovation

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Analysing standardisation processes as technology trajectories in the mobile ecosystem: Implications for competition and innovation

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1 Abstract

The traditional mobile industry expresses worries for the future due to converging technologies and new actors. Standards are the foundation for convergence, and have been central in all current subsectors of the mobile industry. However, subsectors have developed different technological knowledge, routines and path dependencies in their standardisation processes and can be understood as different technology trajectories within the same technology paradigm. The research question in this comparative case study is: What are characteristics, differences and similarities of important standardisation processes in the mobile telecommunication ecosystem? The systematic comparison suggests that the technology trajectories 3GPP and ETSI neither are able to spur necessary innovation in the wider ecosystem, nor to ensure satisfying profit. IETF and 3WC spur innovation through an extensive accessibility to standards, but appropriability conditions are challenging. It is private platforms such as Google and Apple that seem handle both aspects: to enable innovation and adoption by making technology elements public through extension markets, and simultaneously ensure profit by keeping technology private.

This research contributes by clarifying how the tension between private and public goods is played out in major technology trajectories in the mobile telecommunication sector; especially helpful is the distinction between standard openness and extension markets as different means for making technology public. The four concepts developed for assessing the status of standardization processes

can be used for structuring discussions on the issue, and for future analyses of technology innovations in the telecommunication sector.

2 Introduction

The mobile telecommunication industry is based on a networked technology where standards are essential ((Funk & Methe, 2001); (Edquist, 2003)), and assets co-specialized and interdependent (Teece D. J., 1986). It is debated if standardization is an obstacle or enabler to innovation ((Blind, 2013); (Choi, Lee, & Sung, 2011)). The ongoing discussion among mobile network operators (MNO) reflects this; will standards, digitized and converging technologies lead to further innovation and success for the MNOs, or imitation and substitution of their services? (GSMA, 2014). This tension between appropriability and adoption is a returning issue both in the information and communication technology (ICT) industry and other sectors ((West, 2003); (West, 2007); (Laursen & Salter, 2014); (Teece D. J., 1986) (Teece D. , 2006); (Farrell, 2007); (Boer & Hansen, 2013); (West, Salter, Vanhaverbeke, & Chesbrough, 2014); (Laursen & Salter, 2014)). The firm – or sector – faces the dilemma of sharing technology, knowledge and economic return through standards in order to enable variety creation, innovation and growth among its complements, and still be able to protect and profit from own innovation through for instance intellectual property rights (IPR).

What puzzles me is the unresolved tension between openness and control, both in theory and practice. My goal is to provide empirical research that can shed light on the discourse in the mobile telecommunication sector. I do this by comparing and analysing five cases from the wider telecommunication ecosystem. The specific research question is: What are characteristics, differences and similarities of important standardisation processes in the mobile telecommunication ecosystem?

In section three I introduce the theoretical background and four concepts developed for assessing the standardization bodies. Section four describes the research design. Section five is a short description of the cases. The result and discussion of the case comparison are provided in section six and conclusions in section seven.

3 Theory and development of concepts

The tension between appropriability and adoption ((West, 2003); (Teece D. J., 1986)) is present either we discuss technical or non-technical aspects of standards. At the core of this tension is the general discussion of knowledge as private or public goods ((Fagerberg, 2003); (Castellacci, 2008)),

or more specifically Internet openness and the paradox of information (Mansell, 2013). Public goods lead to more innovation, but it is harder to make profit from the innovations. It is easier to retain profit from a private good, but more difficult to spur the necessary innovation among complements in a networked and interdependent market. In principal, the firm – or sector – has to retain some parts of the technology private in order to profit.

Standardization is “a voluntary process for the development of technical, but more and more also other types of specifications based on consensus amongst the interested parties” (Blind, 2013, p. 6). In the first instance, it is shared technical specifications that have public good characteristics and raise the debate on appropriability and adoption. However, it is also recognized that “a variety of market and nonmarket processes determines the evolution of standards” (Greenstein & Stango, 2007, p. 1). Thus, in the second instance, there are non-technical aspects of standards that affect their public and private goods characteristics. These non-technical aspects draw attention in this paper, their private and public good characteristics, and how they play out together with appropriability and adoption conditions in the mobile ecosystem.

The cases I have chosen – standardization bodies – implicitly have public goods characteristics seen from a purely technical perspective. Thus, my focus can turn to non-technical aspects of standards in order to investigate variations in public and private goods characteristics. I have developed four concepts in order to do the analysis; two concern the non-technical aspects of standards and their public and private goods characteristics, and two concern the appropriability and adoption aspects of a technology.

3.1 Standard governance

Standards imply some form of non-technology requirements. The general literature on technology paradigms and trajectories (Dosi, 1982), sectoral systems (Malerba, 2005), and evolutionary economics (Nelson & Winter, 1982) hold that technology implementations are complex social systems which include aspects such as know-how, methods, routines and practices – both planned and unintended. Malerba (2005) emphasizes accessibility, opportunity, and cumulativeness as key dimensions of knowledge related to technology and learning.

According to West (2007), participation, specification processes and goals of standardization are key non-technical dimensions to consider in the specific discussion on standard openness (West, 2007). West and O’Mahony (2009) have compared open source community initiatives, and conclude that the stakeholder’s *design* of the community is critical in addition to technical architecture; organization of production, governance, and intellectual property are important design elements.

Stakeholders' design choices are affected by the wish to retain *control* over technologies and profit, and need for *openness* in order to attract innovative resources. West and O'Mahony make a distinction between the ability to freely *use* the technology, and the allowance to *develop* the technology further. Proprietary software development approaches are at the extreme end of controlling technology (West & O'mahony, 2009). Historically, the practice of protecting innovations and expected profit with patents, copyright and secrecy is widely implemented and accepted (Granstrand, 2005).

I summarize the non-technological aspects of standards in a concept called *Standard governance*. This concept is a main variable when assessing standardization bodies, and it is informed by many indicators on both control and openness. This includes use of patents and other means of controlling and reducing accessibility to technology, and means of sharing and increasing accessibility to standards. Governance of a standard can be a very open, inviting process, or more closed and private. The specific indicators and variable extremes are elaborated on in a later section.

3.2 *Extension markets*

West (2007) introduces willingness to share technology *elements* as an additional way of making technology public (West, 2007). Controllers of a mainly proprietary technology with private good characteristics can choose to give parts of their technology public good characteristics; this strategy is foremost to ensure the adoption of technology and ensure innovation (Henkel, Schöberl, & Alexy, 2014). Revealing of technology (Henkel, Schöberl, & Alexy, 2014) and extension markets (Jansen & Cusumano, 2013) are similar suggested strategic tools for actively sharing technology.

Extension markets are implemented by giving access to elements of a private technology through application programming interfaces (API). Third parties can develop extensions of the core technology, use them, and take part in a market for such extensions. The organization of such extension markets can be more or less sophisticated depending on accessibility and prices; examples of more commercial and accessible markets are Apple and Google's app-stores (Jansen & Cusumano, 2013). In parts of the mobile telecommunication ecosystem it has been a critical capability to provide technology elements as public good and engage developers to use it for innovative complements; recognized players are Apple, Google, Microsoft and the Web/HTML5 (Visionmobile, 2012).

A general observation of standards, even more important for extension markets, is that the revealed technology can be developed continuously or episodically; both cases reach wide adoption due to network effects, but the continuously developed technology is more sustainable due to tacit

knowledge and learning effects ((West, 2007); (Nelson & Winter, 1982)). Furthermore, the price, ease of use and actual accessibility for extension markets vary and affect the adoption.

Extension markets are regarded as the fundament for an open value creation system that leads to higher performance for both the industry and single firm ((Iansiti & Levien, 2004); (Gawer & Cusumano, 2002)). More firms take part in the necessary variety creation, and this will eventually benefit the party that actively shares the technology.

The relevance of the extension market stems from its potential impact on the adoption of a technology, innovation, dynamic and profit among complements and other actors. Thus, a concept called *Extension market* includes these elements. Standardization bodies can be characterized by more or less sophisticated implementations of Extension markets. It can be combined with both open and more closed forms of Standard governance.

3.3 Business models and appropriability

A third concept concerns the ability to extract profit from technology, and is called *Business models and appropriability*. Telecommunication standards with different public and private good characteristics imply a variation in revenues and profits. Furthermore, actors may capture value and ensure profit from very different sources (Visionmobile, 2012), sources that are outside the telecommunication market and with yet different public and private goods characteristics. Thus, size, structure and source of revenues and profits explains how actors are motivated in their balancing between appropriability and adoption, and the more general innovation dynamics going on in the market. The concept Business models and appropriability includes these aspects.

3.4 Innovation performance

Innovation performance is the fourth concept developed to assess the standardization bodies in the mobile telecommunication ecosystem. The differentiator's main intention is to shed light on ability to innovate through engaging other actors, or how to ensure adoption aspects of the technology. Even though it is recognized that wider adoption in networked industries has positive effects ((Teece D. J., 1986); (Iansiti & Levien, 2004); (Gawer & Cusumano, 2002)), the causality between openness and innovation is still controversial. The controversy stems from the tension between control and openness, and the perspective that it is only private goods that ensure private profit (Fagerberg, 2003). Both the questioning of causal relationship and available data challenge investigation into the issue.

The innovation and business ecosystem literature provide indicators on how high innovation performance in a sector can be understood and measured ((Nelson & Winter, 1982); (Malerba, 2005); (Iansiti & Levien, 2004)). High revenues and profits are ultimate signs of high performance both for the single firm and industry. However, in a networked and interdependent industry, innovation is often understood as the presence of creation of variation in the industry sector, and dynamics, growth and adaption of the innovation by complements (Teece D. J., 1986). High revenues and low profit without these other indicators can be a sign of a declining, or not so healthy, firm and sector; innovation is necessary for sustainability (Iansiti & Levien, 2004). From this we can infer that growth, dynamics and variety creation are good signs of high innovation performance in a sector, in the context of financial numbers.

To summarize, I have developed four concepts in order to assess characteristics, differences and similarities between standardisation processes in the mobile telecommunication ecosystem. These concepts will in the following be understood as variables, informed by many indicators. Standards must be understood as both technology specifications and non-technical practises. The recognized tension between appropriability and adoption guides the search for indicators of control, secrecy, sharing and accessibility in both the *Standard governance* and *Extension market* concept. Growth, revenues, profit, dynamics and variety creation are the important indicators for the concepts *Business models and appropriability* and *Innovation performance*.

4 Empirical context and method

I have collected and analysed empirical data on several standard setting organizations (SSOs) and private platforms in the mobile telecommunication industry in order to study the characteristics, differences and similarities of important standardisation processes in the mobile telecommunication ecosystem. SSOs and private platforms are observable cases. They can be understood as technology trajectories that constitute major parts of the mobile telecommunication industry technology paradigm (Dosi, 1982).

This is a comparative case study, with a *most similar case* approach (George & Bennett, 2005). The cases – SSOs and private platforms – are similar as they provide technical specifications with public goods characteristics, and different along other variables. I was initially not able to identify and build on an existing, complete typology. Thus, the study can be described as analytical, theory-driven induction where the goal is to shed light on the relationship between variables.

There are other comparative studies on standards setting in the telecommunication industry ((Takanashi & Lee, 2013); (Farrell & Simcoe, 2012); (Funk, 2009); (Laffan, 2011)), but to my knowledge none that have done a comparison of major technology trajectories across the industry, with a focus on innovation dynamics. Nevertheless, I have used the mentioned studies from the telecommunication sector to inform the data collection. I have chosen cases that are different from those often used in studies of the telecommunication and Internet sector; they often include some form of content, logical and physical layer ((Benkler, 2006); (Fransman, 2010)). To use standards as cases is a new angle and can lead to new results.

I have collected three types of empirical data. Eight *interviews* of industry and standardization experts in the Norwegian mobile network operator Telenor guided the research initially, and enriched the analysis. The standard setting organizations' *web-sites* are the fundament for comparisons and analyses. I have also used available market and actor analyses of the sectors to inform the variables.

An explorative initial phase with assessment of the cases led to a gradual development of relevant concepts, and belonging indicators. These concepts are treated as variables in the analysis of the cases. The variables developed are Standard governance, Extension market, Business models and appropriability, and Innovation performance. The theory introduced above, and suggestions in other case studies and comparisons affected the constitution of the concepts ((West, 2007); (Edquist, 2003); (Takanashi & Lee, 2013); (Funk & Methe, 2001); (Jansen & Cusumano, 2013); (West & O'mahony, 2009)).

Standard governance was the most demanding variable to develop; it took a lot of "soaking and poking" to establish a set of indicators that could inform it (George & Bennett, 2005). A description of the indicators that inform this variable is given in Table 1. The description of the indicators is complemented by an explanation of why they are relevant, and how an indicator can vary for different standard setting bodies. The twelve underlying indicators I use for the variable are implicitly subject to a logic of *family resemblance*; it is not necessary for an indicator to be present in order to categorize the case at the extreme (Goertz, 2005). I provide a more comprehensive description of this variable in order to reveal the richness and complexity that the assessment of the cases is based upon. The other three variables are satisfyingly specified with the conceptual description in the previous chapter, and the later analysis.

Table 1 Standard governance indicators

<i>Separating dimension</i>	<ol style="list-style-type: none"> 1) <i>Description of variable</i> 2) <i>Potential relevance for innovation</i> 3) <i>Variable variance</i>
Membership in SSO and working groups	<ol style="list-style-type: none"> 1) Standards in standard setting bodies are developed in groups with individual members. 2) How easy/controlled it is to become a member on all levels will affect the constitution of such a group, and subsequently the work of the group. 3) The bodies can vary from totally open to a more restricted membership policy.
Membership fee conditions	<ol style="list-style-type: none"> 1) In addition to having restrictions on who can become a member, the standard setting bodies may require a membership fee. 2) The size of a fee can affect the perceived easiness of becoming a member. 3) The bodies vary from totally free to a higher membership fee.
Numbers of actors involved in standard development	<ol style="list-style-type: none"> 1) There are different numbers of actors (firms) involved in the standardization processes. 2) The number of actors says something about the complexity in a process, and how easy decisions come about. 3) Numbers can vary from many to one.
Financing	<ol style="list-style-type: none"> 1) The financing of the standardization body can tell something about the stakeholders – and financial stakes – of the sector. 2) This may skew the actions and decisions in the standardization processes. Some standards are financed by the members, which again are commercial actors in the industry. Other standards are financed by interest groups and universities. This latter group may also be subject to commercial interests, but in more intricate ways. 3) Idealistic versus commercial interests.
Effect of large organizations	<ol style="list-style-type: none"> 1) The effect of large – and commercial – organizations is a concern for those who believe that knowledge and ability to make good decisions (for the standards) are equally distributed among independent individuals. 2) Commercial actors would – as an obligation to their owners – seek to arrange perceived good solutions for the owners. Others will hold that ability to change and innovation for the customers and society – and eventually the commercial companies – is better taken care of by competent individuals. 3) Some standard setting bodies seem to be highly affected by large organizations, while others mainly consist of independent individuals.
Decisions and voting	<ol style="list-style-type: none"> 1) The development of standards involves decisions on how to proceed and finalize a standard. Initiation, governance, completion and decisions on standard specifications are all aspects of this process. 2) It leaves room for different conclusions, and different effect on market performance. 3) The standard setting bodies are different with regards to process as well as voting.
Mission	<ol style="list-style-type: none"> 1) The mission is a statement of overall motivation for the standard setting bodies, what it wants to achieve; standards and technology as public or private good is implicit here. 2) If the actual standards adhere to the mission they could affect the overall market performance to develop in different directions. 3) Missions seem to be both very technically oriented, industry oriented or more idealistic.
Patents	<ol style="list-style-type: none"> 1) Standards are consensus on specifications, but can include patents held by private parts. 2) Patents ensure compensation for Intellectual Property Rights, and affect the cost of using the standard in the first instance and potentially performance in second instance. 3) Standard setting bodies vary from trying to reach a royalty free state, to having a FRAND

	policy for patents; FRAND means patents licensing on Fair, Reasonable and Non-Discriminatory terms.
Availability of standards	<ol style="list-style-type: none"> 1) Standards are described in (digital) documents provided by the standard setting bodies. 2) Less available standards – or a high price – could imply to exclude users, or a less efficient diffusion of standards. In this way access to standards can affect performance in several ways. 3) More or less available standards.
Transparency	<ol style="list-style-type: none"> 1) In the above listing of variables we have illustrated how standard setting bodies can differ, and affect performance through actions. 2) Actions can be subject to external judgements, and be perceived negative by others. Transparency ensures that it is easier for the external environment to affect standard setting bodies – for good or bad – based on facts rather than suspicion. 3) More or less transparent.
Path dependency	<ol style="list-style-type: none"> 1) Path dependency is the tendency for standard setting bodies to make choices that are affected by existing decisions, knowledge, processes, investments, etc. In the case of standard setting bodies, existing standards could potentially highly affect choices. 2) The concept of path dependency is recognized to affect performance both positively and negatively. On the one hand path dependence ensures scale, critical mass, deep insight, efficiency and other elements that serve the users. On the other hand path dependency decreases the ability to necessary change. 3) The standard setting bodies vary from being path dependent by declaring backwards compatibility, to claiming pure technological functionality.

5 Case description

The cases drawn for comparison are either *standard setting organizations* or *private platforms*. The standard setting organizations are ETSI, 3GPP, 3WC and IETF. These institutions set standards for respectively telecommunication in general, mobile telecommunication, the web and Internet. They have often been put in the same category and treated as similar (Farrell & Simcoe, 2012), but are very different with regards to practices of sharing and control of technology.

ETSI and 3GPP belong to the regime of industry-led standard setting bodies in the mobile telecommunication sector. 3GPP (3rd Generation Partnership Project) covers mobile (cellular) telecommunication network technologies. 3GPP is governed and financed by six different telecommunication standard development organizations, one of them ETSI. It recruits its participants from for instance ETSI.

ETSI is the EU recognized European Telecommunications Standards Institute, and produces standards for the wider information and communication sector. Its members are paying firms in the industry, as well as academic and public institutions. The larger commercial firms have to pay the most for being members. The participants in the standardization processes are recruited from the members.

3WC and IETF are bodies that are run by communities of volunteers, initiated and supported by influential stakeholders. 3WC (World Wide Web Community) is still led by the Tim Berners-Lee, the inventor of the web. It has the mission to lead to the World Wide Web to its full potential by developing protocols and guidelines that ensure the long-term growth of the Web. It adheres to open standard principles that will fuel development of new technologies and innovations for humanity. Any organization or individual can participate in standardization processes for free. 3WC is financed by Berners-Lee and a few universities.

IETF (Internet Engineering Task Force) is an open community which is concerned with the evolution of the Internet architecture and operation. It develops the Internet standards through open working groups. Any individual can participate for free. It is financed by The Internet society, a professional membership organization of Internet experts.

The final type of standardization process I will study is the imposing of standards by *private platforms*. Apple and Google are examples which control influential standards in the mobile industry, respectively iOS and Android. These are private companies that have succeeded in establishing their technologies as crucial platforms in the mobile telecommunication industry.

6 Results and analyses

6.1 Assessment of standard governance

The extant literature and industry discussion are focussed on openness as the important differentiator between standards. I find that commercial interest is the most noticeable difference between SSOs and private platforms compared in Table 2; there is a strong tension between creating and protecting existing markets versus a more idealistic perspective toward creation of good technological solutions and ensuring innovation. The differences come from: the ways the standardization bodies invite and accept participants into their processes, cost of participating, the effect of participants, commercial interests, IP policies and missions, and how path dependency is manifested. I denote the extremes for this variable non-commercial and commercial. It reflects the discussion on the nature of a good, whether it is public or private. Jansen and Cusumano (2013) suggest a similar governance model for software ecosystems, with and *community* and *private entity* as the extremes (Jansen & Cusumano, 2013).

Table 2 Comparison of SSOs and private platforms in the mobile ecosystem

<i>Separating dimension</i>	<i>W3C</i>	<i>IETF</i>	<i>3GPP</i>	<i>ETSI</i>	<i>Private platforms</i>
What is this?	Web	Internet	Mobile	Telecom	E.g. Google, Apple
Standards developed	HTML5	TCP-IP	GSM, 3G, 4G	e.g. DECT, TETRA (GSM)	Apple: iOS Google: Android
Membership in SSO and working groups	Individual	Individual	Membership organization assign individual	Membership organization assign individual	Private
Membership fee conditions	No fee	No fee	Membership organization has paid, e.g. ETSI	Membership fee, vary with size. E.g. universities have low fee	Private
Number of actors involved in standard development	Many actors (operators, HW, universities)	Many actors (content, operators, HW, SW, universities)	Many actors (content, operators, HW, SW, universities)	Many actors (content, operators, HW, SW, universities)	One central player in each “private platform”
Financing	Universities, inventor Tim Berners-Lee foundation	Internet society	Membership organizations, e.g. ETSI. Some are larger contributors	Membership fee	Private. Financed on commercial terms.
Effect of large organizations	All individuals equal	All individuals equal	Larger organizations have more voting power	Larger organizations have more voting power	Private
Mission	Innovation to the best of society	Technology concerns. Running code.	Backwards compatibility.		Private missions
Decisions and voting	Consensus. Moderator plays important role.	Consensus. Moderator plays important role.	Consensus. Can come to voting where larger organizations have more votes.	Consensus. Can come to voting where larger organizations have more votes.	Private
Patents	Prefer royalty free standards	Accept patents on terms that are Fair, Reasonable and Non-Discriminatory	Accept patents on terms that are Fair, Reasonable and Non-Discriminatory ¹	Accept patents on terms that are Fair, Reasonable and Non-Discriminatory ² .	Use patents actively to protect technology ³ .
Availability of standards	Freely available on web-sites	Freely available on web-sites. Patents restrict use.	Freely available on web-sites. Patents restrict use.	Freely available on web-sites. Patents restrict use.	Not available. E.g. Google based on Open source, however “closed”

¹ The electronic and hardware industry providing components in the telecommunication market hold many US patents (IFI Claims Patent services, 2014), for instance Samsung, Sony, Qualcomm, LG, Intel, Ericsson and AT&T. This indicates that patents are a significant commercial method also in this part of the industry, however attempting to be managed on fair terms.

² Ibid.

³ Google and Apple score high on several assessments of their patent activity, both regarding patent power (Thomas & Breitman, 2013) and number of US patents (IFI Claims Patent services, 2014)

					through governance practices (Laffan, 2011). Apple is proprietary technology.
Transparency	Fully transparent	Fully transparent	Regarded as being fair, transparent and efficient.	Regarded as being fair, transparent and efficient.	Not transparent
Path dependency			Backwards compatibility important		
Important websites and sources	www.w3.org	www.ietf.org	www.3gpp.org	www.etsi.org	(Laffan, 2011)

Figure 1 show the variable Standard governance as a horizontal dimension, and how I have assessed the cases. 3GPP is a standard setting organization for the mobile industry, with paying members from the industry and a clear ambition of ensuring the market through backward compatibility. In the case of 3GPP backward compatibility is not only signalling high level of commercial ambitions for 3GPP, but also a high degree of self-imposed path dependency. It is positioned to the right in the illustration. The traditional SSOs in the mobile industry – ETSI and 3GPP – are similar to Private platforms when it comes to commercial motivations, although less so, and for different reasons.



Figure 1 Assessment of standards according to the variable Standard governance

Melody describes SSOs such as 3GPP as *open* standard bodies (Melody, 2013). However, this is compared to Private platforms with their heavy use of IPR. 3GPP is closed in the sense that the participants are recruited from the mobile industry, and it has a cost to participate. The missions are clearly commercial to the best of those that already are stakeholders, for instance with backward compatibility. However, they produce standards that are accessible for others. Standards are currently a self-imposed regime, however based in historic political processes where standards for fundamental infrastructure have been imposed to the best of society.

Apple and Google are positioned even farther to the right on the dimension Standard governance. According to Melody these actors are closed, playing a game of secrecy and patents (Melody, 2013). Patents are not only used to protect own profit from specific technologies, but to exclude

competitors from access to technology in general. Laffan has done a comprehensive study of Google's position in the mobile industry, and its use of open source (Laffan, 2011). She concludes that while seeming open through its use of open source technology and involvement with the developer community, the company uses its governance of code to keep a tight control of its resources.

I have placed IETF on the left side of the dimension Standard governance. On this end of the scale technological performance is most important. It is the same with W3C, which provides standards on a very idealistic basis with open innovation to the best of society, and technical merit and sharing as important values. These bodies are the providers of Internet and web standards, and represent more idealistic stakeholders such as Internet society and Tim Berners-Lee.

According to this comparison the Non-commercial standard setting bodies are making their goods completely public. The Commercial standard setting organizations are providing only partly public goods: 1) the 3GPP and ETSI support their own peers, whereas 2) private platforms are providing highly private goods, but have still made their technology a de-facto standard. Private platforms have done this partly by using extension markets – that is, made elements of their technology public.

6.2 *Making goods public through extension markets*

In my data, I find that the existence of a sophisticated Extension market is a significant *differentiator* between the cases; therefore Extension market is an important variable with the existence and non-existence of such markets as the extremes. Private platforms – for instance Google and Apple – differ significantly from 3GPP and ETSI with their sophisticated use of Extension markets (Jansen & Cusumano, 2013); (Visionmobile, 2014)). Mobile network operators – represented by their association GSMA – have had focus on Extension markets through standardized interfaces or so-called APIs (application programming interfaces) for several years. Nevertheless, GSMA reports that mobile network operators' extended markets have not been successful in general (GSMA, 2014). The analyst Alan Quayle observes that mobile operators partly do not provide APIs and extension markets, and partly do not succeed (Quayle, 2014).

Figure 2 shows the variable as a vertical dimension. I have positioned Private platforms and GSMA&ETSI on opposite extremes. W3C (HTML5) is also providing a different, but widely used and freely available extension market (Visionmobile, 2014). HTML5 is both a highly public standard and recognized as providing an extension market. Google and Apple are proprietary technologies – or practise commercial Standard governance – with a sophisticated extension markets. I have not enough information to confirm that also IETF offer some form of extension market.

The variance between the cases for the variable Extension markets takes another pattern than for Standard governance. This means that the presence of an Extension market can be combined with either of the extremes of Standard governance.



Figure 2 SSOs and private platforms, and assessment of standard openness

6.3 Business models, appropriability and innovation performance

A report from the research program EU Future Internet analyses the Internet sectors in Europe, with specific attention to US dominance in high growth areas (EuropeanCommision, 2012). The report provides interesting data on Internet revenues, growth and dynamics. I have taken the opportunity to transpose the dataset and focus more purely on technological separators rather than regional. Figure 3 shows a European Internet industry where there are significant differences between sectors. Although the data are focused on revenues that belong to the Internet field they are still relevant; the innovation dynamics in the sector are specified, and the web sector made explicit. I have here ascribed the standardization bodies I compare to the Internet sectors. This is a general indication of the footprint of the standardization bodies; in practise the different Internet sectors take advantage of standard specifications from all the different bodies.

The *Services and Software*, and *Web* sectors are growing more and are perceived more dynamic. Standards from W3C and IETF have been important in these sectors. Considering the wide distribution of the standards, the revenue level for the *Web* sector is low. The low ability to extract revenues and profit reflects – as expected – the public good characteristics of the standards. Internet and the Web have “created a variety of new business opportunities and ways to make money” (Cusumano & Goeldi, 2013, p. 39), however “taking money from these new business models has been difficult” (Cusumano & Goeldi, 2013, p. 242). Despite the innovation Internet and Web has generated, the ability to generate revenues and profit take three forms: enhancing existing business models (online sale), substituting existing business (travel agencies and book retailers), or creating totally new businesses (Internet portals, e.g. Google). The two former models are characterized by

having their revenue sources in a different sector than the Web-sector; the latter model is rarer, but it has been possible to develop new revenue sources with for instance advertising and transaction fees. All three models extract revenues in private goods outside the traditional mobile industry. (Cusumano & Goeldi, 2013)

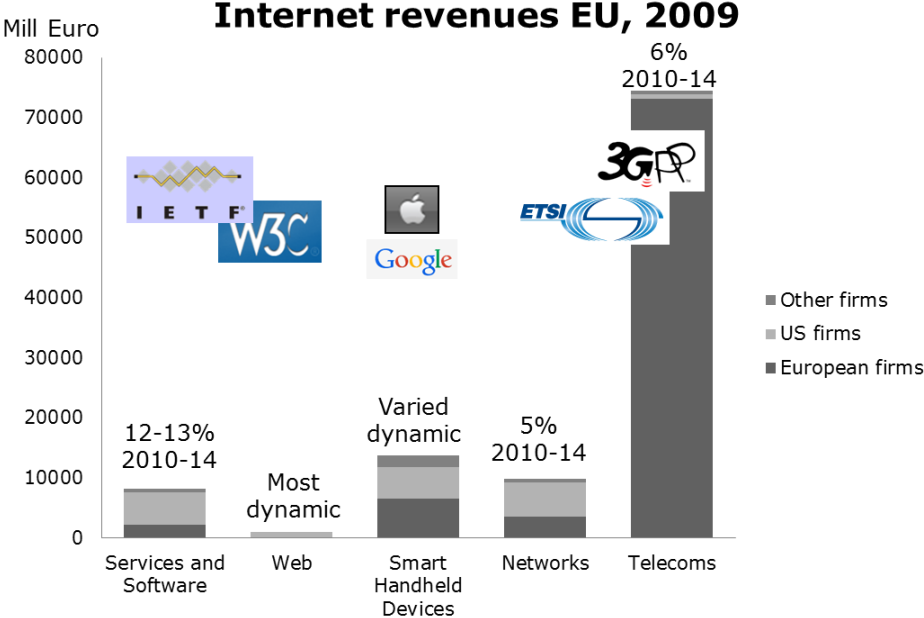


Figure 3 The size and growth potential of the European Internet sector (European Commission, 2012)

The sector *Services and software* experiences high growth. Figure 4 confirms this tendency with numbers from the Norwegian ICT market. Norway was not impacted by the 2008 financial crisis, and the IT services (including SW, excluding HW) and telecoms continued in their growth paths. High revenues and growth in the Services and software sector indicates that there is an appropriability source that may have private good characteristics (West & O'mahony, 2009).

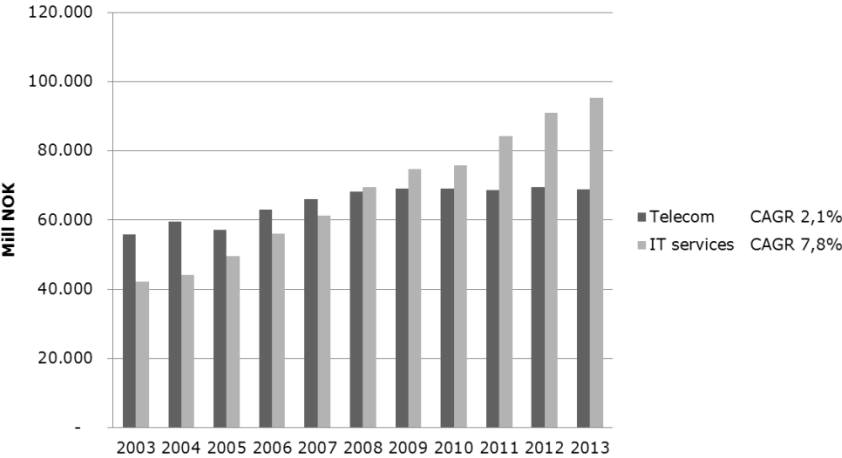


Figure 4 Growth in the Norwegian ICT industry 2003-2013

In the sector *Smart Handheld Devices*, the actors Google and Apple are successful⁴ as individual companies, with high revenues, profit, growth and a dynamic ecosystem in the mobile sector. Google and Apple have been able to spur high degree of innovation by complementing developers. Google extracts its main revenues from advertising, whereas Apple’s revenues come from the mobile device (Visionmobile, 2014). The appropriability sources are outside those of the traditional mobile network operators, founded on goods that have distinct private goods characteristics.

The *Network* and *Telecoms* sectors grow more slowly; GSMA recently reported general stagnation and inability to create necessary variety and innovation among complements (GSMA, 2014). Mobile subscriptions are the main source of revenues for the mobile network operators, while providers of network infrastructure sell hardware and software to network operators. Thus – they are in the same business, and dependent on extracting revenues *within* the traditional mobile ecosystem; this explains some of the challenges they experience with new types of actors entering the market. The mobile network operators are based on standards, however within the “club” of operators; thus, the revenues are extracted from technology with private goods characteristics. The numbers in Figure 3 also show that the Telecoms sector outperform all other sectors when it comes to size. However, a substantial size combined with low growth and innovation dynamic is also the sign of inertia in an industry restricted by its inherited routines and path dependencies (Nelson & Winter, 1982).

Table 3 Summary of appropriability and innovation performance assessment

	<i>Innovation performance</i>	<i>Business models and appropriability</i>
W3C & IETF		
Sector: Web	High	Low
3GPP, ETSI		
Sectors:	Low	Stagnating
• MNOs		
• Networks		
Private platforms		
Firms:	High	High
Google, Apple		

Table 3 summarizes a high-level assessment of the different sectors along the variables *Innovation performance* and *Business models and appropriability*; the extremes for both variables are high and

⁴ The Finnish company Nokia was stagnating in 2009. As of 2014 Nokia is owned by Microsoft, and is again among the important private platforms in the mobile telecommunication ecosystem – however we await the higher performance reports. One hypothesis for Nokia’s failure is its lock-in with the traditional Telecoms sector.

low. Although this analysis is only an indication, we can infer that the growth and innovation dynamic are higher in areas affected by standard setting organizations W3C and IETF, and the private platforms Google and Apple. The growth is slower, and ability to engage complements lower, in the telecoms sectors where ETSI and 3GPP dominate. Furthermore, we can infer that the private platforms are individually able to profit, whereas the mobile network operators currently experience stagnation. The web sector has had difficulties to extract revenues and profit, whereas the Services and software sector makes profits. The Services and software sector is not subject to further analysis in in this paper, and not included in the table.

6.4 Combination of results and summary of findings

Table 4 combines the assessment of the standard setting bodies along the variables Standard governance, Extension markets, Business models and appropriability, and Innovation performance. I include aspects that are important indicators for this general comparison. First, I report whether Standard governance is commercial or non-commercial, and have private or public goods characteristics. Second, I state to what degree the cases have Extensions markets, and how private or public goods characteristics are relaxed. Third, I assess Business models and appropriability conditions: financial and non-financial motivation; revenue sources, and; appropriability opportunities. Finally, I assess Innovation performance: whether the sectors are dynamic or stagnating with regards to engaging complements in using the technology.

This analysis is not suggesting strong causal links between the variables. However, there is a pattern that indicates a relationship between public good characteristics, and high degree of innovation performance. Furthermore, the comparison suggests that it is only one combination that reaches both high degree of innovation performance and profitability: commercial standardization bodies that have made parts of their offerings public through extension markets.

This implies that presence of either extension market or non-commercial Standard governance is a *sufficient* condition for reaching high innovation performance, as we see it for respectively private platforms, and 3WC and IETF. However, it is *necessary to* control resources with some degree of private goods characteristics in order to extract profit, as in the case for Private platforms. The 3GPP and ETSI cases with Standard governance skewed toward commercial objectives and private goods characteristics are not (anymore) *sufficient* to reach neither high innovation performance, nor profit. An additional Extension market is *necessary* to grow and sustain, as we observe for Private platforms. The variables used in the comparison can be perceived as too absolute. Knowledge accessibility and cumulateness provide important perspectives on how firms and technologies can reach high degree

of appropriability beyond technological accessibility ((Malerba, 2005); (Lundvall, 2007); (Nelson & Winter, 1982); (West, 2007)). This is not elaborated on in the paper.

Table 4 Summary of findings

	<i>W3C</i>	<i>IETF</i>	<i>3GPP/ETSI</i>	<i>Private platforms</i>	
				<i>Google</i>	<i>Apple</i>
Standard governance	Non-commercial	Non-commercial	Commercial, across many MNOs	Commercial	Commercial
	Public goods	Public goods	Private goods	Private goods	Private goods
Extension markets	Yes	NA	No	Yes	Yes
	All public goods	All public goods	All private goods	Some public, most private	Some public, most private
Business model and appropriability	To the best of society	To the best of society	Subscription	Advertising	Devices
	Weak appropriation model or appropriation external to ecosystem	Weak appropriation model or appropriation external to ecosystem	Appropriation within ecosystem Stagnation and profit pressure	Appropriation external to ecosystem Profitable	Appropriation external to ecosystem Profitable
Innovation performance	Dynamic	Dynamic	Large sector, stagnation	Dynamic and growing	Dynamic and growing

6.5 Alternative explanations

Commercial standard governance seemed to be sufficient in order to explain high profitability for the Telecoms sector up till quite recently. This is no longer the case and invites to a closer examination of how the conditions has changed. It used to be incredibly important to provide an industry with standards in early phases in order to build scale and volume – and eventually provide affordable services to users ((Teece D. J., 1986); (Langlois & Robertson, 1992); (Perez, 2010)). This point was also made by several of the informants, some of them having followed the mobile sector for decades. The development in the mobile telecommunication industry coincides with that of the modern software industry which gradually has had to cope with openness requirements (West, 2003). According to Jansen and Cusumano, software today is more like a system of complementary and interdependent activities and actors where extension markets are an important strategic tool (Jansen & Cusumano, 2013). This could just as well be an explanation of the processes going on among the mobile network operators.

I have denoted the SSOs 3GPP and ETSI as commercial, together with the Private platforms. One significant difference between them is the heavy use of patents and secrecy by the Private platforms. An explanation of Private platforms' current success can be their use of IPR (West, 2003), rather than their use of Extension markets.

It is a fact that mobile operators are not one actor – like for instance Google – but many small and large operators in different countries. The mobile sector is regulated on a national basis. Thus, it is an even more challenging process to reach consensus on Extension markets across mobile operators. The success of private platforms may be explained by that fact that they have less challenging decision processes, or are less strictly regulated.

7 Conclusion

This paper reports characteristics, differences and similarities of important standardisation processes in the mobile telecommunication industry. Both non-commercial Standard governance and presence of sophisticated Extension markets spur Innovation performance in the market. The strategies of 3WC and IETF are sufficient for high innovation performance, while the appropriability conditions for single firms are lower. Private platforms such as Google and Apple combine commercial Standard governance with presence of Extension markets and seem to balance necessary control for profit with innovation among complements. 3GPP and ETSI adhere to commercial standardization governance without the use of extension markets; they are currently neither able to create higher level of innovation dynamics in the wider industry, nor being profitable.

The research also provides a framework for doing future assessments of other telecommunication technology trajectories and standard processes. The principal nature of the analytic framework may contribute more generally to structure debates on technology and innovation dynamics in complex, networked markets.

7.1 Limitations and further work

There are some limitations to the analysis. One person has been doing the data collection, coding and analysis; it could lead to skewed conclusions. On the other hand this ensures a consistent analysis across the cases. Further work should try to identify more specific cases that would affirm or weaken the suggested theory in this paper for the investigated or other standardization bodies.

7.2 Implications for industry, and policy instances

There are some implications from the research for both individual firms and public authorities. The research suggests that firms should consider how to give access to technology through extension markets in order to create the necessary innovation and adoption among complements; profit must be founded on some sort of private goods, either within or outside the market in question. For mobile network operators specifically, it is very difficult to compete with technologies that have public goods characteristics; such technologies may be highly valuable for enhancing value, but profits should be expected to be captured elsewhere.

Net neutrality regulations were originally meant to hinder MNOs from taking advantage of the monopoly conditions of their access services; this was done by giving other services the right to flow undisturbed on top of the network. Today the Web and Internet are more settled and we observe many large and successful commercial services; these services have to large degree private goods characteristics, similar to the providers of Internet access, but extract their profit on different arenas. This observation should inform the current debate on net neutrality; in a converging market it is both a question of ensuring a fair and sustainable balance between many different competing private and commercial interests, as well as ensuring the interests of end-users and service variety.

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