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**Spectrum policy and innovation: A Japanese perspective**

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**Abstract**  
This paper investigates how spectrum policy affects the diffusion of innovation in the telecommunications sector, and is part of a general discussion on expanding spectrum policy aims to address sector innovativeness.  
We argue that innovation can be analytically depicted not only as the appearance of new technology, but also as physical network expansion of said technology, and adoption by end users. This definition is used in contrast with previous work on spectrum policy and innovation, which tends to use R&D or infrastructure investment as proxies for innovation, resulting in a more limited understanding of the innovation process.  
The study surveys the telecommunications industry in Japan over a period of 13 years (2001-2013), and discusses the effect of spectrum allocations and other regulatory acts on the expansion of the 3G mobile network.  
We found that spectrum policies excluding allocations had a negative effect on the expansion of the physical network, while the growth of said network correlated strongly with 3G penetration.  
This may suggest that the effect that spectrum policy has on innovation is most likely mediated by the role of competition in the infrastructure layer and is more pronounced in the contraction stage of the innovation life cycle. These results provide a preliminary basis for gaining a better understanding of the ways in which the policy environment relates to the evolutionary processes behind innovation.

**Keywords:** Radio spectrum, Innovation, Japan, Telecommunications
1. Introduction

In the era of ubiquitous wireless telecommunications, spectrum regulatory environments are called upon to achieve many objectives, sometimes incompatible. Alongside adequate interference management and efficient use of spectrum, scholars are now including innovation as a policy aim. Researchers such as Peha (2005) and Nicita and Rossi (2013) have argued that besides signal quality and sector competition, spectrum policy also has an effect on incentives to invest and innovate, and by extension, the long-term dynamism of the telecommunications sector. However, in such works the definition of innovation tends to be vague, making it difficult to incorporate innovation in policy models.

In the light of this lack of a more robust discussion on the role policy plays on innovation, this study looks at the evolution of a landmark telecommunications technology, namely 3G, and the extent of the influence spectrum policy had on its rise and consequent recline.

The case under investigation is Japanese telecommunications, and in particular the 3G network, in the period 2001-2013. By taking a look at the diffusion of this technology, and the role of policy in it, we hope to make a small contribution to the empirical discussion on the relationship between spectrum policy and innovation.

This study is structured in four parts. Following this introduction is a quick discussion on the definition of innovation used in this study, as well as a short background on Japanese telecommunications policy. The research design specifics and results are presented in the following sections, concluding with a summary of the present work and intended future additions to the research.

2. Background

a. Innovation frameworks

The importance of innovation for the growth of a system, whether that is the economy or a single sector, has been generally agreed upon from Schumpeter onwards. However, when researchers have tried to incorporate innovation in policy modelling, they have stumbled on the issue of how exactly to measure and define innovation.

To solve this question, many works use research and development spending or general sector investment as proxies for innovation. This approach is problematic in that for one, there is evidence that suggests that R&D or general infrastructure spending do not fully capture innovation effects (such as discussed in Audretsch and Feldman, 1996 and more recently in Kim et al., 2011 and others). Furthermore in terms of the theory, these proxies are
developed from a linear understanding of innovation, that is, as a process beginning with basic research, followed by applied research and development and ending with production and diffusion.

The problem with this approach is that these systems do not take into account the effect of other technologies and the ways users interact with them. In order to study such processes by which an innovation comes to be in a dynamic landscape of competing and complementary technologies (not to mention other sources of innovation), horizontal innovation models were developed (Kline and Rosenberg, 1986). These models differ significantly from linear frameworks because they can account for the disruptive to existing market structures elements of innovation (or creative destruction).

Nonetheless, while generally believed to be more representative of actual networks, this type of framework has not been sufficiently explored with respect to wireless technologies. It is this gap that this study wishes to address by looking at the expansion and contraction of 3G technology as part of the larger Japanese telecommunications environment.

b. Spectrum regulation in Japan

The ICT industry has for several years been a growth powerhouse in Japan, contributing significantly to GDP growth. In 2011 the ICT industry had the highest economic spillover among all industries in Japan, and within that industry, telecommunications accounted for 38% of total sales (MIC White Paper 2013). ICT and telecommunications in particular has been a strong feature of the Japanese economy and has as such been the focus of significant government attention.

From a regulatory perspective, the Radio Act is the primary legal text for the management of spectrum related issues. The Act states that the main policy aims of radio regulation are the “equitable and efficient use of radio spectrum” (Radio Act). The agency tasked with achieving this aim is the Ministry of Internal Affairs and Communications (MIC), which is in charge of spectrum allocation, assignment, and management.

Japan does not currently have any spectrum co-management or sharing regimes (such as ASA models), nor has it held any spectrum auctions, although a bill was passed in the 180th ordinary session of the Diet (2011) permitting them. Assignments and allocations are managed at the ministry level and comprise of four stages; originally a study group or committee will submit a report on the need for a re-allocation or not. After 2003 this process was streamlined with the Action Plan for Spectrum Reallocation. Once the reallocation needs
have been established, the ministry issues a set of application guidelines, usually at the same
time as, or closely followed by, a call for opening plans from interested parties. Finally, the
bands are assigned based on a ministerial process that prioritises frequency needs as
determined by the subscriber base and market fairness, but also puts heavy stress on
minimising disruptiveness.

3. Research design

The relationship of interest in this study is the influence of spectrum policy on innovation
diffusion in telecommunications. More specifically, we attempt to answer the question of
whether specific regulatory actions have an effect on the diffusion of a specific technology
(3G), while taking into account the influence of other technologies. To illustrate this
relationship a simple logit regression was used. The study surveyed innovation in the
Japanese telecommunications industry in the years 2001-2013.

The originality of this study comes from the inclusion of the horizontal effect among
competing innovations, by looking at the life cycle of 3G not in and of itself, but as it is
shaped by other technologies and policy. To introduce all these different innovation variables,
we started with the basic definition of innovation as invention made valuable (Schumpeter,
1912). Therefore, in this study innovation is interpreted as consisting of three elements,
namely the appearance of technology (invention), its expansion, and creation of additional
value.

In a telecommunications context, invention has been established based on the major
technological changes of the period in mobile telephony (PHS, 2G, 3G, 3G+, and BWA).
This grouping was selected in part due to the availability of data.

Capturing expansion on the other hand serves to showcase the role of diffusion, namely
the physical expansion of the network, in the success of an innovation. Practically this is
measured by tracking changes in the infrastructure layer, in this case the number of base
stations, and more specifically the ratio of 3G base stations to the total number of base
stations. The base station data was extracted from ministry reports on the number of base
stations by category (aviation, telephony etc), published quarterly.

Finally, the value added element comes from the final adoption of the new technology,
which can be seen from the subscription rate. For consistency with expansion data, the ratio

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1 One thing the reader needs to be aware of is that in the Japanese regulatory regime, ministerial documents
described as “guidelines” are not actually meant to be followed on a voluntary basis. While mutual
consent among the different parties under regulation is greatly valued by policy makers, guidelines are always complied
with and to date no guideline has been (officially) challenged.
of 3G to total mobile subscriptions is used. Mobile telephony subscription information was obtained from monthly reports from the Telecommunications Carriers Association (TCA) made public under a ministerial ordinance, and compared with ministry data.

To approach the central research question, the above data were regressed with spectrum policy events (represented using dummy variables) to see if there was a relationship present. In order to make the model more manageable, we created two policy categories, spectrum allocation and other spectrum management regulatory activities (such as the introduction of mobile number portability). This distinction aims to try to see if qualitative differences in the policy content play a role vis-a-vis the diffusion of innovation. Policy data were extracted from MIC White Papers, the Action Plan for Spectrum Reallocation, and consecutive progress reports issued biannually by the MIC. All data are presented in a quarterly format, resulting in 52 observations.

4. Results

b. Overview

Overall, spectrum policies (non-allocation) had a weak effect on the expression of innovation, in particular on infrastructure diffusion.

While specific allocation policies seemed to coincide with the expansion and contraction of the 3G network, this was not consistently the case in other technologies, and the regression results showed no significant effect between policy events and number of base stations. A negative relationship nonetheless arose between the ratio of 3G bases to the total number of bases and non-allocation policies, implying that such regulatory acts may play a greater role in the final stages of diffusion of an innovation than allocation policies.

Finally, the penetration of 3G among end users was not directly affected by policy. However, there was a strong correlation present between changes in the numbers of 3G base stations and 3G subscribers, which may suggest a mediation effect between policy and end-user diffusion.

c. Base stations

Figure 1 shows the change in number of base stations by technology (PHS, 2G, 3G, 3G+, BWA and total base stations) in the time frame studied. It is quite indicative of the rise and decline of 3G technology, especially if we see the effect 3G stations have in replacing the

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2 Note that the Japanese fiscal year begins in April, making 1st quarter April-June, 2nd July-September, etc.
prevalence of PHS stations as telecommunications companies gradually switched off. It should be noted that this switch-off was not preceded by specific regulation, but rather was the result of a series of industry-led initiatives.

The graph also shows some of the most influential regulatory acts during that time, such as the introduction of MNP or the opening of the 900MHz band, represented by vertical lines crossing the number of base stations. We can see here visually that some peaks and troughs are preceded by policy acts in the expansion of 3G bases, but that is not the case in all technologies.

Looking at the expansion of 3G bases we can see a condensed version of the life course of an innovation. A slow beginning, shown in the small number of bases of the early adapters, and more so if we see it’s effect on total base numbers (minimal). Then, gradual expansion, turning into exponential growth after other technologies (first PHS and then 2G) begin to get switched off.

The fall of 3G is somewhat complicated by the Great East Japan Earthquake that hit the country on March 2011. The aftermath of the earthquake is quite visible in the infrastructure layer, more so on 3G stations. However, the relatively quick recovery (surpassing previous levels within a year of the event) can be interpreted as a sign of victory of 3G over older competing technologies, which did not recover their disaster losses. Nonetheless, contraction of the 3G network is not far behind, as can be seen after the 900MHz and 700MHz

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3 PHS, or Personal Handy-phone System is a TDMA/TDD based telecommunications technology. It was developed by NTT in 1989 and individual cells have limited range compared to 2G cells. Therefore, PHS connectivity requires a large number of small cells, which explains the far greater number of PHS bases compared to those of other technologies.
allocations at the tail end of 2011/beginning of 2012. These were originally intended to improve the QoS of 3G and assist the post-earthquake reconstruction. Rather, as can be witnessed from the consequent drop in 3G base stations shortly after, these bands served as a jumping point for the dispersion of newer technologies (in particular 3G+) instead.

To test the consistency of the relationship between policy events and changes in the number of base stations, three regressions were run. The change in the ratio of 3G stations to total stations was tested against dummy variables for frequency band allocation events, dummies for non-allocation policies, and combined policy dummies.

From these regressions, a weak relationship emerged between non-allocation spectrum regulation and the reduction in 3G bases, as seen in figure 2.

| ratio_3g_to~l | Coef. | Std. Err. | t   | P>|t| | [95% Conf. Interval] |
|--------------|-------|-----------|-----|------|---------------------|
| d2_management| -.1115909 | .0471086 | -2.37 | .022 | -.2062114 \ -\ .0169704 |
| _cons        | .1590909  | .0184775  | 8.61 | .000 | .1219777 \ .1962041 |

Figure 2. Regression result

The regression result shows that the ratio of 3G bases to total bases is negatively associated with policy actions. The fact that the coefficient is negative means that such policies are more likely to have an effect in the second stage of the innovation’s life cycle, that is, in managing its decline. Such policies can be understood as “switch-off heralds”. That is, they are intended to prepare the ground for replacing one technology with another, and similarly, for the reduction in base of station numbers of the older technology. To summarise, after the initial allocation, additional allocations do not necessarily assist the expansion of the innovation, whereas other regulatory acts may have an effect on its decline - or, to see it in a positive way, in the promotion of the newer technology.

d. Subscriptions

In the second stage of studying the effect of policy on innovation we looked at the end result, that is, subscription rates. The Japanese telecommunications market in 2001-2013 was a highly saturated market, presenting sluggish albeit still positive growth (see image 3). Technology-wise, in the time frame studied, Japanese subscribers had mostly abandoned PHS, allowing us to observe the expansion of 3G.
The ratio of 3G subscribers to the total number of subscribers tells a similar story about technological penetration as the base stations data do. Figure 4 below shows more clearly the life cycle of 3G in Japan, presenting a typical innovation life-cycle growth, although it should be noted that the front tail is somewhat shorter than standard diffusion models and we see a very sharp drop in 2012. As mentioned above, this drop is easily understood as a result of the switch to newer connection technologies such as 3G+ and BWA, and marks the decline of 3G.

A similar three regressions to the ones mentioned in the previous section were run for the ratio of 3G subscriptions to total subscriptions against the same policy dummy variables. No significant relationship emerged from these tests; this result is not unexpected since regressions with a few dummy variables tend to not present high significance.
To probe the question of the factors influencing the end result of innovation, that is end-user penetration, a correlation test was made between the ratio of 3G base stations and ratio of 3G subscriptions (figure 5). The correlation was quite strong, which can be understood as a matter of course; bases are necessary for the expansion of the network and the increase in the number of network points, or in other words, subscribers. Given that policy does not have a direct effect on penetration, but does have an effect on infrastructure growth, further studies are needed to verify the presence or not of a mediation effect.

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Figure 5. Correlation output

**e. Policy implications**

Before we continue with the policy implications of the findings, we need to stress two factors that probably affect the end outcome of this study. First, the employment of a regression using dummy variables as the method of investigation was primarily meant for simplicity purposes and as a tool for a first foray into the topic. Knowing that such regressions typically predict weak relationships, the model could be improved on before specific conclusions are drawn from it.

Secondly, the lack of a robust effect of allocation policy may be attributable to the peculiarities of the Japanese regulatory environment. On one hand, this lack of effect may seem like a paradox given that consecutive Japanese ICT strategies have stated the expansion of infrastructure as a central policy target. On the other hand, the MIC has also stated its preference for avoiding conflict and disruptive allocation events in favour of a more stable regulatory environment. It could theoretically be argued then that a country with a more dynamic allocation system (such as auctions or secondary spectrum markets) would experience different results.

Overall however, for a country and sector that adheres to beauty-contest type allocations, we can generally conclude that a significant role for regulators in terms of the life course of innovations is to help manage the end of a diffusion cycle. In Japan this is achieved by promoting consensus among the affected players to settle on a switch off date, while at the
same time enabling newer technologies to express themselves even before the dominant
technology has reached its predicted peak.

5. Conclusion

This study took a look at how spectrum policy in Japan interplayed with the diffusion of
3G over a period of 12 years. Due to the conflicting nature of spectrum policy aims, and
given that innovation was not a primary aim of Japanese regulators until very recently, it
should come as no surprise that we found evidence for a weak effect of policy on innovation.
This was shown as a negative relationship between spectrum management and growth of base
stations, implying that policy, in the Japanese context at least, is more significant in the end
of an innovation’s diffusion cycle. In terms of spectrum management, this possibly reflects
the regulators’ willingness to help degradation along for the sake of deploying newer
technologies. The fact that this effect does not appear to carry over in the subscription rate
however, despite the strong relationship between network expansion and subscription raises
questions on the possibility of a mediation effect.

f. Limitations

This work is intended as part in a series, and therefore as a stand alone study faces a
number of limitations. For one, it has limited claims to generalization, as the policy
environment of Japan (especially in the sense that no spectrum auctions are held) does not
lend itself easily to cross-country comparison. The policy effect may be more pronounced in
a country where competition for spectrum is ingrained in the regulatory framework.

Furthermore, at this point we looked at only technological innovation, putting aside
temporarily other sources of market transformation, such as for instance, services innovation.
Looking further to include different sources of innovation may also provide additional
strength to the model.

g. Further work

To address the limitations of the current study, further work with a focus on cross-country
comparison is planned. The study also intends to look at other innovation sources, especially
in terms of services, as opposed to only the connection technology, which may be more
salient to the end consumer. Finally, other readjustments to improve the model fit and method
of investigation will be necessary in order to draw more specific implications from the
findings.
Hopefully these additions will help extract a more comprehensive model for the effect of policy on innovation. Eventually, by overcoming the above mentioned limitations, we hope to come to a better understanding of the pressures created by technological and social change on spectrum regulators, to the eventual benefit of both policy makers and the general public.

References
Ministry of Internal Affairs and Communications (MIC), 2001-2013. White paper on Information and Communications, Tokyo, Japan.