A Global Survey of Spectrum License Exemptions[1]

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Abstract

Analysis of the ITU World Telecommunications Regulatory Database shows that license exemptions for public or private use of 2.4 GHz and 5 GHz bands are not a globally ubiquitous regulatory policy. Based on the responses from 75 countries to the ITU's global survey of regulatory agencies, we find that roughly one third of the countries stated that broadcast (for public, private, 2.4, or 5 GHz uses) required a license, one-third require less onerous simple registration, and one-third of the cases allowed for unlicensed broadcast (with the use of type-certified equipment). In a small fraction of cases (2%) use is forbidden. Said another way, roughly two-thirds of all cases from the 75 respondents did not enjoy full license exemptions. The 75 responding countries are fairly evenly distributed amongst geographic regions and economic levels of development. In general, we find the more onerous restrictions usually apply to the 5GHz band and to public users (including wireless ISP's or institutions interested in reselling capacity). Using bivariate analysis of variance we find that license exemptions correlate with Internet penetration and, thus, countries that do allow unlicensed broadcast in these bands are also those with the highest number of per capita Internet users. This remains true when, through a standard least squares linear regression, we control for a country's population, region, and level of economic development.

[1] This paper is based on data from the 2005 ITU World Telecommunications Regulatory Database compiled by the Regulatory Reform Unit of the Telecommunications Development Bureau. Special thanks to Susan Schorr, Nancy Sundberg, and Doreen Bogdan. The dataset studied is from March 2005. Subsequent datasets, updated to May 2006, include a larger number of countries.
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1 Introduction

For many of us, the explosion of WiFi hotspots, Bluetooth ear pieces, high-quality cordless phones, and other creative uses of 2.4 GHz radios has been palpable. And for those happy few of us hard at work in telecommunications policy we know that a critical factor in this outburst has been the presence of license exemptions (unlicensed bands) at 2.4 GHz (and 5 GHz). Unlicensed broadcast on 2.4 and 5GHz is a common policy for spectrum almost everywhere across the globe, or so it would seem. But is this true? Analysis of responses from a global survey of national telecommunications regulators suggests that license exemption is *not* an omnipresent rule of global spectrum management. In a global survey, conducted by the ITU with the assistance of this author and analyzed for the first time in this paper, we find that two-thirds of all countries responding do not allow unlicensed use of these bands. We study these responses trying to explain the global variation with a set of national factors. In addition, we examine whether license exemptions correlate with an indicator of overall ICT penetration and use.

In certain ways, license-exemptions (or, so-called unlicensed operation) are a return to the earliest use of the radio waves for communications. Initial use of the radio waves was without government restrictions or regulations. It is said that in the aftermath of the sinking of the Titanic the need for the US government to regulate nautical radio communications was discerned (Lessig 2001); ships nearby to the Titanic might have been able to rescue passengers had their been more systematic processes for radio communication. The result was an initial regime of spectrum regulation in the US that followed mostly a command-and-control model where spectrum was allocated by the government according to their whims and biases. These licenses (and the ones to come) would generally stipulate restrictions on frequency, power, location, and often type of use.

Since certainly the 1980's it became clear that this command-and-control model had been failing in the USA and elsewhere (Faulhaber 2005). In the USA the FCC began experimenting with a new period in spectrum management that focused on markets and the application of property rights to radio spectrum. The result was, most noticeably, a series of spectrum auctions occurring in many nations across the globe.

Only recently have governments began to explore even more flexible licensing regimes. In the words of Larry Lessig, "Liberating spectrum from the control of government is an important first step to innovation in spectrum use. Liberating spectrum from the control of the market is a second and much more controversial step." This second form of "liberation" has been advocated in the form of a spectrum commons (Buck 2002) or open access spectrum models (Noam 1995).

While the exact details and arguments for spectrum commons or open access models differ, certainly they both include (perhaps at the extreme) the case of unlicensed spectrum use if such license-exemptions allow broadcast by all comers without requirements of registration (and thus support a collective property right of sorts) and

without the application or payment of fees (and thus support an open access user fee of sorts).

In the USA the FCC introduced license-exemptions in the 70's and 80's initially envisioning bands for use by cordless phones, garage door openers, and leaky microwave ovens. These license-exemptions require broadcasters to make use of type-certified equipment by which the FCC and other country's regulators limit in particular output power.

In recent years, the definitions of unlicensed spectrum have normalized around two major sets of frequencies: the Instrument, Scientific, and Medical band (ISM) at 2.4 GHz (specifically 2.4-2.4835 GHz) and a newer allocation in the 5-Ghz to 6-Ghz range adopted at the World Radiocommunication Conference (WRC) in June 2003 (WRI 2003). With the rise of WiFi and other broadband wireless access Internet technologies, the interest in license exemptions, and the importance of them, has exploded globally.

The arguments for these license exemptions are many: it is now technically much easier for radios to tolerate interference and to operate with considerable more flexibility (e.g. cognitive radios), exemptions reduce entry barriers and this should enhance innovation and encourage small- and medium-enterprises, and exemptions should reduce costs to operators and thus tariffs to users.

All this does sound like, as Lessig puts it, *liberation*. So one might assume that the world has converged towards this inspired set of policies and unlicensed spectrum bands exist across the globe. But during the most recent Global Symposium for Regulators (GSR), which occurred in Tunis just prior to the 2005 World Summit, we note the somewhat cautious tone of their official communication:

> "We, the regulators participating in the 2005 Global Symposium for Regulators, have identified the following: …
>
> "Recognizing the role that both non-licensed (or license-exempt) and licensed spectrum can play in the promotion of broadband services, balancing the desire to foster innovation with the need to control congestion and interference. One measure that could be envisaged is, for example, to allow small operators to start operations using license-exempt spectrum, and then move to licensed spectrum when the business case is proved" (Muleta 2006).

In this study we see that there is certainly not a regulatory consensus on unlicensed broadcast. Indeed we find that there is a wide range of policies globally around the use of these popular 2.4 and 5 GHz bands.

2 Related Work

To date there have been very few global surveys of spectrum license-exemptions. In 2003 the ITU added a question to their global survey of regulators, to wit: "Is there a policy for licensing Wireless LAN (e.g. WiFi 802.11)?". The results from this new question were not conclusive and, to our knowledge, have not been closely analyzed. We found that 80 countries replied to this initial question, 31 responding that they had some specific regulations in place and 49 stating that there were not specific regulations. Unhappily, due to weaknesses in the wording of the question, it is not entirely clear if a "no" response means that licenses are still required thought that might be a fair inference in most cases. (The wording of this question was crafted with my input and I am willing to accept blame for its clumsy nature.)

Those respondents specifying that their country had specific WLAN policies in place were asked to specify the details of their policies. Some example responses can be found in Table 1 and range from stipulating license exemptions to a number of countries replying that a policy is under development.

Table 1 Example responses from 2003 WLAN question
(Source: 2003 ITU World Telecommunication Regulatory Database)

Bahrain	No license required.
Ireland	License-exempt unless the operator intends to provide public telecom services, in which case they must apply for a General or Basic telecoms license.
Jamaica	Once service is offered to the public, licensing is required.
South Korea	The policy is in place, but it is yet to be implemented.
Mauritius	WLAN within a radius of 500 meters has been defined as license-free.
Namibia	We issue a permit after it was verified that equipment is type approved.
Oman	Policy is being developed.
Paraguay	All electromagnetic radiation with power equal or greater to 10 milliwatts.

An earlier study of policies for broadcast in these bands, focusing on Africa, was performed by Neto, Best and Gillett (2005). In this study all 54 countries of the African continent were surveyed via email (and in some cases a telephone follow-up). The surveys went to each country's regulator or, where required, other local informants and experts. In the end, survey results were compiled for 47 of the 54 countries. The results showed significant diversity in regulation of these bands on the African continent. For instance, for the 2.4 GHz band, 3 countries (6%) allow unlicensed use of this band for type-certified equipment, 19% did not require a full license but did require registration

for use of the band, the rest of the respondents required some sort of license or in a single case (Zimbabwe) barred use completely.

Finally, The Wireless Internet Institute (2003) claims, without specific support save a self-referential citation that "41 percent of developing countries allow unlicensed use of wireless Internet devices and/or spectrum, compared with 96 percent of developed countries." Despite attempts we were not able to verify or document their claim.

3 Methodology

The ITU conducts an annual survey of its member regulators. These surveys query regulators on a broad range of relevant topics including spectrum, competition, interconnection, pricing, numbering, and so forth. We collaborated with the ITU in developing new questions that probe the regulation of spectrum bands that are unlicensed. The survey is conducted by the Regulatory Reform unit of the ITU's Development Bureau.

The 2005 global survey of regulators included the following questions on WLAN regulations:

- How does your country treat the PUBLIC provision of wireless local area network services in the 2.4GHz and 5GHz bands?
- How does your country treat the PRIVATE provision of wireless local area network services in the 2.4GHz and 5GHz bands?
- Please indicate the exact frequency ranges and any restrictions on the power, range, location or service type for WLAN users in the 2.4 and 5 GHz bands

The distinction between "public" and "private" use is that private users are individuals or institutions using the network for their internal purposes while public use includes wireless ISP's or institutions interested in reselling capacity. We note, however, that the wording might have allowed for some misinterpretation of this meaning (e.g. "public" for public sector use and "private" for private sector).

The raw responses from this survey instrument was then compiled by the ITU and made available to interested researchers.

4 Key Findings

Responses to the WLAN questions were received from 75 countries by March of 2005. In early 2006 a larger set of respondents were accumulated into a new dataset; this paper is based on the earlier and smaller database.

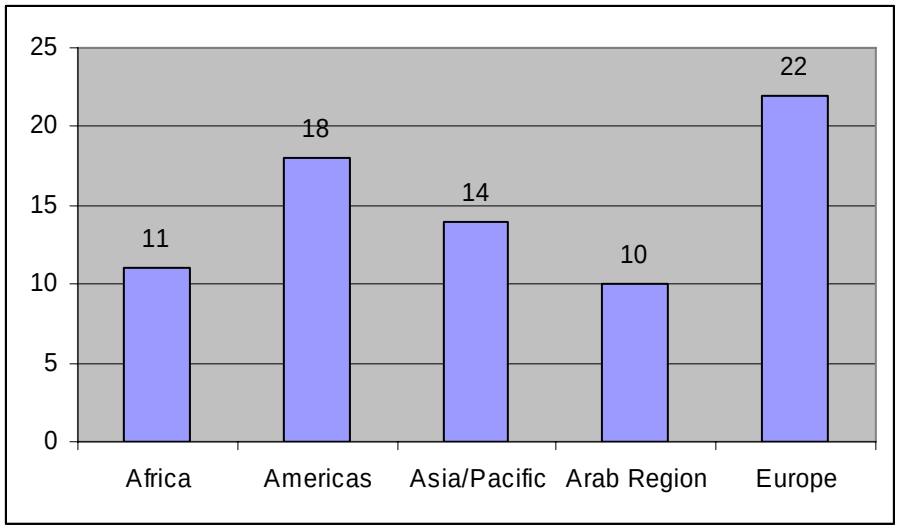


Figure 1 Geographic distribution of responses to WLAN question.

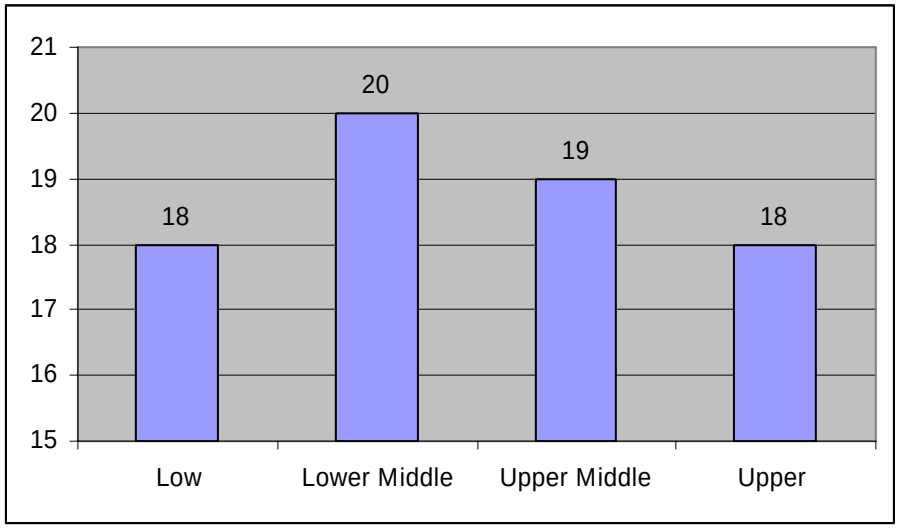


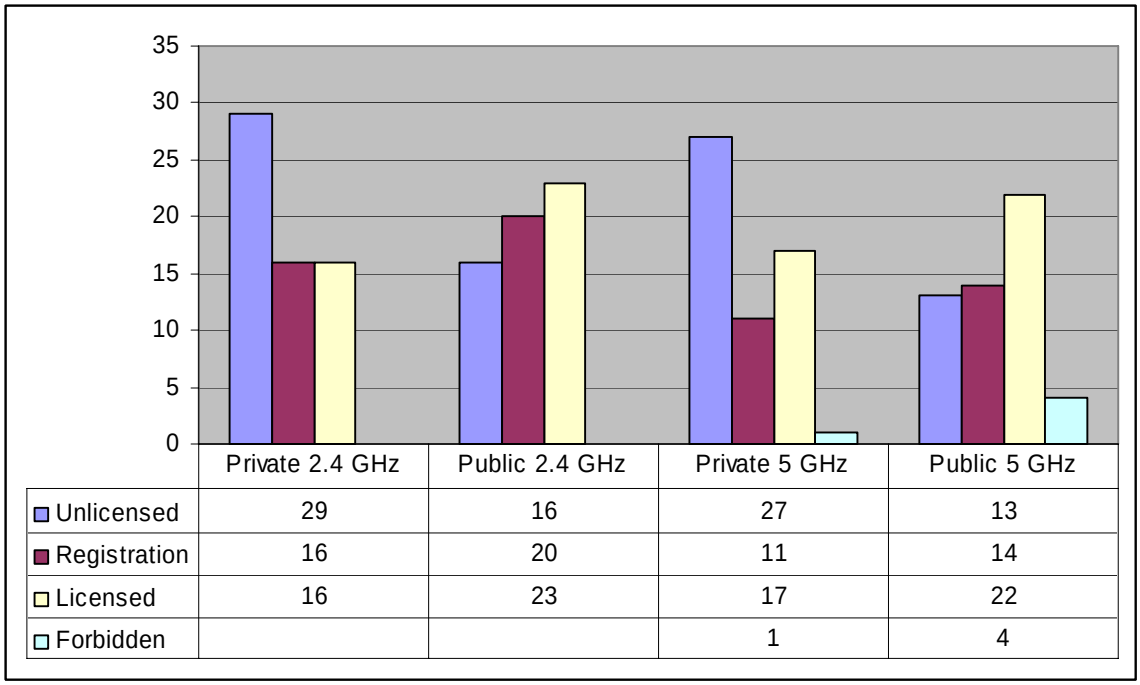
Figure 2 Distribution of responses according to World Bank country income categories.

These responses are broken down by region in Figure 1 and a country's income level (as categorized by the World Bank) in Figure 2. We can see that responses are fairly evenly distributed between major income groups and geographic regions.

4.1 Overall Status of WLAN Regulation

In Figure 3 we can see the response rates for the four primary WLAN questions described in Section 3. And in Figure 4 we show the responses to all four of these questions aggregated into a single chart. The overall finding from Figure 4 is that roughly one third of the responses (for public, private 2.4 or 5 GHz) stated that spectrum use required a license, one-third require less onerous registrations, and one-third of the cases allowed for unlicensed broadcast. In a small fraction of cases (2%) the use is forbidden. Said another

way, roughly two-thirds of all cases from the 75 respondents did not enjoy full license exemptions.



	Private 2.4 GHz	Public 2.4 GHz	Private 5 GHz	Public 5 GHz
Unlicensed	29	16	27	13
Registration	16	20	11	14
Licensed	16	23	17	22
Forbidden			1	4

Figure 3 Licensing requirements for public and private broadcast and 2.4 and 5 GHz

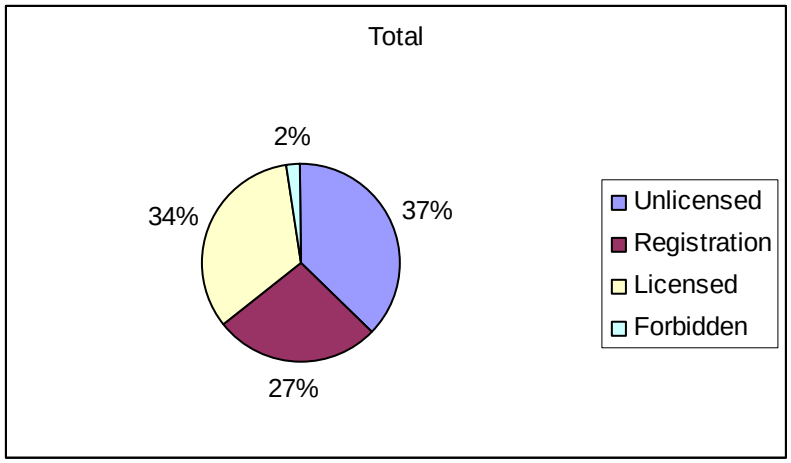


Figure 4 Considering all cases together (public and private, 2.4 and 5 GHz) we see nearly even distribution between unlicensed, registration, and license required

A closer examination of the data reveals that there are some variations between the treatment of private versus public uses and 2.4 versus 5 GHz. All forbidden use is in the 5GHz band. But, otherwise, there are no significant variations between regulations of 2.4 and 5 GHz within a single country. For instance, if the 2.4 GHz band is licensed than in 91% of the cases the country also licenses the 5 GHz band; similarly if the 2.4 GHz band

is license exempt than 90% of the time so is the 5 GHz band (R^2 = .71, χ^2 = 170, p < .0001). There is more within country variation in how private versus public use is regulated (R^2 = .42, χ^2 = 100, p < .0001). Interestingly, for instance, 53% of those countries that require public use operators to register allow private users, in the same band, to broadcast without license.

Given these three major licensing regimes (and in the case of 5 GHz bands a forth regime, namely *prohibited*), we would like to understand which countries gravitate towards which sort of policies. Figure 5 and 6 show how these regimes breakdown by income category and geographic region. A simplification is to state that lower income countries are more restrictive than high income countries and Africa is more restrictive than Europe. These differences are statistically significant. Indeed, through a contingency analysis we find that the most significant differences by region and income level are with the 5GHz band and private use. But, in the end, region and income level explain little of the variation in application of these different policies (with R^2 measures never exceeding 0.10).

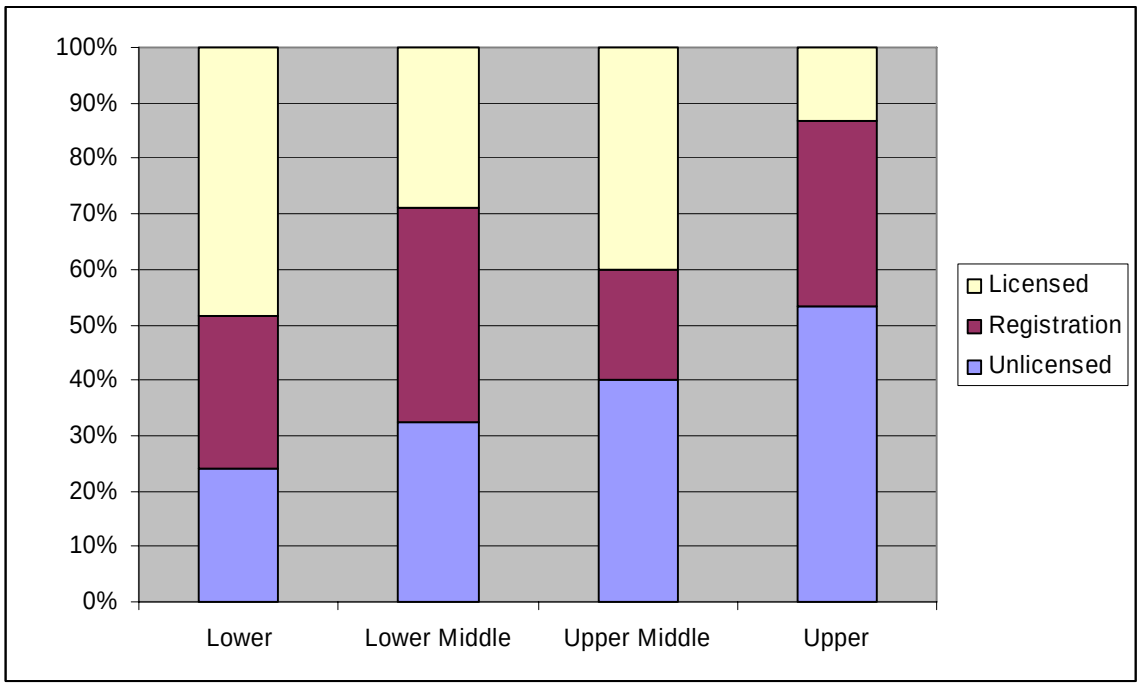


Figure 5 2.4 GHz band regulations by income category (χ^2 = 12.6, p<0.05)

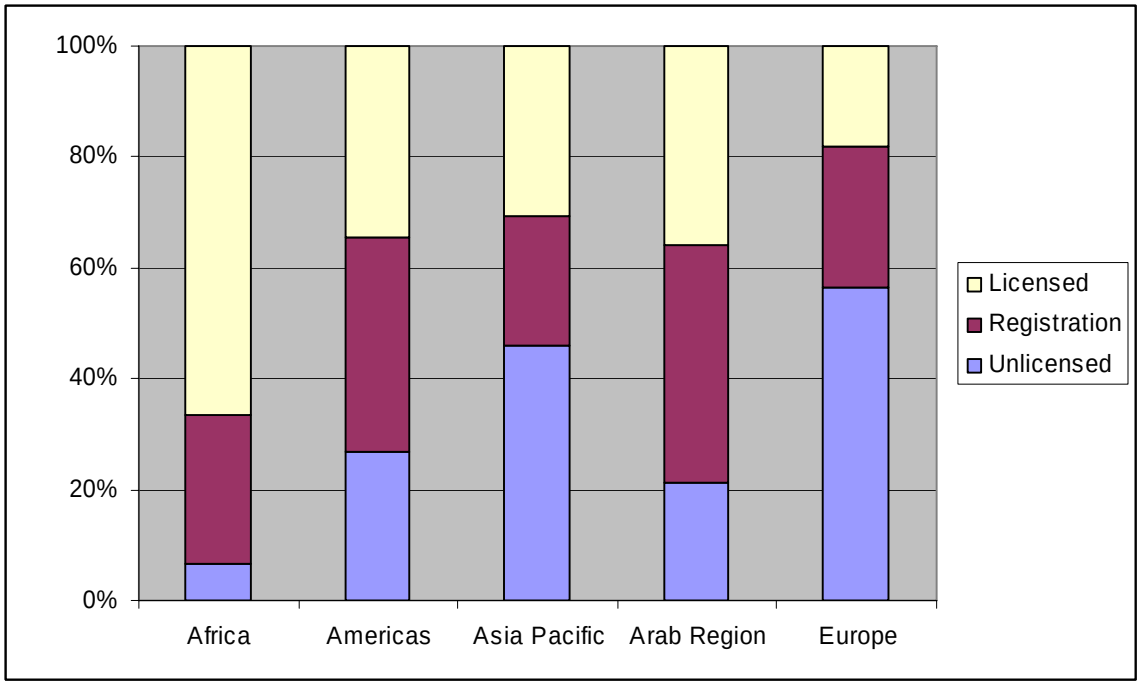


Figure 6 2.4 GHz band regulations by geographic region.($\chi^2 = 20.78$, $p < 0.0078$)

In summary we find that there is considerable variation across countries in their regulation of these frequencies. We find that income level or region of the country has only limited power to explain this variation. We do find that countries mostly treat 2.4 and 5 GHz similarly but when there is variation it is to increase the strict control of 5 GHz. And we find that more countries treat public versus private use differently with tighter controls on public use.

4.2 Regulations and ICT penetration

Finally, we would like to see if variation in licensing policies correlates with variation in levels of Internet penetration. In some ways this offers a glimpse into the most interesting question, namely, do we see enhanced Internet use in countries with more liberalized spectrum policies?

4.2.1 Bivariate analysis

To study this relationship we first perform a one-way analysis of variance between our Internet penetration metric (number of Internet users per 100) and our variable coding regulation regime type. These ANOVA results, one for each of the two principle spectrum bands and private versus public use, are summarized in Table 2. We see that there is a statistically significant relationship between the two bands and public and private use. Of these groups, we can see that the 5 GHz band and the license requirements for public use of the spectrum have the strongest correlations with an R^2 of 0.25 and 0.33 respectively.

In all four of these cases the mean number of Internet users per 100 is smallest for Forbidden regimes, next larger for Licensed, larger still for Registration required, and largest for Unlicensed. In other words, we see a strict increase in average number of Internet users per 100 populations as we move towards more liberalized or "lighter" regulations and the most dramatic jump comes for the Unlicensed regimes. These means are depicted in Figure 7.

Table 2 Summary of one-way analysis of variance with Internet Users per 100 for four regulation areas.

	R^2	ANOVA
2.4 GHz	0.18	*F(2, 101) = 11.18, p < .0001*
5 GHz	0.25	*F(3, 90) = 9.78, p < .0001*
Private	0.15	*F(3, 97) = 5.83, p < .001*
Public	0.33	*F(3, 93) = 15.53, p < .0001*

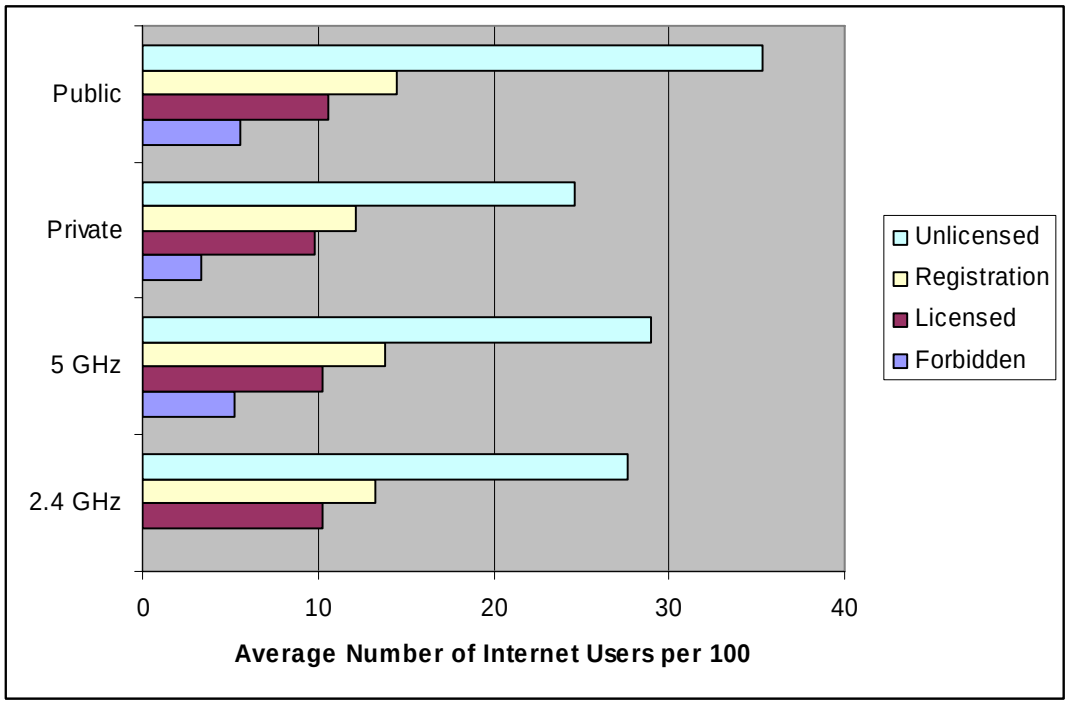


Figure 7 Average number of Internet users per 100 population for each of our licensing regimes grouped by 5 and 2.4 GHz and Public and Private use (ANOVA's shown in Table 2)

In Table 3 we provide the full details for the group with the strongest ANOVA result, namely the case of public use licensing requirements.

Table 3 One-way analysis of variance of Internet users per 100 by Public regulation of both 2.4 and 5 GHz

	df	Sum of Squares	Mean Square	*F*	Significance
Between	3	10679.92	3559.97	15.53	< .0001
Within	93	21321.69	229.27	.	.
Total	96	32001.62	.	.	.

4.2.2 Multivariate linear regression

In our final analysis we perform an ordinary least squares linear regression mixed model with number of Internet Users per 100 as our response variable. The estimated parameters include two continuous terms, the log of the country's population and national GDP, and two nominal variables, the license regime type and the region. The dummy indicator variables are enumerated in the term list for Table 4 where the details of the linear regression are offered. The results reported here are for 2.4 GHz but the overall conclusions are the same for the 5 GHz band.

Two important findings are suggested in Table 4. First is that the whole model does a good job of explaining variation of the response variable, indeed explaining about 50% of that variation. Second, we see that only three of the terms of the model enjoy statistical significance (at the .05 level) and those are the log of population, log of national GDP, and the dummy for Unlicensed regimes. (At the 0.1 level we can include the dummy for the African region in our list of statistically significant terms.)

We are not surprised to find that richer and smaller countries enjoy greater Internet use and the beta coefficients for these terms demonstrate that. But much more interesting is the fact that this regression gives further support to our bivariate finding above that countries allowing license-exempt broadcast in these two bands enjoy higher Internet penetration. This regression furthers the result by demonstrating that *countries that allow unlicensed use of 2.4 or 5 GHz bands have higher levels of Internet use even when we control for a country's size, region, and level of economic development.*

Table 4 Standard least squares regression for response variable of number of Internet Users per 100.

Term	Expanded Beta	Standardized Beta	*t*	*p*
Intercept	34.03	0.00	1.58	0.12
Forbidden	-3.67	-0.10	-0.49	0.63
Licensed	-4.17	-0.18	-1.27	0.21
Registration	-2.10	-0.10	-0.59	0.56
Unlicensed	9.94		2.50	0.02
Log(Population)	-6.28	-0.57	-4.07	<.0001
Log (GDP)	3.46	0.51	4.27	<.0001
Africa	-8.52	-0.31	-1.74	0.09
Americas	1.42	0.05	0.30	0.76
Asia/Pacific	5.80	0.25	1.29	0.20
Arab Region	-2.69	-0.10	-0.65	0.52
Europe	3.99		1.26	0.21
WHOLE MODEL				
Observations	67			
R^2	0.55			
Adjusted R^2	0.48			
F-Statistic	7.89			
p	<.0001			

5 Conclusions

Scholars (Best & Maclay 2002; Bar & Galperin 2005) have argued that three forces are revolutionizing the reach, price, and capabilities of Internet. These forces are the advent of new and cheap wireless technologies; the entrance of SME's and non-profit actors as operators; and the emergence of flexible and indeed exempt spectrum licensing regimes. In this paper, based on the analysis of an ITU dataset, we find that the latter component (flexible spectrum license regimes) have yet to enjoy universal application world-wide. In an analysis of the 2.4 and 5 GHz bands we find that in two-thirds of the cases considered, across 75 participating countries, unlicensed broadcast was not allowed.

While not ubiquitous, we do find that license exemptions correlate strongly with Internet penetration. Thus, countries with many per capita Internet users are more likely to allow unlicensed broadcast on these bands. An immediate concern is that this is due to some exogenous effect, for instance rich countries naturally have more Internet users and they also have better funded regulatory agencies that adopt "state of art" policies which include these license exemptions. Under this explanatory framework, license exemption tracks Internet use without necessarily contributing to it. But in a multivariate linear regression we see that unlicensed broadcast on these bands still contribute positively to an explanation of Internet use even when we control for a country's economic

development, region, and population size. This offers further evidence that license exemptions might indeed be the source of some expansions in Internet use.

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