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SPECTRUM ALLOCATION IN LATIN AMERICA: AN ECONOMIC ANALYSIS

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Like elsewhere in the developing world, wireless markets now play a crucial role in Latin American economic growth. Mobile telephone networks increasingly provide the communications infrastructure that has largely been lacking throughout the region. Yet, governments have generally made only modest allocations of bandwidth available to Latin American wireless operators, either absolutely (in terms of spectrum each country could allocate) or relative to other countries in Asia or the European Union. Using an empirical model estimated on mobile phone data for 40 international markets, we show that very large social gains are available to countries that succeed in permitting more liberal use of radio spectrum. Two of the most striking examples of this approach are Guatemala and El Salvador, each of which utilizes about 50% more bandwidth for mobile telephony than the Latin American mean. We conduct simulations, using our calibrated model, to project country-by-country gains from expanding access to radio spectrum. Substantial efficiency increases are possible, which dominate gains associated with extracting public funds via auctions, the area of focus in the economic literature.

Key words: spectrum allocation, auctions, revenue extraction, mobile telephone competition, telecommunications policy, Latin American wireless markets

JEL Categories: K23, L43, L51, L96, P14

I. INTRODUCTION

Over the past fifteen years, "spectrum auctions" have swept the globe. In many countries, competitive bidding has replaced beauty contests, with strong endorsement (and guidance) of academic economists.[1] The transition to market-based *rights assignments* has been healthy, but a sound license auction is not identical to good *spectrum allocation* policy. In fact, on important margins the two aspects of public policy conflict. This is seen where auction revenues are enlarged by policies encouraging monopoly in the output market, but also appears when such seemingly uncontroversial rules as reserve prices or bidding credits are instituted in competitive bidding schemes.

Since the seminal work of Ronald Coase (1959), who observed that efficiency would result not by eliminating radio interference but from arriving at the optimal level of spillovers,[2] the consensus view of economists has been that permitting markets to allocate radio waves would result in substantial efficiencies versus administrative allocation.[3] Wireless icenses, even if assigned by auction, are still generally limited in scope by regulations that determine the services provided, technologies used, and business models deployed. Moreover, spectrum is allocated to the license by government regulators; bandwidth cannot generally be bid away from one market to be used in another. With these restrictions, marginal valuations of spectrum differ widely across bands due to regulation, and bidders are blocked from arbitraging inefficiencies.

At the same time, wireless markets are advancing rapidly.[4] In Latin America, as in other developing markets, mobile phone networks are supplying valuable social overhead capital (SOC), stimulating economic growth. Waverman et al. (2005, p. 18), studying African economies, find that "[d]ifferences in the penetration and diffusion of mobile telephony certainly appear to explain some of the differences in growth rates between developing countries… there are also increasing returns to the endowment of telecoms capital (as measured by the telecoms penetration rate)… Our analysis suggests the need for regulatory policies that favour competition and encourage the speediest rollout of mobile telephony." This research builds on the widespread view that telecommunications networks are key components of SOC (Hardy 1980; Leff 1984; Norton 1992; Greenstein & Spiller 1996), and recent studies that wireless systems in particular drive developing country growth.[5]

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1 See for example Cramton (2002), Klemperer (2002a,b), Milgrom (2004), McAfee and MacMillan (1996).

2 This observation became famously enshrined as the "Coase Theorem," and was elaborated in Coase (1960).

3 The consensus holds. In 2001, "37 Concerned Economists" with expertise in spectrum policy and antitrust economics petitioned the U.S. FCC to liberalize radio spectrum rights so as to effectively permit private property in radio waves. See Rosston (2001b).

4 This market phenomenon does not conflict with the inefficiency of license rigidities, in that the spectrum policy issue is whether services would be provided sooner, less expensively, and more widely with more liberal allocation rules.

5 See for example: Dasgupta, et al. (2001); Waverman et al. (2005); U.N. (2004); Annan (2005);

Yet, spectrum policies in Latin America are, on the whole, extremely conservative. This appraisal reflects both the general structure of regulation, and the quantitative outcome. On average, Latin American countries allocate only about 100 MHz to mobile phone carriers' licenses, compared with a mean of about 266 MHz in the European Union.[6] Some of the differential is attributable to demand differences, but we find that there remains a statistically significant restriction on bandwidth imposed by policy makers across both sets of markets. Given that the spectrum not used in cellular markets is essentially left idle, there would be little to no opportunity cost in permitting more liberal use.

Two Latin American countries, Guatemala and El Salvador, have enabled such use with far-reaching legislative measures enacted in 1996 and 1997, respectively. Wireless markets in these markets are relatively robust, exhibiting high degrees of competitiveness, as measured by industry concentration and retail prices. Other Latin American countries, while not undertaking such ambitious policy measures, have enabled relatively liberal spectrum allocations for mobile telephony. These include Chile and Paraguay. The experience of these nations may inform policy makers as to what might be achieved through less restrictive spectrum policies, and offers interesting data for public choice scholars wishing to explain the divergence regulatory regimes – a worthy pursuit we refrain from herein.

The primary task of this paper is to evaluate the spectrum policies now in place and to estimate potential gains from liberalization for those countries that have yet to adopt such a framework. We first present estimates of the social value of allocating additional spectrum to mobile phone markets in several of in six of the largest markets in Latin America. We show that, in response to an increase of 20 MHz, the average change in consumer surplus in our sample is approximately US$41 per capita. This magnitude is over 11 times the average increase in revenues in the industry, suggesting that the gains accrue overwhelming via *consumers'*, rather than *producers'*, surplus.

In the second part of the paper we discuss the prospects for spectrum market reform. A liberal property rights regime permits firms to transact for spectrum rights as for other inputs, allowing optimization of production. Liberalization is particularly conducive to innovation and competitive entry, precisely because administrative allocation is predictably hostile to firms or technologies that threaten to upset the existing distribution of industry rents (Hazlett 2001). Without the necessity of obtaining permission from regulators to use spectrum in a novel way, markets can be expected to exploit efficient opportunities in wireless just as in other markets.[7]

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[6] For the sources, see Table II.1 below for Latin America and Appendix 1 for the European Union.

[7] This was the initial insight of Coase (1959), but the argument for private spectrum rights was based on general theory and observations in other markets (including the land market). Subsequent liberalization of spectrum rights in some markets has provided empirical support for Coase's intuition. See, e.g., Faulhaber (2005); Hazlett & Spitzer (2006). The empirical research in this paper can be seen as providing a further test of Coase's normative model.

II. WIRELESS MARKETS IN LATIN AMERICA

Spectrum allocation policies in Latin America are usefully evaluated with respect to the market for mobile phone services.[8] First, this application constitutes the dominant spectrum-based service in terms of service revenues. Second, the next most economically important industry, radio and television broadcasting, is intensely political and much less likely to be (in the near term) liberalized.[9] Third, this sector today plays a vital role in economic development, providing basic telecommunications infrastructure for most residents and businesses. And fourth, this industry is broadly studied by investors, yielding data and opening the way for empirical estimates of the social value of policy reforms.[10]

The average amount of spectrum allocated to cellular service in Latin American countries (equally weighted) is 102 MHz, well below the average in the European Union of 266 MHz. We consider two possible reasons for this gap.

(1) A market hypothesis: In Latin America the demand for mobile services does not justify a higher allocation. This could be consistent with a rational use of scarce resources, where marginal spectrum not used for mobile telephony is more productively deployed elsewhere.

(2) A regulatory hypothesis: the regulatory authorities in the region have inefficiently constrained spectrum access, over-conserving bandwidth. the market demands. This would constitute non-market failure.

We note that the explanations are not mutually exclusive.

[8] This paper uses the terms “wireless telephone,” “mobile telephone,” and “cellular” interchangeably.

[9] This is true even in Guatemala and El Salvador. See Hazlett, Ibarguen & Leighton (2006).

[10] For example, Hazlett, Mueller and Muñoz (2006) study the transition to digital TV in Europe. Using estimates from the mobile phone market, they provide a lower bound for the social value of TV band spectrum.

TABLE II.1: BASIC STATISTICS FOR MOBILE PHONE MARKETS IN LATIN AMERICA

Country	(a) **Average Price per Minute (APM)** US$ (October 2003)	(b) **Spectrum** MHz (October 2003)	(c) **HHI** (1-10000) (Dec. 2003)	(d) **Penetration** (%) (Dec. 2003)	(e) **GDP** (US$ billions) (Dec. 2003)	(f) **GDP adjusted by PPP** (US$ billions) (Dec. 2003)	(g) **Population** (millions) (Dec. 2003)	(h) **GDP per capita** (US$) (Dec. 2003)	(i) **GDP per capita adjusted by PPP** (US$) (Dec. 2003)
Argentina	0.097	120	3266	18	127.30	442.04	38.32	3322	8763
Bolivia	0.126	88	3942	15.2	8.10	22.73	7.80	1038	3574
Brazil	0.174	110	4298	26.4	505.54	1373.22	172.99	2922	7708
Chile	0.144	140	2790	51.1	73.37	161.90	16.65	4408	15575
Colombia	0.101	100	5501	14.1	80.01	296.44	45.85	1745	7724
Costa Rica	0.085	93	10000	14	17.70	39.50	4.15	4263	8169
Ecuador	0.244	80	5115	18.9	27.20	49.31	13.86	1962	5249
El Salvador	0.155	137.87	3297	17.6	14.94	28.38	7.54	1981	3458
Guatemala	0.111	140	3591	17	24.74	51.06	16.56	1494	4551
Honduras	0.311	65	10000	6.2	6.95	18.12	7.02	989	2500
Mexico	0.267	120	6154	29.1	636.55	943.89	105.98	6006	9504
Nicaragua	0.273	84.84	5009	8.5	4.15	14.20	8.71	477	2454
Panama	0.307	49.56	5000	26.76	12.86	19.80	3.04	4231	8431
Paraguay	0.201	176	3566	29.85	5.60	26.38	5.90	948	3776
Peru	0.215	80	4041	10.61	60.79	143.10	28.23	2154	5020
Uruguay	0.260	90	5919	25	11.21	27.50	3.42	3275	8307
Venezuela	0.298	57	3570	27.3	84.28	125.81	27.63	3050	8535
Average LA	0.198	101.84	5003.47	20.92	100.07	222.55	30.22	2604	6665

Sources:

(a) Authors' calculations based on advertised postpaid subscription prices using equally weighted averages for plans having 100-400 minutes of use per month offered by the larger wireless carriers in each country. Information collected from web pages of these companies.

(b) Authors' calculations based on database in Hazlett (2004).

(c) Authors' calculations based on TELECOM-CIDE database.

(d) AHCIET, Observatorio económico del sector de las telecomunicaciones.

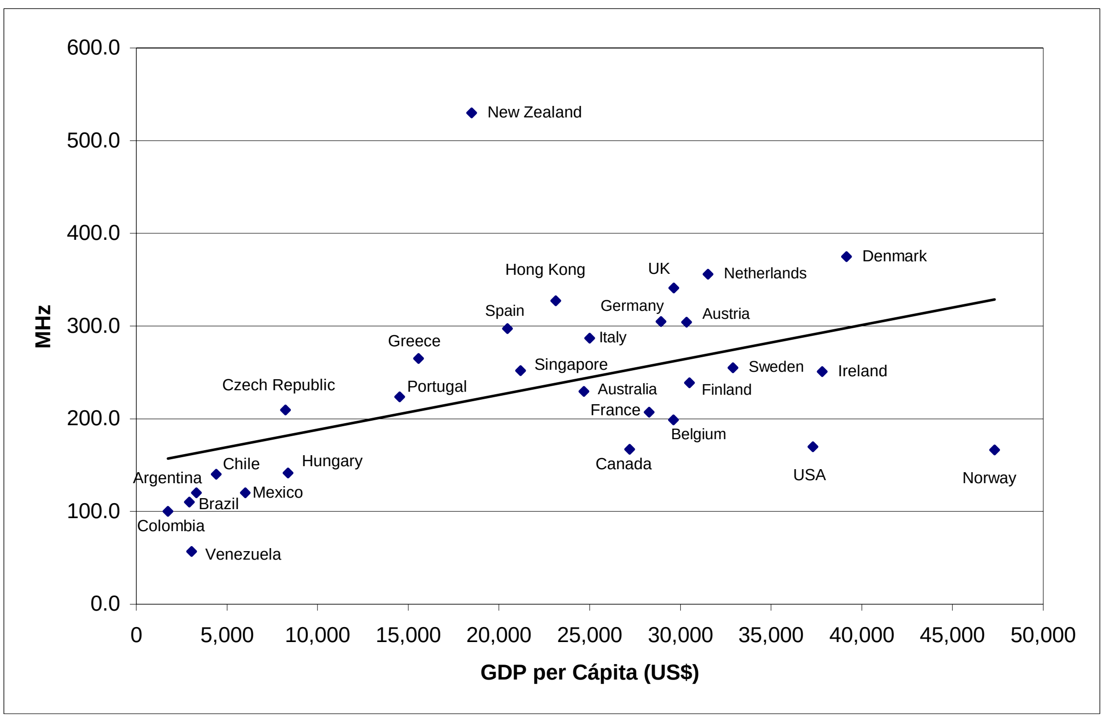
(e), (f), (g), (h), (i) World Economic Outlook, IMF.

Note: Penetration is defined as phone subscribers per 100 population.

Figure II.1 illustrates the situation for a sampling of countries included in quarterly mobile phone market data published by Merrill Lynch (2003). This dataset includes six Latin American countries: Argentina, Chile, Brazil, Mexico, Venezuela and Colombia. As can be seen from Figure II.1, all six countries allocate substantially less spectrum to mobile telephony than what is predicted by their per capita national income.[11] This L.A. sub-sample features the largest economies in the region, and we note that most of the remaining countries have even more parsimonious spectrum allotments.

The quantity of spectrum efficiently allocated to wireless phone service is presumably a function of other factors in addition to GDP per capita. Such other variables should be accounted for. Moreover, additional countries throughout Latin America should be included in the analysis if we are attempting to provide a regional explanation of spectrum policies. To enable this broader statistical inquiry, we generated a new database, adding all the Latin American countries (excluding the Caribbean). The information for the additional (11) Latin American countries[12] is only available annually through 2002**,** not quarterly. Hence, the new database is an annual panel from 1999 to 2002, with data for 40 countries (29 from the original Merrill Lynch sample, with an additional eleven Latin American countries).

FIGURE II.1: SPECTRUM VS. GDP PER CAPITA



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[11] The data in Figure II.1 corresponds to the end of second quarter 2003.
[12] The additional 11 countries are those considered in Table II.1.

This expanded database permits estimation of a simple regression, the quantity of spectrum assigned to mobile telephony as the dependent variable, with a vector of independent variables, including Population, Population Density, GDP per capita, a Not Calling Party Pays Dummy (=1 if mobile phone calls received incur connection charges), an Auction Dummy (=1 if country assigns licenses by competitive bidding), and a Latin America Dummy (=1 if country is in Latin America). See Table II.2. Here the coefficient of interest is that associated with the Latin American dummy. It is estimated to be negative and of a statistically significant magnitude. These estimates are similar in both a completely pooled regression and using a random effects model. This implies that, controlling for wireless demand factors, cellular spectrum allocations are substantially lower than in Latin America than in the rest of our global sample. The estimated amount is about 55 MHz lower than elsewhere, all else equal, or over 50% of the Latin American mean. This evidence tends to support the regulatory hypothesis, namely that governments in Latin America systematically under-allocate radio spectrum relative to other countries.

TABLE II.2: REGRESSION RESULTS.
DEPENDENT VARIABLE: BANDWIDTH ALLOCATED TO MOBILE PHONE SERVICE (MHZ).

	TOTALLY POOLED MODEL (robust estimation)	RANDOM EFFECTS MODEL
Independent Variable	*Estimated coefficient (t-statistic)*	*Estimated coefficient (z-statistic)*
Population	-0.498 (-0.42)	-0.417 (-0.24)
GDP/capita	0.00262** (2.52)	0.00257** (2.44)
Pop Density	0.00934 (1.64)	0.00963 (1.15)
Not Calling Party Pays Dummy	-75.732* (-4.10)	-76.583*** (-1.83)
Latin American Dummy	-54.679** (-2.44)	-56.479** (-2.17)
Auction Dummy	40.257** (2.46)	39.445** (2.10)
Constant	123.521* (4.63)	124.763* (4.36)
No.Observations	134	134
R-Squared	0.2786	0.2785

*, **, *** refer to 99%, 95%, and 90% confidence levels, respectively.

III. SPECTRUM POLICY AND CONSUMER WELFARE

III.1. Configuring Property Rights to Radio Spectrum

Latin American states generally conform to the standard regulatory procedures found elsewhere. Radio waves are administratively allocated by the national government (Lueck and Miceli 2005). Property rights to spectrum are not directly assigned to private parties, as with land, but treated as state property. Regulators then determine permissible spectrum uses, and enact rules allowing various parties (public and private) to access radio spectrum (to engage in "resource appropriation"). There exists a range of regulatory methods for assigning access rights, but they can be neatly summarized as a mix of two polar strategies: governance and exclusion (Smith 2002).

With governance, state regulators protect the underlying resource by prescribing behavioral rules that limit dissipation, aiming to avoid "tragedy of the commons." These rules may impose licensing restrictions (limiting spectrum use to those receiving special permits) or focus solely on transmitting devices (as in license-exempt bands). Exclusion, conversely, delegates the determination of usage rules to property owners, who are given rights to appropriate resource value within a defined space. Such owners may be private parties, public entities, or collectives (as own a "commons"), the key feature being that the agent (or agents) possessing the resource rights are able to exclude rival users (Hazlett 2005).

The administrative allocation of radio spectrum has heavily favored governance in assigning access rights, and has done so under two basic formats.

(1) *Traditional license*. Spectrum is allocated to a license by the regulatory authority, and the licensee is granted permission to provide the service or services specifically defined. A broadcast TV license is an example. The licensee receives the right to transmit at a certain location, with a specified transmitter height, power, frequency, and time of day. Transmission technology and business model (subscription, advertiser supported, etc.) are defined as well. Allocated bandwidth cannot be used except as specified. A TV licensee cannot turn of (or modify) its broadcast signal, using allotted frequencies for wireless broadband connections, for instance.

(2) *License-exempt.* Spectrum is allocated for use by a class of devices. Wireless users access this bandwidth by use of regulator-approved radios. Instead of regulating both a licensee and the transmitting equipment used by the licensee, the government authority regulates only the latter. Users then enjoy non-exclusive rights to access radio spectrum allocated for license-exempt use. Governance aims to control conflicts via three sets of rules: (a) power limits, (b) technology standards, and (c) behavioral rules (Hazlett & Spitzer 2006). Power limits, in particular, reduce many conflicts by allowing local users a degree of de facto exclusivity. Such limits simultaneously exclude many options, however, including economically viable deployment of wide area wireless networks such as those providing mobile phone services.

These governance approaches address potential spillovers between spectrum users, the "interference" problem in radio. But they do so by centralized decision making of government regulators. The costs and benefits of alternative spectrum deployments are not evaluated by spectrum owners who internalize gains or losses depending on how competitive markets reward such decisions, but by commissioners lacking incentives for efficiency. Rather, such political actors rationally maximize political support; given the nature and distribution of license rents, as well as the economic interests of bureaucrats, agency officials, and the communications bar, decisions are reliably protectionist (Noll et al. 1973; Owen 1999; Hazlett 2001; Faulhaber & Farber 2002).

There are two principal paths to the spectrum markets anticipated by Coase (1959). The first is via a broadening of the spectrum use rights granted in the traditional license, expanding the "bundle of sticks" (Merrill and Smith, 2002). In the limit, this produces a private property right to allocated spectrum, what has been called a *Liberal License* (Hazlett 2005) or EAFUS, exclusively assigned, flexible use spectrum (Hazlett & Spitzer 2006).

To a degree, this policy has been globally applied with respect to cellular licenses, which are typically far more permissive than broadcast licenses.[13] This is a natural development for two reasons. First, the keen government interest in the content of broadcasters – which produce news and information, key inputs into political support functions – is lacking with common carrier communications. The standard motivation for extensive regulation of broadcasting, which is to engage in quid pro quo transactions related to "public interest" broadcasting and to influence the information distributed by licensees, is absent with services where the licensed operator supplies conduits rather than content. The sharp distinction in the political demand to regulate across the two sectors – far and away the economically most important sectors in wireless communications -- is illustrated by the fact that countries adopting license auctions have generally exempted broadcast licenses from competitive bidding, retaining a wider degree of political control over their distribution (Hazlett 1998).

Second, the structure of mobile telephone networks is far more complex than that of broadcast facilities, which send a given signal from one point to many receivers. Mobile phone systems, in contrast, involve numerous base stations (about 20,000 in a national U.S. network) serving millions of subscribers – and each subscriber transmits as well as receives. A service provided with the use of millions of mobile emitting devices, which share extensive infrastructure (U.S. mobile phone networks have incurred in excess of $175 billion in capital expenditures over the past two decades) and frequency space, virtually begs for the delegation of exclusive rights to responsible agents.

In some countries, then, cellular licenses grant fairly broad spectrum use rights, with licensees given broad discretion over services, technologies, and business models. In the limit, this can be seen as a private property right to spectrum. This, however,

[13] It should be remembered that the regulation of broadcast radio drove the creation of most spectrum property rights regimes. For the U.S. history, see Hazlett (2001).

continues to leave in place the underlying spectrum allocation structure, meaning that EAFUS rights are granted only on a case-by-case basis. In the United States, cellular license rights approach EAFUS status, but very little bandwidth has been made available under this model despite considerable excess demand for bandwidth by wireless network operators (Bazelon 2005) and extremely high social value associated with incremental allocations (Hazlett & Muñoz 2006).[14]

The other path to liberalization entails structural reform of the spectrum allocation process, which may require legislation. While the barriers to such institutional change are considerable, the interesting fact is that two Latin American economies succeeded in spectrum liberalization via national statutes just a decade ago. In 1996, Guatemala created explicit private property rights to radio spectrum, *titulo de usufructo de frecuencia* (TUFs). Such devices define ownership by specifying:

a. the band or frequency ranges;
b. hours of operation;
c. geographical coverage area;
d. maximum effective radiated power by the TUF holder;
e. maximum field strength or signal strength on the border of the coverage area;
f. order and title number;
g. issue date and expiration;
h. name of title holder;
i. blank spaces for endorsement of reassignment to another party.[15]

Any person or entity is entitled to request a frequency, triggering the TUF assignment process.[16] The independent regulator is constrained to issue requested, non-conflicting rights. Petitions are subject to opposition on the grounds of radio interference with existing services, but strict time limits for adjudication, as well as binding arbitration mandates, are designed to block excessive administrative barriers to entry. Rights to contested TUFs (with multiple claimants) are required to be assigned via auction. TUFs carry 15-year terms, with an additional 15 years at the option of the TUF holder. According to the International Telecommunications Union, Guatemala has "probably the world's most liberal radio spectrum regulatory model."[17]

El Salvador arrived at a similar policy outcome via less radical means in a 1997 statute.[18] Concessions for the use of frequencies extend for a 20 year period, and can be transferred or subdivided in frequency, geographic, and time dimensions without

[14] In 2004, the U.K. spectrum regulatory authority, Ofcom, released its plan to transition about 70% of prime airwave space (frequencies below 3 GHz) to a model similar to EAFUS.
[15] *Ley General de Telecomunicaciones. Legislative Decree No. 94-96* (Oct. 17, 1996, Article 57). A copy of a TUF is featured in Hazlett (2001, p. 447).
[16] *Ley General de Telecomunicaciones. Legislative Decree No. 94-96* (Oct. 17, 1996, Article 61).
[17] Intenational Telecommunications Union, Radiocommunications: *SPU newslog on radiocommunication issues* (Dec. 19, 2003), http://www.itu.int/osg/spu/newslog/categories/radiocommunications/2003/12/19.html.
[18] *Ley General de Telecomunicaciones. Legislative Decree No. 142* (Nov. 6, 1997).

regulatory approval.[19] Rights holders are free to choose technologies. While a National Table of Frequency Allocation (TFA) describes the type of services frequencies are allocated for,[20] rights holders may deviate from TFA specifications without penalty. This results in generic license flexibility.[21] Additionally, the regulator is directed, as in Guatemala, to issue requested licenses, using auctions for contested applications. To the extent these rules are administratively or legally enforced, they can be said to enable a market in radio spectrum (Hazlett, Ibarguen & Leighton, 2006).

These idiosyncratic spectrum policies illuminate possible paths to liberalization, an important normative exercise left for later research. These outliers also assist our empirical analysis of Latin American spectrum regimes, and are usefully employed for this purpose here. Experiences in Guatemala and El Salvador illustrate how additional radio spectrum, and additional radio spectrum rights, may promote efficiency. This informs our inquiry into the social value of spectrum liberalization, which is premised on an econometric evaluation of consumer welfare in mobile telephone markets.

III.2. Empirical Investigation of the Relationship between Spectrum and Retail Prices.

In Hazlett & Munoz (2006), we sought to answer the question: *What factors influence the prices and outputs of mobile phone usage, looking across countries?* An empirical model, motivated by a theoretical model, offered a number of variables to test. Merrill Lynch data were available for 29 wireless phone markets, providing quarterly

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[19] *Ley General de Telecomunicaciones. Legislative Decree No. 142* (Nov. 6, 1997, Articles 15-16). The transfer of concession rights is treated as a private contract and must be registered in the telecommunications registry of the regulator (*Reglamento de la Ley de Creacion de la Superintendencia General de Electricidad y Telecommunicaciones. Executive Decree No. 56*. May 13, 1998, Articles 19, 27). Concession holders are liable for violations, including out of band emissions. *Ley General de Telecomunicaciones. Legislative Decree No. 142* (Nov. 6, 1997, Article 15).

[20] *Ley General de Telecomunicaciones. Legislative Decree No. 142* (Nov. 6, 1997: Articles 10). See also *Regulation of the Law of Telecommunications. Executive Decree No. 64* (May 15, 1988: Article 52). At the time a concession is awarded, the regulator issues a document called a "Resolution" in which the characteristics of the concession are specified. This includes: "(a) a reference to the fulfillment of the dispositions of the CNAF [national table of frequency allocation] that are applicable, and, (b) the technical background of the system in terms of the service to offer; central frequency and bandwidth of the transmitting stations; geographical locations of the fixed transmitting stations; coverage area or link direction; operation timetable; nominal power of the transmitters; effective maximum radiated power; maximum intensity of the electrical field in the surrounding of the covered area; modulation type; type, gain and pattern of the radiation of the antennas of the transmitter stations; type, gain and pattern of reception of the antennas of the receiving stations, whenever they have to be protected; altitude and location of the antennas above the terrain level and above sea level; and a spectrum diagram of the signals emitted by the transmitters after the filtering state, as it corresponds." *Regulation of the Law of Telecommunications. Executive Decree No. 64* (May 15, 1988: Article 55).

[21] The classification of services, while non-binding, may provide a coordinating function. In any event, service categories are provided by International Telecommunications Union allocations (non-binding agreements between countries) and by international markets for telecommunications equipment. A small country's spectrum, even in the most open regulatory environment, will largely conform to world markets to capture economies of scale in manufacturing transmission and receiving equipment.

information on prices (proxied by mean revenue per minute of use) and output (minutes of use), 1999I-2003II. [22]

TABLE III.1: DESCRIPTION OF VARIABLES IN EMPIRICAL MODEL

RPM	Revenue per minute in US$ for mobile voice services, a proxy for price.
Q	Output, measured as total minutes of use per month (totmin), in millions.
HHI	Herfindahl-Hirschman Index in the market (0 to 10,000), with market shares based on subscribers.
Spectrum	Aggregate bandwidth available for mobile phone service by all operators in the market. Measured in MHz.
Density	A proxy for capital costs. Measured as mean inhabitants per square kilometer.
Agdppc	Adjusted (by PPP) Gross Domestic Product per capita in US$.
Fixprice	Mean price of 3-minute call in US$ using fixed network (peak period).
Dumfix	Dummy variable = 1 if *Fixprice* is zero, and zero otherwise.
Aln(*Fixprice*)	It is obtained as (1-*dumfix*)**ln*(*Fixprice*)

The estimated model is briefly described here.[23] Price is predicted by a system of simultaneous equations, one a Mark Up equation (including supply side variables predicted to affect price) and the other a Demand equation (with demand side variables thought to influence price). The quantity of minutes, included as an independent variable in either equation, is endogenous, leading us to instrument this variable. Fixed effects are included, to adjust for unobserved characteristics between markets (countries) occurring within our panel dataset. Included variables are described in Table III.1. Empirical results are displayed in Table III.2.

[22] A more complete review of Hazlett & Muñoz (2006) database is available in Appendix 2.

[23] The reader is referred to Hazlett & Munoz (2006) for more detailed descriptions and analysis.

TABLE III.2: LOG-LOG RESULTS. DEPENDENT VARIABLE = LN(RPM).
ALL ESTIMATIONS USE A FIXED EFFECTS MODEL.

	The Mark up equation V.3	The Demand equation V.4
Ltotminhat	0.109621 (1.54)	-0.867165* (-11.85)
LHHI	6.561295* (2.69)	
LHHI2	-0.352471** (-2.41)	
Lspectrum	-0.391080** (-2.33)	
Lspectrum2	0.031232*** (1.87)	
Ldensity	-7.175110* (-6.44)	
Lagdppc		8.347920** (2.48)
Lagdppc2		-0.284226*** (-1.62)
aLfixprice		4.838753* (4.61)
aLfixprice2		0.972481* (4.16)
CONSTANT	-0.500565 (-0.05)	-45.34805* (-2.77)
No.Observations	451	451
R-Square	0.8188	0.8237
DW	1.99	2.0032

3SLS estimation in Panel Data adjusted by serial correlation. Values of t-statistics in parentheses:
*, **, *** refer to 99%, 95%, and 90% confidence levels, respectively.
Source: Hazlett & Muñoz (2006)

These results suggest a positive dependence of equilibrium prices on the Herfindahl-Hirshman index and a negative dependence on allocated bandwidth. The magnitude of either relationship is substantial, leading us to conclude that policy makers should focus relatively more effort on promoting lower retail prices. This is done either by allocating more radio spectrum (or allowing markets to allocate more radio spectrum) to be used by mobile phone carriers, or by permitting more liberal use of spectrum already allocated.[24] The increase in spectrum availability both increases efficiency directly, lowering marginal costs of wireless services, and indirectly, by lowering fixed costs. The latter facilitates entry by competitors, intensifying price rivalry. It also clearly facilitates the provision of new services, although these effects were beyond the scope of

[24] With more uses of spectrum permissible, more valuable wireless applications can be deployed.

our empirical study. It is clear, however, that more liberal spectrum policies facilitate the introduction of advanced technologies and innovative services (such as wireless broadband, e.g.) by removing regulatory entry barriers (Rosston 2001b).

The empirical results also prompt an investigation into the spectrum policies of particular countries, which we here pursue for the Latin American region. By obtaining estimates of the consumer welfare effect of spectrum allocation across countries, this calibrated model can then be deployed to estimate the change in consumer surplus and service revenues in a given market for a hypothetical increase in the amount of spectrum allocated to mobile telephony. In particular, we perform this exercise in each of the six Latin American countries included in the Merrill Lynch dataset.[25]

III.3. Simulations

The estimates of the empirical model suggest that the amount of allocated spectrum is critical, but also important is the level of industrial concentration, which is affected by the regulator in determining the number of licenses and in setting other rules which impact operator size, entry barriers, and competitive rivalry. Theoretically, we assume that firms are competing á la Cournot and that the marginal costs of a firm decrease in the amount of spectrum available for its use.[26] With equally efficient firms a uniform allocation of spectrum across rival operators would minimize the concentration ratio and, according to the regression, minimize retail price, ceteris paribus. In this section, then, we consider choices a regulatory authority makes with respect to the total quantity of spectrum allocated to the mobile telephone sector.

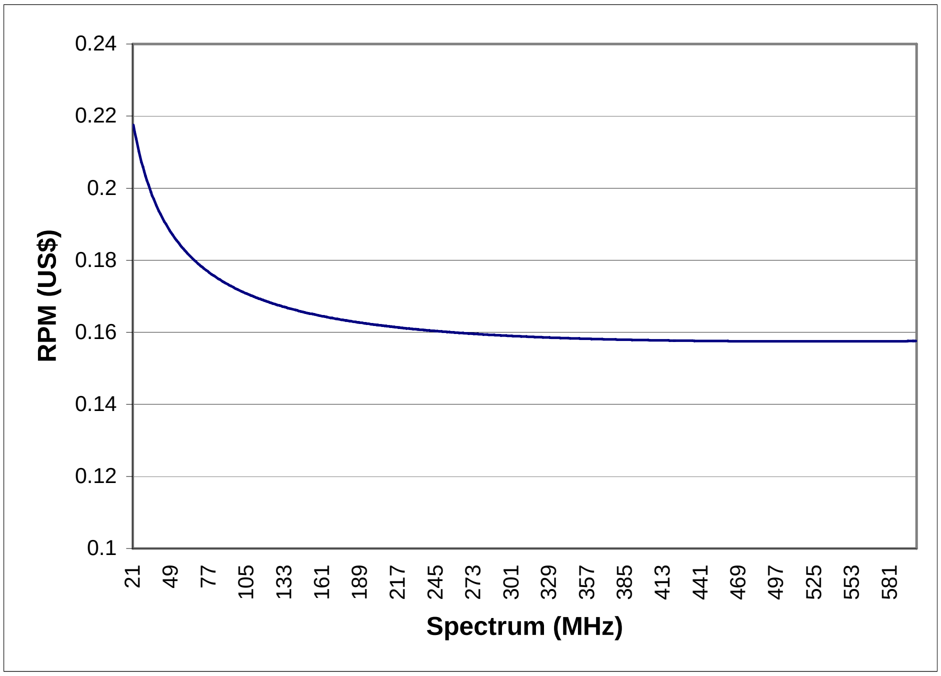
III.3.1. Direct Effects of Changes in Spectrum on Retail Price

Figure III.1 illustrates the direct effect of an increase in spectrum on the average revenue per minute (*RPM*) in mobile telephony. The function is obtained with empirical results displayed in Table III.2, when all the other (non-Spectrum) exogenous variables are fixed at their mean sample values, and the quantity of spectrum (in MHz) allotted to the mobile telephony sector is then varied. As is seen, price is decreasing in the amount of allocated spectrum, with the rate of decrease declining. Retail prices are reduced because marginal costs are lower with more abundant inputs, a standard result.

[25] Out of sample predictions are difficult to obtain due to the use of a fixed effects model, where a different intercept is obtained for each country in the sample. In this context, we do not have an intercept available for countries out of the sample. Predictions could be produced by making assumptions about how similar is the intercept of the excluded country to one or more countries included in the sample, but the selection would be under criticism.

[26] Reed (1992) shows that marginal cost is decreasing in capital and spectrum, and that these two inputs are substitutes.

FIGURE III.1: RETAIL PRICE AS A FUNCTION OF SPECTRUM ALLOCATION: THE GENERAL CASE



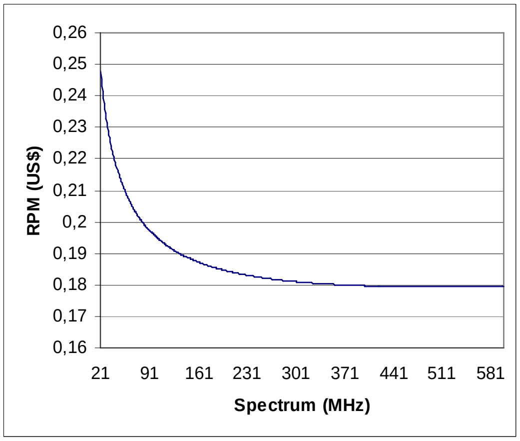
It is important to note that in order to obtain Figure III.1 we also had to select the mean value for the fixed effects. If we want to study the direct effect of an increase spectrum in a particular country, the Spectrum-Price relationship in figure III.1 changes due to particular characteristics of that country (which differ from the sample mean). We are, however, able to make these adjustments for each of the six Latin American countries in the database, and present them as six panels of Figure III.2. We observe that, while the opportunity for consumer welfare increases is available across the entire range of countries, the magnitude of the gains (via retail price reductions) varies widely. This is largely a product of the reality that the more restrictive policy regimes present the largest opportunities for gains from liberalization.

III.3.2. Country Pricing Simulations

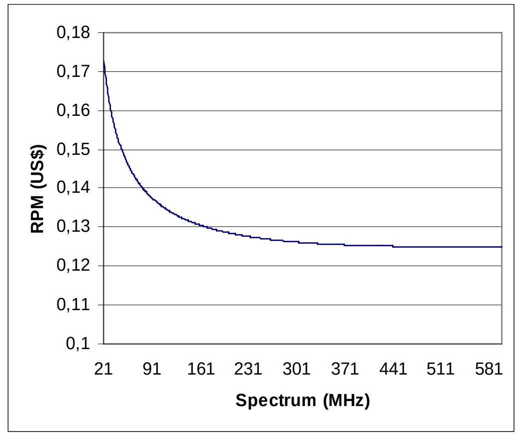
The country simulations ask the question: *If regulators were to make more spectrum available to mobile telephone networks, where would retail prices (RPM) be?* The results suggest that, for a given increase in allocated bandwidth, Chile has the potential to reach the lowest retail prices (for countries in the sample), with revenue per minute falling around US$0.085, while Mexico and Venezuela are bounded below by US$0.19. The sources of these differences are in the country specific mean values for the other explanatory variables, and differences in institutional aspects captured in the fixed effects constants.

FIGURE III.2: PRICE AS A FUNCTION OF SPECTRUM ALLOCATION:
6 LATIN AMERICAN MARKETS

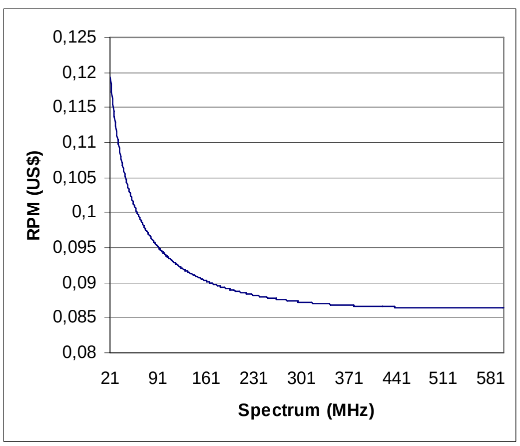
ARGENTINA



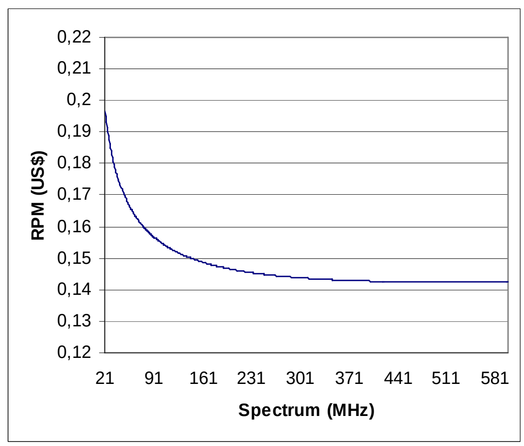
BRAZIL



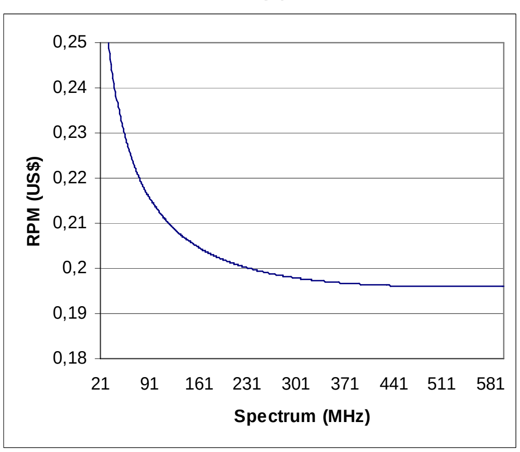
CHILE



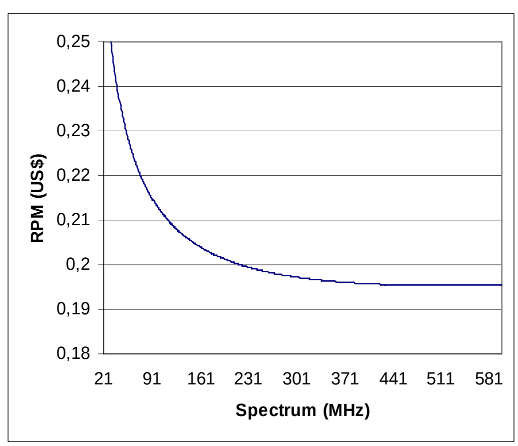
COLOMBIA



MEXICO



VENEZUELA



III.3.3. Country Welfare Analysis

In order to translate spectrum-policy induced price changes into economic welfare changes, we use the model calibrated in Table III.2 to perform various simulations as follows:

1. Initial values are assumed for the exogenous variables that mimic the values these variables take in the target market. Using our model's parameter estimates, the instrument is calculated; the Mark Up equation then yields the expected *RPM* in the benchmark case.

2. An increase in Spectrum is assumed, say 80 MHz. The corresponding *HHI* is obtained through the selected *HHI*-Spectrum elasticity (which was set to equal -0.3 as in Hazlett & Muñoz [2006]). The Mark Up equation is then used to predict the new (post Spectrum addition) *RPM*. From the percentage change in *RPM* and the demand elasticity at the initial level of output (in total minutes of use), we then estimate the change in output (*MOU*s).

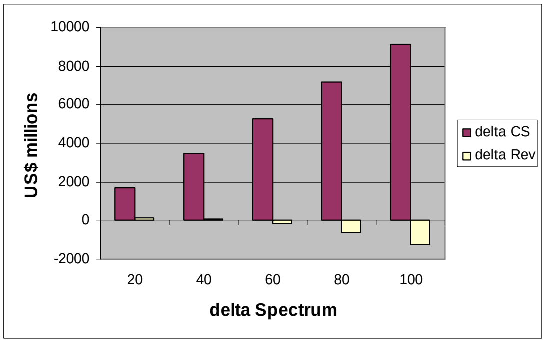
3. Given the change in prices and output we get the expected change in Consumer Surplus and Revenues (per month). We estimate net present values, assuming these flows as perpetuities discounted at 5% per annum.[27]

Results for the six Latin American countries are displayed in Fig. III.3. Potential gains, of course, depend on the size of each market and so it is unsurprising that the most populous countries, Brazil and Mexico, are predicted to have the highest incremental consumer surplus. Other results, however, are interesting. For instance, additional Spectrum allocations generate approximately as high an increase in consumer surplus in Venezuela as in Mexico, despite the Venezuelan economy's much smaller size. This outcome appears to be driven by the extremely parsimonious spectrum allocation for mobile telephony in Venezuela (57 MHz). It is also noteworthy that, across countries, revenues tend to increase very modestly for low increments of new Spectrum allocations but to then decline with larger allocations. This is consistent with the public choice hypothesis that regulators seek to achieve revenue maximization (i.e., pro-incumbent policies) rather than consumer welfare maximization.

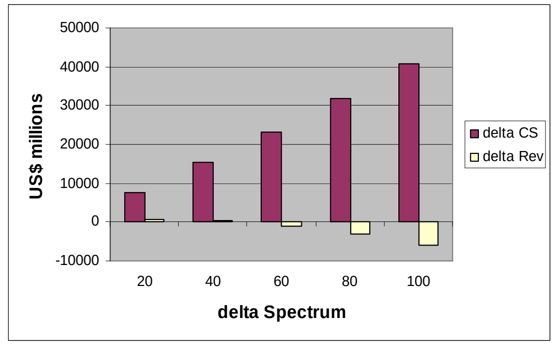
[27] This can be thought of as a real social discount rate. Since growth is expected for many years in wireless phone markets, it is not implausible that even if the (gross) discount rate is ten percent, that a net discount rate of 5% (reflecting anticipated growth of five percent) would be appropriate.

Figure III.3: Change in Consumer Surplus and Revenues: The Effect of Additional Spectrum Allocations

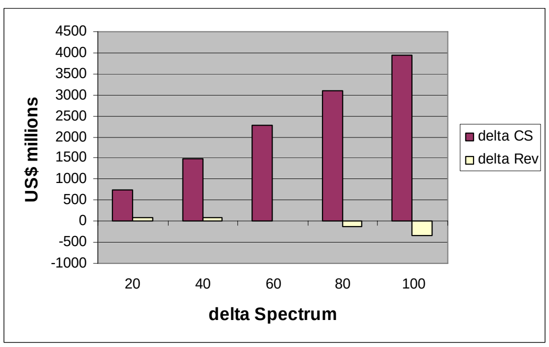
Argentina



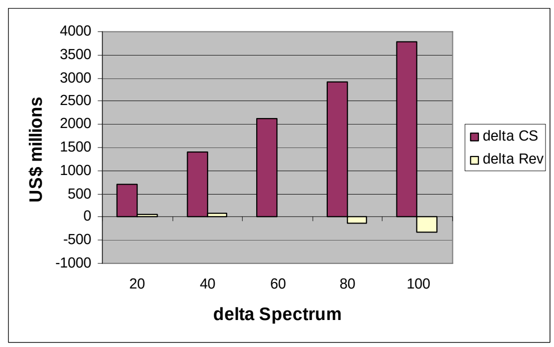
Brazil



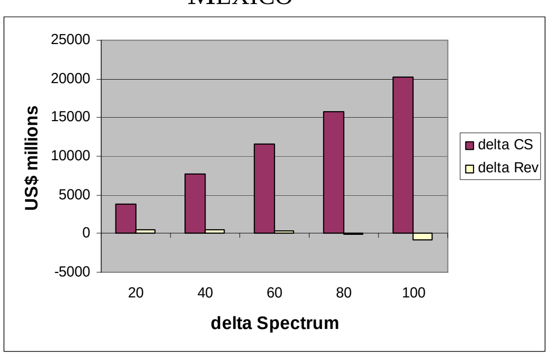
Chile



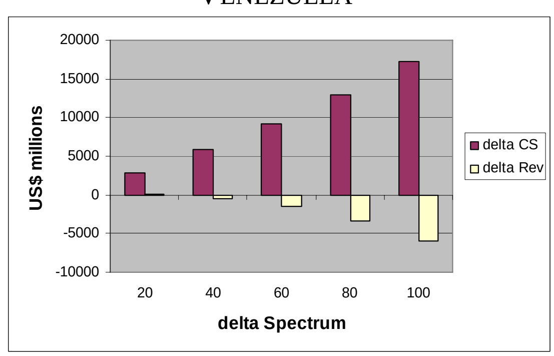
Colombia



Mexico



Venezuela



IV. IMPROVEMENTS REQUIRING INSTITUTIONAL CHANGES

IV.1. Introduction.

The evidence from mobile telephone markets suggests that spectrum is relatively under-allocated by governments in Latin America, but that regulatory outcomes vary widely. The government of Paraguay has allocated mobile phone carriers 170 MHz, and the Chilean government 140 MHz, of radio spectrum, comparatively generous allotments even as these regimes use conventional administrative techniques.[28] Guatemala and El Salvador have permitted similar bandwidth to be utilized in mobile phone markets, but achieved this outcome through regime shifts described above. In this Section we attempt to formally model the key determinants involved in the *political process* wherein bandwidth is allocated, or otherwise made available, for use by mobile phone carriers.

IV.2 Spectrum Regimes: Three Simple Models

Suppose that there exist just two firms and two services in the industry. We will identify the firms with super indexes and the services with sub indexes.

We assume that firm *i* solves:

$$\underset{q_1^i, q_2^i}{Max} \left\{ P_1\left(q_1^i + q_1^j\right) q_1^i + P_2\left(q_2^i + q_2^j\right) q_2^i - c\left(q_1^i, q_2^i\right) \right\}$$

Analogously, firm *j* solves for q_1^j, q_2^j. Distinct cost functions result from differing regulatory schemes. The following models are introduced as simple benchmarks to discuss spectrum policies found in Latin America.[29]

Model I: Spectrum Assigned to Services

In this case, the regulatory authority assigns spectrum to each operator to provide a specific service, with licenses awarded by either beauty contest or competitive bidding. The problem of minimization of costs for firm *i* is then given by:

$$c\left(q_1^i, q_2^i\right) = \underset{K_1^i, K_2^i}{Min} \left\{ r\left(K_1^i + K_2^i\right) + F\left(\overline{S}^i\right) \right\}, \text{ s.t.}$$

$$f_1\left(K_1^i, S_1^i\right) = q_1^i$$
$$f_2\left(K_2^i, S_2^i\right) = q_2^i$$
$$S_1^i \le \overline{S}^i, \quad S_2^i = 0 \quad and \quad \overline{S}^i + \overline{S}^j = \overline{S}$$

---

[28] As references see:

a. Chile: *Ley General de Telecomunicaciones N° 18.168.*
b. Paraguay: *Ley de Telecomunicaciones Nº 642 and Decreto Nº 14135.*

[29] These models are based on Muñoz (2004).

The two first constraints are the production functions for services 1 and 2. For simplicity, we assume that there are just two factors, capital (*K*) and spectrum (*S*). The capital cost is given by *r*, while spectrum $\overline{S}^i$ is acquired by firm *i* at cost $F(\overline{S}^i)$.[30] The last constraint is determined by regulation. A quantity of $\overline{S}^i$ MHz is allocated to the license of firm *i*, which authorizes the firm to supply service 1. Service 2 is not authorized by the license, although the licensee, if unconstrained, could provide the service with some fraction of $\overline{S}^i$.

The constraints for firm *j* are a mirror image of those of firm *i*, and total allocated spectrum is divided between the two licenses:

$$S_2^j \leq \overline{S}^j, \quad S_1^j = 0, \quad \overline{S}^1 + \overline{S}^2 = \overline{S}.$$

Mirroring firm *i*, firm *j* is authorized to provide service 2 but not service 1. As a result, each firm enjoys monopoly power in its authorized output market, yet rents are partially, if not fully, extracted through $F(\overline{S}^i)$ in the license award.

<u>Model II: Spectrum Assigned to Firms</u>

This case represents an intermediate position on a spectrum liberalization continuum.[31] The regulatory authority allocates spectrum to licenses, which are then distributed to firms (through auctions or beauty contests), and it does not constrain the services that firms may supply in using this bandwidth. Cost minimization for firm *i* is then given by:

$$c\left(q_1^i, q_2^i\right) = \underset{K_1^i, S_1^i, K_2^i, S_2^i}{Min} \left\{ r\left(K_1^i + K_2^i\right) + F(\overline{S}^i) \right\}, \text{ s.t.}$$

$$f_1\left(K_1^i, S_1^i\right) = q_1^i$$
$$f_2\left(K_2^i, S_2^i\right) = q_2^i$$
$$S_1^i + S_2^i \leq \overline{S}^i \quad and \quad \overline{S}^i + \overline{S}^j \equiv \overline{S}$$ [32]

[30] Spectrum is typically not "owned" in a strict legal sense. Rather, a license, yielding effective control of the use of frequencies for particular purposes (set by the regulator), is acquired. See Hazlett (2001).

[31] Liberalization of spectrum policy, following Kwerel & Williams (2002), can be broken down into two component parts. The first encompasses the flexibility given a particular licensee to use the spectrum allocated to its license. More flexibility cedes additional property rights to wireless operators. The second encompasses the process whereby spectrum is allocated (or reallocated) from class of licenses to another. This permits spectrum to be bid out of one deployment and diverted to another without special regulatory action.

[32] This constraint does not preclude "spectrum sharing" between the two services. The total capacity of the allocated spectrum, then, can be defined in multiple dimensions. This added complexity is avoided here, with no loss of analytical power.

The result is distinguished from that of the previous model due to the altered regulatory constraint. In this case, a total amount of $\overline{S}^i$ MHz is allotted firm *i*'s license, with the firm being authorized to optimally distribute bandwidth between the two services. Under this scenario, both firms compete in both markets.

Increased spectrum flexibility has two effects. First, firm *i* is able to deploy frequency space where it produces the greatest incremental profit, increasing the value of the license. Second, as firm *j* also receives the same flexibility, monopoly rents are dissipated, decreasing the value of the license. As a result, the sign of license value windfalls associated with a shift from Model I to Model II are theoretically ambiguous. Hazlett (2004) finds empirically that, for countries implementing ambitious spectrum liberalizations, wireless license sales prices are observed to be about 38% lower than in other countries, adjusting for other factors. This implies that the value of preclusionary effects may dominate productive effects, in terms of license values. This creates a dichotomous policy choice. Governments will tend to prefer Model I if the policy goal is to maximize licensee rents which, in turn, maximize auction receipts; Model II if the objective is to maximize social welfare.

<u>Model III: Spectrum Assigned by Markets</u>

In this case, private property rights are assigned to the spectrum resource, wireless firms enjoying full flexibility for the use of assigned airwave space *and* the ability to acquire additional bandwidth from regulators.[33] As a result, spectrum use rights flow to their highest valued uses.[34] This optimization process encompasses the distribution of spectrum within firms, between firms, and among rival services. The cost minimization problem for firm *i* becomes:

---

[33] In the polar case, spectrum rights are exhaustively assigned to owners. This would still leave room for considerable regime variation, as exclusive rights could be defined differently. It should be noted that we fix the total amount of spectrum available to users across Models II and III, which aids comparative statics.

[34] This was the logic employed by Ronald Coase (1959), who suggested that private property rights in spectrum would not only substitute for government allocation, they would lead to more efficient levels of radio interference. Interestingly, Coase erred by simultaneously arguing that his analysis depended only on radio spectrum users possessing use rights rather than ownership of spectrum itself. Coase professed to be agnostic as to how broad the "bundle of sticks" enjoyed by spectrum owners were. This conflicts with his argument, later dubbed the Coase Theorem (Coase 1960), that markets discover optimal spillovers. To institute least-cost solutions, market participants require ownership over all efficient resource uses. But these efficient uses are not known a priori, they are exactly what Coasean market transactions are presumed to discover. Hence, for optimal production and/or mitigation, a bundle of narrowly-defined, technology-specific use rights is unable to yield the necessary scope for efficient resource use. The assumption that a given bundle of sticks can be regularly updated to include innovative new use rights does not overcome this problem. Relying on regulators to continually define new use rights reverts to precisely the central planning Coase sought to pre-empt by endowing marketplace agents with ownership rights. But only if these rights encompass broad control over the "thing itself," *in rem* rights in legal theory, will the full panoply of efficient options be revealed. See Merrill and Smith (2002), Hazlett (2005).

$$c\left(q_1^i, q_2^i\right) = \underset{K_1^i, S_1^i, K_2^i, S_2^i}{Min} \left\{ r\left(K_1^i + K_2^i\right) + \upsilon\left(S_1^i + S_2^i\right) + F\left(\overline{S}^i\right) \right\}, \text{ s.t.}$$

$$f_1\left(K_1^i, S_1^i\right) = q_1^i$$

$$f_2\left(K_2^i, S_2^i\right) = q_2^i$$

$$S_1^i + S_2^i + S_1^j + S_2^j \leq \overline{S}$$

Distinct from the previous models, the objective function here includes a market price for spectrum (υ), which results from the equilibrium between supply, $\overline{S}$, and demand in the factor market. In this case spectrum flows not only to the more efficient use intra-firm (as in Model II), but also to the more efficient firms. Rent extraction continues within the assignment process, with rents presumably reduced compared to Model I, and plausibly reduced from Model II.[35]

Blanco (2005) studied the impact on Consumer Surplus of the transitions from Model I through III. Assuming Cobb-Douglas production functions in each service, she showed in simple examples that consumer surplus increases significantly more in the transition from Model I to Model II than in the transition from II to III. She recognizes that this result underestimates the impact of property rights because her evaluation does not consider the gains from flexibility in the introduction of new services or new technologies. There are, however, other reasons why the benefits from the transition from model II to III are underestimated in her study. The total amount of spectrum liberalized is assumed to be the same in models II and III, which severely truncates potential effects of a liberalization process that permits an increasing amount of spectrum to be deployed in more efficient uses. Nevertheless, her study suggests that regulatory inertia may not result from political opposition to property rights, per se, because Model II does not require explicit property rights and yet represents a significant social welfare improvement over Model I.

IV.3. Categorizing Latin American Spectrum Regimes

Models I, II and III represent benchmarks allowing us to chart the fundamental economic changes associated with spectrum liberalization. We now ask: *How extensive are exclusive spectrum rights in Latin America?* We review the spectrum regulatory regimes of each country in the region,[36] identifying key aspects. A summary is provided in Table IV.1, where in the last column we classify each country according to Models I to III, based on the characteristics indicated by the variables displayed in other columns.

---

[35] Note that it is theoretically possible that a price increase obtains from Model II to Model III, because in the latter the cost of Spectrum is included as a marginal cost. Under plausible assumptions this outcome does not obtain; moreover, consumer surplus increases over the interval II to III.

[36] Details of legal documents reviewed are given in Appendix 3.

TABLE IV.1. LEGAL ASPECTS OF LICENSES IN LATIN AMERICA[37]

Country	(a) Is service license distinct from wireless license?	(b) Is the wireless license associated with a service?	(c) Does the service license permit new services?	(d) Technological neutrality?	(e) Spectrum command & control?	(f) Spectrum property rights?	(g) Positive administrative silence?	(h) Is license revoked if licensee provides unauthorized service?	(i) Model
Argentina	yes	no	yes	yes	intermediate	no		no	Model 2
Bolivia	yes	yes	no	no	yes	no		yes	Model 1
Brasil	yes	yes	no	no	yes	no		yes	Model 1
Chile	yes	no	no	no	yes	no	yes	yes	Model 1
Colombia	yes	yes	no	no	yes	no		yes	Model 1
Costa Rica			no	no	yes	no		yes	Model 1
Ecuador	yes	yes	no	no	yes	no	yes	yes	Model 1
El Salvador	yes	no	yes	yes	no	no		no	Model 3
Guatemala		no		yes	no	yes	yes		Model 3
Honduras	yes	yes	no	no	yes	no		yes	Model 1
Mexico	yes	yes	no	no	yes	no		yes	Model 1
Nicaragua	yes	yes	yes	yes	intermediate	no	yes	yes	Model 2
Panama	yes	yes	no	no	yes	no		yes	Model 1
Paraguay	no	yes	no	no	yes	no		it depends on the contract	Model 1
Peru		yes	yes, but restricted ones*	no	yes	no	no	it depends on the contract	Model 1
Uruguay	yes	yes	no	yes	yes	no		yes	Model 1
Venezuela	yes	yes	no		yes	no	no		Model 1

* Those considered "services of added valued."

(a) In most of the Latin American countries a wireless operator needs two licenses, one for the service (usually called a public service license) and a second one for spectrum.
(b) In addition, the wireless license also establishes the service(s) to be provided with the bands contained in the license.
(c) The cross constraint established in (b) is usually redundant because, as column (c) shows, the licensee usually needs new service licenses to provide services not explicitly authorized in the original service license (even if the wireless license were not linked to a particular public service).
(d) In this paper we take technological neutrality in a broad sense. The regulatory authority in a country is technologically neutral if it does not impose direct constraints over the technology used by providers of a service. The authority can, however, impose indirect constraints over technology such as quality requirements.
(e) In most of the countries the use of spectrum is administrated by the regulatory authority instead of markets forces. This is called a command and control approach.
(f) In most of the countries the wireless license does not transfer property rights over spectrum to the licensee. The exception is the case of Guatemala, which grants title to spectrum use rights.
(g) When an existing service provider or an entrant applies for a new service license the authority usually has a deadline to answer the request. If the authority does not provide an answer before the deadline is met, then a positive administrative silence means the application should be considered approved.
(h) The provision of an unauthorized service by a licensee is usually subject to penalty. In most cases this can be as severe as the revocation of the original service license.
(i) Based on the information provided in the previous columns, we assigned each country to one of the reference models discussed in the previous section.

[37] Sources: Authors' conclusions based on legal documents described in Appendix 3.

Table IV.1 suggests that the dominant regulatory structure assigns spectrum use rights for specific services (Model I). In many countries a wireless license is formally distinct from a service license and operators, in markets such as mobile telephony, are required to have both in order to provide service. This procedure restricts spectrum use rights even in instances where the wireless license does not explicitly fix the service.[38] Most countries define standards for operators, restricting technology choices and violating the commonly stated regulatory goal of technological neutrality.[39]

Departing from Model I are the regimes found in Argentina and Nicaragua, which we categorize as Model II. Either regime features relatively liberal rules with respect to the use of spectrum allocated to a given license, but does not enable firms to move unallocated spectrum into productive use. Since relatively little spectrum has been allocated to licenses, this is an important constraint. Guatemala explicitly defines property rights to the use of frequencies (*titulo de usufructo des frecuencia)* and extends the property regime by granting parties the right to petition for access to unoccupied bandwidth, imposing an obligation on the regulator to issue such rights by competitive bidding. El Salvador has enacted a functionally similar process, although property rights are not explicitly granted. Licenses are defined by international spectrum allocation templates, but licensees are granted the freedom to engage in any non-interfering use within the spectrum allocated to the license. Mechanisms are also specified for parties to obtain unassigned licenses from the regulator. While the regulatory authority is not mandated to issue to such licenses, as in Guatemala, we note the empirical similarity in the mobile markets. As of 2003, either country featured four national networks, with carriers using 140 MHz in Guatemala, and 137.9 MHz in El Salvador. We classify these systems as approximated by Model III.

<u>IV.4. Some Empirical Evidence on Social Welfare Gains</u>

Liberalization – transition from Model I to Model III -- is theoretically predicted to increase social welfare. This implication is subject to empirical falsification by examining how regimes that expand the use of markets to allocate radio spectrum fare, compared to those that use traditional regulatory means. Here we examine preliminary evidence on this question, hoping that the discussion will motivate additional economic research.

<u>Fixed Effects in Hazlett-Muñoz (2006)</u> The empirical model estimated in Hazlett & Muñoz (2006) predicts cellphone rates for 29 countries using simultaneous Mark-up and Demand functions. Country fixed effects are included, which produce estimated intercept terms reflecting institutional differences across national markets. Neither of the Model III Latin American countries are included in the dataset, but two Model III

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[38] Exceptions exist. In Peru the services considered of "added valued" can be provided without special authorization. In most countries the provision of an unauthorized service can lead not only to a fine, but to revocation of both the wireless license and the original service license.

[39] A standard statement by the U.S. regulatory authority for telecommunications states, with respect to broadband rules: "Regulatory policies must promote technological neutrality, competition, investment, and innovation to ensure that broadband service providers have sufficient incentive to develop and offer such products and services." FCC website, http://www.fcc.gov/broadband/ (visited March 20, 2006).

countries (Australia and New Zealand [Hazlett 2004]) are. These countries have two of the four lowest intercept terms in the 29 country sample (see Table IV.2), suggesting that, after adjusting for other international differences, prices in these markets are idiosyncratically low.

TABLE IV.2: ESTIMATED FIXED EFFECTS IN EMPIRICAL MODEL IN TABLE III.1[40]

	Country	*Instrument*	*Mark Up*	*Demand*
1	Argentina	13.26016	-11.73317	2.201876
2	Australia	24.49232	**-24.25885**	0.501348
3	Austria	-3.121995	2.397172	-0.495855
4	Belgium	-11.14916	10.29278	-0.517807
5	Brazil	12.51787	-9.562772	3.795469
6	Canada	19.80599	**-22.89501**	-5.796666
7	Chile	10.672	-9.54166	1.76135
8	Colombia	6.938907	-5.436192	2.507958
9	Czech	-3.499747	4.166013	1.003745
10	Denmark	-5.368913	3.993615	-0.893913
11	Finland	10.92925	-11.57904	-0.278466
12	France	-1.573813	2.870583	1.703584
13	Germany	-7.358545	8.61986	1.719612
14	Greece	-0.622958	1.399664	1.370348
15	Hong Kong	-35.52169	31.95396	-6.090915
16	Hungary	-1.591769	2.51927	1.492491
17	Ireland	0.509622	-2.146538	-1.417607
18	Italy	-5.515051	6.802065	1.618917
19	Mexico	5.668315	-2.74681	3.448297
20	Netherlands	-12.40686	12.33217	0.275037
21	New Zealand	8.078712	**-11.85054**	-6.445173
23	Norway	10.32911	**-11.97703**	-1.204958
24	Portugal	-2.286175	2.978714	1.148437
25	Singapore	-33.99011	31.6884	-2.021412
26	Spain	0.658262	0.722913	1.895967
29	UK	-7.751999	8.911876	1.266412
30	US	5.297437	-6.34778	-3.535385
31	Venezuela	10.36946	-6.889524	4.609543

<u>Prices and Market Concentration in Latin America</u> Cellular telephone rates appear to be generally below average under the more liberal Latin American spectrum regimes, while

[40] Source: From Hazlett and Muñoz (2006), the Mark Up equation defines the equilibrium price. In the table we observe country fixed effects, finding those for the two most liberal spectrum regimes included in the sample, Australia and New Zealand, among the four lowest values (in bold). This implies that, ceteris paribus, liberal regimes are associated with lower price per minute in mobile phone markets. We also note that the fifth lowest Mark Up fixed effect was obtained for Argentina, a country featuring an intermediate level of liberalization.

competitiveness appears to be higher as it is shown in Figure IV.1 where we graph some of the information contained in Table II.1.

FIGURE IV.1: AVERAGE PRICE PER MINUTE (APM) AND MARKET CONCENTRATION (HHI) IN LATIN AMERICA

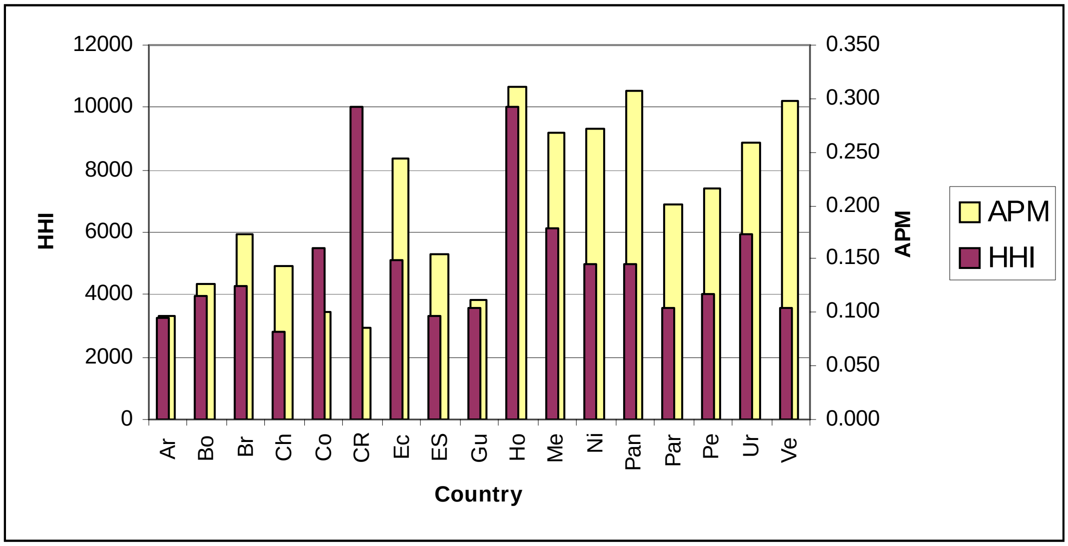

Figure IV.1 shows that APM is not directly linked to concentration. In fact, the lowest price is observed in Costa Rica where the supply of wireless telephony is concentrated in a state monopoly. However, as Blanco (2005) points out, subsidies seem to explain these low prices. On the other extreme, Venezuela shows one of the highest values for APM, despite of the fact that the concentration index is one of the lowest in the region. It is important, however, to observe the countries with the most liberal regimes in the region: El Salvador and Guatemala. Both of them present APMs and concentration indexes among the lowest in Latin America. Their situation is comparable to Chile and better (from a social point of view) than Brazil, despite differences in size and GDP per capita. We suspect that spectrum liberalization drives these results. In fact, although the spectrum assigned to wireless telephony in both countries is still below the trend line in Figure II.1, the gap is only about 16 MHz for Guatemala and 20 MHz for El Salvador, well below the average 55 MHz for the region.

In order to illustrate the impact of liberalization, we performed a simple exercise asking how much additional spectrum should be assigned by the regulator in (for example) Mexico to mobile telephony, in order to reach the same concentration index as in Guatemala (that is 3591) under the current regulatory framework, and then simulated the increase in consumer surplus associated with that policy (using the method discussed above). The exercise showed that the required increase in Mexico was 158 MHz, implying an *annual* increase in consumer surplus of US$ 1.786 billion. The final Revenue per Minute (RPM) would be around 15 cents, differing from the 11 cents in Guatemala due to other (non-Spectrum, non-HHI) country-specific factors.

V. CONCLUSION

This paper has evaluated spectrum allocation policies in Latin America. The analysis shows that, in most of the countries of the region, regulatory authorities have inefficiently constrained spectrum access. The exceptions appear to be Guatemala and El Salvador where, despite of the small size of their economies, the amount of spectrum used in the mobile phone market is among the largest of the region. The main difference between these countries and the rest of Latin America is that they have implemented liberal telecommunication reforms. Public policy allows resources to flow to their highest valued uses, which is economically efficient.

Other countries, like Chile and Paraguay, have approached the results of liberalization by regulatory action to make more spectrum available to mobile phone networks. Yet, our simulations for six of the largest Latin American markets suggest that the social value of increasing mobile spectrum allocations is still very high -- on average, US$41 per capita for an increment of 20 MHz. This illustrates the general tendency of regulators to under-allocate frequency rights.

Transition to liberalization can (and likely will) take different paths. One option is for regulators to expand the rights held by licensees to use spectrum already allocated to their licenses, and to then expand the spectrum allocated to such liberal licenses. A second option is to engage in structural reform of the spectrum allocation process as in Guatemala and El Salvador, both of which achieved their policy outcomes through legislation enacted quickly during the aftermath of general democratic reforms. Such policy changes are seen to achieve high social returns. Where they will occur, and what institutional mechanisms raise or lower their probability, are excellent topics for public choice analysis of wireless telecommunications markets.

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APPENDIX 1: SPECTRUM ALLOCATED TO WIRELESS TELEPHONY IN THE EUROPEAN UNION (2003) [41]

Countries with Auctions	**MHz**
Austria	304.2
Belgium	199.0
Denmark	375.0
Germany	305.0
Greece	265.0
Italy	286.8
Netherlands	355.8
United Kingdom	341.0
Countries with Beauty Contests	
France	207.0
Finland	238.8
Ireland	251.0
Luxembourg	85.6
Portugal	223.6
Spain	297.2
Sweden	255.1
Average Allocation	266.0

Source: Authors' elaboration based on Hazlett (2004) database.

[41] The list of EU countries was taken from http://userpage.chemie.fu-berlin.de/adressen/eu.html. Only the members as of December 2003 were included.

APPENDIX 2: MOBILE VOICE MARKET DATABASE

Our main source of information was:

"Global Wireless Matrix 2Q03: Quarterly Update on Global Wireless Industry Metrics," Merrill Lynch Global Securities Research & Economics Group, Global Fundamental Equity Research Department. This includes quarterly data for the wireless market in 46 countries, first quarter 1999 through second quarter 2003. All data were obtained from this source except the following:

Spectrum, Auction: The main source is each country's telecommunications regulator and Communications Ministry. The Economist Intelligence Unit ViewsWire database, the European Commission and the European Radio Communications Office are secondary sources.

AGDPPC (Adjusted by PPP GDP per capita): International Monetary Fund (IMF), World Economic Outlook (WEO) Database. April 2003.

Density: It was constructed as population/area, where population is from Merrill Lynch and area is from the World Bank's World Development Indicators 2003.

Fixprice: It was taken from the International Telecommunications Union's World Telecommunications Indicators 2002 database.

Our sample is comprised of all observations in the Merrill Lynch database for which we have data for all the relevant variables from the first quarter in 1999 through the second quarter in 2003. (While Merrill Lynch data technically begin in fourth quarter 1998, the data for that quarter are very incomplete.) Our sample included the following 29 countries:

Argentina	Hong Kong	Venezuela
Australia	Hungary	
Austria	Ireland	
Belgium	Italy	
Brazil	Mexico	
Canada	Netherlands	
Chile	New Zealand	
Colombia	Norway	
Czech	Portugal	
Denmark	Singapore	
Finland	Spain	
France	Sweden	
Germany	United Kingdom	
Greece	United States	

Of the 46 countries in the Merrill Lynch database, many could not be used due to missing data (for variables not included in the ML database). The most difficult data to identify included *Spectrum* and *Fixprice*. To enable the inclusion of additional country data, *Fixprice* was adjusted in the following countries:

- Canada: The reported values are zero from 1991 to 1994; thereafter it is not reported. We used an assumed value of "0" after 1994.

- Sweden: The value increases monotonically until 1999; it is not reported thereafter. We used the variable with missing values (i.e., data from Sweden were not included in regressions using *Fixprice*).

APPENDIX 3: SPECTRUM LAW IN LATIN AMERICA

Argentina	Reglamento de Licencias para Servicios de Telecomunicaciones. Decreto PEN 764/2000 con fecha 3 de Septiembre del 2000, Anexo I.
	Reglamento sobre Administración, Gestión y Control del Espectro Radioeléctrico. Decreto PEN 764/2000 con fecha 3 de Septiembre del 2000, Anexo IV.
Bolivia	Ley de Telecomunicaciones: Ley 1632 aprobada el 5 de Julio de 1995 y modificada por las leyes 2328 y 2342 del 2002.
	Fuente: Reglamento a la Ley de Telecomunicaciones. Decreto Supremo 24132 del 27 de Septiembre de 1995 (incluye modificaciones hasta Febrero del 2001).
Brasil	Agencia Nacional de Telecomunicaciones, ATO N. 50.312 del 13 de Mayo del 2005.
Chile	Ley N° 18.168, General de Telecomunicaciones y modificaciones posteriores.
Colombia	LEY 555 DE 2000 por la cual se regula la prestación de los Servicios de Comunicación Personal, PCS y se dictan otras disposiciones.
Costa Rica	Reglamento a la Ley Reguladora de los Servicios Públicos, N° 7593 de 9 de Agosto de 1996
	Reglamento General de Servicios de Telecomunicaciones (RGST) Publicado en La Gaceta Nº 27 del 7 de febrero de 2002.
Ecuador	Ley especial de Telecomunicaciones Reformada, Ley No. 184 Registro Oficial No. 996 (incluye modificaciones hasta Marzo 2000).
	REGLAMENTO GENERAL A LA LEY ESPECIAL DE TELECOMUNICACIONES REFORMADA, DECRETO EJECUTIVO No. 1790, REGISTRO OFICIAL No. 404, 4-SEP-2001
	Reglamento para el Servicio de Telefonía Móvil Celular
El Salvador	Hazlett (2004)
Guatemala	Hazlett (2004)
Honduras	Ley Marco del Sector de Telecomunicaciones, Decreto 185-95 del 5 de Diciembre de 1995 y Actualización de la Ley Marco del Sector de Telecomunicaciones, Decreto 118-97 del 25 de Octubre de 1997. Reglamento General de la Ley Marco de Telecomunicaciones.
Mexico	Ley Federal de Telecomunicaciones, LEY PUBLICADA EN EL DIARIO OFICIAL DE LA FEDERACION EL 7 DE JUNIO DE 1995.
Nicaragua	Reglamento De Uso Del Espectro Radioeléctrico Y De Los Servicios De Radiocomunicaciones
	Reglamento de Títulos Habilitantes. Acuerdo Administrativo N° 006 de Enero 7 del 2005.
Panama	LEY No. 31 (De 8 de febrero de 1996) "Por la cual se dictan normas para la regulación de las telecomunicaciones en la República Panamá"
	Decreto Ejecutivo No. 21 (De 12 de enero de 1996) "Por el cual se dicta el Reglamento sobre la Operación del Servicio de Telefonía Móvil Celular"
Paraguay	LEY Nº 642 DE TELECOMUNICACIONES
	Decreto Nº 14135, POR EL CUAL SE APRUEBA LAS NORMAS REGLAMENTARIAS, DE LA LEY Nº 642/95 "DE TELECOMUNICACIONES", Asunción, 15 de julio de 1996.
Peru	D.S. No. 013-93-TCC, Aprueba el Texto Unico Ordenado de la Ley de Telecomunicaciones. Promulgada: 28 de abril de 1993.
	Texto Único Ordenado del Reglamento General de la Ley de Telecomunicaciones, DECRETO SUPREMO Nº 027-2004-MTC
	DECRETO SUPREMO Nº 040-2004-MTC, 21 Diciembre del 2004.
Uruguay	REGLAMENTO SOBRE EL ESPECTRO RADIOELÉCTRICO 25/03/03
	REGLAMENTO DE LICENCIAS DE TELECOMUNICACIONES, 25/03/03
Venezuela	LEY ORGÁNICA DE TELECOMUNICACIONES, 1 Junio del 2000.