Property Rights to Radio Spectrum in Guatemala and El Salvador: An Experiment in Liberalization

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In most countries, wireless communications rely on administrative allocation of radio spectrum. The inefficiencies associated with this centralized approach have led economists, starting with Coase in 1959, to suggest "propertyzing" radio spectrum. Critics of this approach assert that property rights impose prohibitive transaction costs and inhibit development of wireless services. Reforms enacted in Guatemala (in 1996) and El Salvador (in 1997) have largely implemented policies suggested by Coase, yielding a natural experiment. Evidence generated in the mobile telephone market suggests that these regimes are associated with relatively efficient policy outcomes, including abundant spectrum availability and a high degree of competitiveness, and with correspondingly low retail prices and high rates of output (minutes of use). Further, such markets appear to avoid high transaction costs in the public or private sectors. We conclude that these liberal reforms tend to produce results consistent with Coase's policy conjecture.

1. INTRODUCTION.

> After the publication of my FCC article, I was invited [by the Rand Corporation]… to prepare a report on Problems of Radio Frequency Allocation… A draft report was prepared which advocated a market solution… [Reviews] were highly critical and as a result, the report was

suppressed. Here is an example that illustrates the character of the comments that were made:

> "This is a remarkable document…. Time has somehow left the authors behind… [T]hey ignore the social, cultural, and political values which have come to inhere in mass communications, in particular, broadcasting, as well as fifty years of administrative law developments… I know of no country on the face of the globe – except for a few corrupt Latin American dictatorships – where the 'sale' of the spectrum could even be seriously proposed." (Coase 1998:579)

An administrative system for allocating radio spectrum rights was adopted in the United States and most other countries in the 1920s and 1930s (Hazlett 1998). This approach was criticized by Ronald Coase, Bill Meckling, and Jora Minasian as early as 1959 and 1960, who advocated that defining and distributing exclusive frequency rights would allow competitive markets to more efficiently allocate rights (Coase 1959). This was then seen as an intensely controversial proposal (Coase 1998). Today, however, economists have widely embraced the property rights approach (Rosston & Hazlett 2001), and auctions are widely used to assign wireless licenses. But the underlying resource, radio spectrum, continues to be allocated administratively in the typical case.

Exceptions now exist, however, "where the 'sale' of the spectrum could even be seriously proposed," or *implemented*. In Guatemala in 1996 and El Salvador in 1996-97, sweeping telecommunications reforms were enacted by statute.[1] While technically quite distinct, they are highly similar in function. Private parties are granted exclusive control over wireless bandwidth. Instead of narrow use rights that limit licensees to supplying a particular service (such as broadcast TV) via a specified technology (such as the analog TV standard, NTSC), entities are given broad latitude to determine what types of wireless transmissions to engage in over defined frequency spaces. Regulators, instead of managing market activities, are largely constrained to defining, distributing, and enforcing requested spectrum rights.

The policy innovation forms a natural experiment testing the property rights proposal. To the extent that these regimes succeed in improving efficiency in wireless markets, they constitute "proof of concept" for spectrum markets. In addition, the procedures under which rights are established and distributed can yield empirical results advancing positive analysis of the institutions of spectrum policy.

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[1] Spectrum liberalization has also occurred in recent years in New Zealand and Australia. See Crandall, 1998; Australian Productivity Commission, 2002; and Hazlett, 2008.

Such research is important in at least four respects. First, radio spectrum is a fertile field for economic analysis, having led directly to discovery of the Coase Theorem (Coase 1959, 1960). Dean Lueck (1995:419) writes, "The broadcast spectrum holds a special, almost holy, place in the economic analysis of law and the economics of property rights." Second, radio spectrum is economically important. Currently, wireless phone service (the dominant industry within the wireless sector) generates about $570 billion in annual revenues worldwide,[2] and is growing rapidly. Waverman et al. (2005) estimate that the economic importance of wireless is actually much higher in the developing countries of Africa than in wealthier countries. Policies that allow greater efficiencies to be realized in this sector are likely to have substantial social impact. Third, spectrum property rights, while winning academic adherents, have yet to replace administrative allocation save in isolated instances.

Finally, while critiques of the Coasean view have persisted for more than four decades, these can be usefully subjected to empirical scrutiny. An opponent of spectrum liberalization wrote in 1980 that, "(r)ights to spectrum are not susceptible to legal enforcement as are private property rights. In the past, allocation by the market of rights to use the spectrum has been found to be impossible, or inefficient… The market cannot be an efficient substitute for the administrative process…in achieving allocational efficiency" (Melody 1980). More recently, proponents of categorical allocations of unlicensed bandwidth, often called "spectrum commons," have argued against exclusive spectrum rights by asserting that such rights reduce wealth due to transactions costs and monopolization. Such empirical conjectures are crucial to the ongoing policy debate over how to create, regulate, and distribute spectrum rights.[3] Careful analysis of the development of these spectrum markets based on property rights should help clarify the gains or losses associated with this approach and may offer a valuable perspective for policy reforms in several countries and international organizations (Cave 2002, FCC 2002, and ITU 2004).

This paper evaluates the policy experiments in airwave ownership in El Salvador and Guatemala. In Section 2, we describe the standard approach to spectrum allocation as practiced by most countries. The next two sections describe, respectively, the Guatemalan and Salvadoran spectrum regimes. Section 5 considers administrative results of the reform efforts in these two countries by examining the number of rights assigned to commercial users. Section 6

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[2] *Global Cellular Revenues at US$570 Billion in 2005,* Cellular-News (Nov. 11, 2005); http://www.cellular-news.com/story/13725.php.

[3] See, for example, Benkler (1998, 2002), Hazlett (2001), Faulhaber and Farber (2002), Baumol & Robyn (2006), Hazlett & Spitzer (2006).

examines the effectiveness of the liberalized regimes in promoting competitive entry and consumer gains in the commercial wireless telephone market, comparing Guatemala and El Salvador to other countries in Latin America. Interference disputes are addressed in Section 7, as well as the public costs of regulation. Section 8 offers our conclusion that, in this preliminary analysis, Coase's property rights approach appears to deliver substantial social benefits.

2. STANDARD SPECTRUM ALLOCATION

The U.S. Radio Act of 1927 created an independent government agency to determine how radio waves were to be used according to "public interest, convenience, and necessity."[4] Even when license assignments moved from beauty contests to competitive bidding, as many countries did in the 1990s, the use of frequencies was still determined by the regulator (Hazlett, 1998). Administrative spectrum allocation has thus pre-empted the formation of a market in wireless bandwidth.

  This regime, which still prevails in the U.S. and has been adopted by most other nations, has long been criticized by economists. Coase (1959) noted that, by assigning exclusive spectrum rights to private parties, the "price system" would discover optimal resource use, including spillovers from interference. Minasian (1969) wrote that "government planning is inefficient, as it operates without the constraints of competition for profits…" In 2001, a petition to the Federal Communications Commission from 37 policy economists advocated widespread deregulation of frequency use by exclusive licensees.[5]

  Despite consensus among economists,[6] a regime switch from administrative allocation to private ownership constitutes radical reform. As such, policy recommendations face a substantial burden. Indeed, prior to deciding that private property rights could effectively govern radio spectrum, Ronald Coase was undecided as to whether decentralized decision making would improve efficiency

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[4] Radio Act of 1927 (Public Law No. 632, February 23, 1927).

[5] The signatories were: Martin Neil Baily, Jonathan Baker, Timothy Bresnahan, Ronald Coase, Peter Cramton, Robert W. Crandall, Richard Gilbert, Shane Greenstein, Robert W. Hahn, Robert Hall, Barry Harris, Robert Harris, Jerry A. Hausman, Thomas W. Hazlett, Andrew Joskow, Alfred E. Kahn, Michael Katz, Robert E. Litan, Paul Milgrom, Roger G. Noll, Janusz Ordover, Bruce M. Owen, Michael Riordan, William Rogerson, Gregory L. Rosston, Daniel L. Rubinfeld, David Salant, Richard L. Schmalensee, Marius Schwartz, Howard Shelanski, J. Gregory Sidak, Pablo Spiller, David Teece, Michael Topper, Hal R. Varian, Leonard Waverman and Lawrence J. White.

[6] Similar proposals to enact rules enabling a market in radio spectrum have been made over the years. (DeVany et al. 1969; Minasian 1975; Webbink 1980, 1988; Kwerel & Williams 1992, 2002; White 2000; Hazlett 2001, 2003).

relative to government spectrum allocation. While Coase ultimately became convinced that market transactions would prove superior,[7] empirical observation of markets functioning with private spectrum ownership remains of keen interest.

3. GUATEMALA'S REFORM

3.1. THE 1996 STATUTE AND ITS ANTECEDENTS

Before the enactment of the 1996 *Ley General de Telecomunicaciones*,[8] private radio spectrum users were licensed under a model similar to that used by the U.S. Federal Communications Commission (FCC). One agency regulated broadcasting and allocated all frequencies below 800 MHz,[9] while an office inside Guatel, the state telephone company largely privatized in 1997, allocated all frequencies above 800 MHz. These entities zoned the radio spectrum, allotting blocks of bandwidth for particular uses patterned after the FCC's Table of Frequency Allocations. They then divvied up the blocks into individual licenses, established rules of operation, and assigned these licenses to users. Foreign nationals were not allowed to apply for a license. The licenses were awarded free of charge;[10] with demand for licenses exceeding supply, an extra-legal market arose whereby bribes and side payments rationed licenses.

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[7] Coase came to favor private property rights for spectrum based on theoretical arguments, or rather the lack thereof. This sprang from a proposal for property rights advanced by University of Chicago law student Leo Herzel (1951). Herzel's proposal was then savaged by a critic (Smythe, 1952). Coase later summarized: "[O]n reading Herzel's article I did not immediately jump to the conclusion that a market with pricing would be superior to regulation by the FCC. It was necessary to take into account the existence of transaction costs. However, my investigations… led me to believe that the problem of establishing a system of property rights… was not as difficult as one might have supposed, and they certainly made it abundantly clear to me that the Federal Communications Commission conducted its affairs in an extremely imperfect way. The question of whether pricing should be used to allocate the use of the radio frequency spectrum was, however, clinched for me by the reply to Leo Herzel's article… written by Dallas Smythe, who had been chief economist of the Federal Communications Commission. His objections were so incredibly feeble (I refer to them in my [1959] article), that I concluded that, if this was the best that could be brought against his proposal, Leo Herzel was clearly right" (Coase 1993:249).

[8] *Ley General de Telecomunicaciones*, Decreto 94-96, 14 de Noviembre de 1996 (Guatemala).

[9] This agency was officially entitled, "Dirección General de Radiodifusión y Televisión Nacional." It still exists, but its duties have been dramatically reduced. Specifically, it manages the state radio station, T.G.W., provides a register for radio announcers, coordinates radio and TV networks for official government communiqués, and oversees media content.

[10] Licensees purchased a nominal tax stamp (usually less than $40) and posted a moderately-priced bond as a performance guarantee.

The Guatemalan government granted rights to provide commercial mobile telephone service to a private company, Comcel, in 1989. This company paid a percentage of its profits to Guatel, and Guatel in turn stayed out of mobile telephony. The government granted no other parties rights to offer mobile telephone service. At the end of 1996, the number of mobile subscribers was less than 50,000. When the majority of Guatel's assets were reorganized in 1997, the firm was renamed Telgua; it was then privatized in 1998 (NERC 1999).[11] Telgua was sold to investors with a license to provide nationwide wireless phone service, initiating competition in the sector.

The *Ley General de Telecomunicaciones*, adopted in November 1996, significantly revamped Guatemala's spectrum policies. The result is perhaps the most liberal spectrum regulatory policy in the world. There are two essential features of this regime. The first is that the law establishes a presumption that radio waves are to be available for the use of those who request them, and for the purposes requested. As Pablo Spiller and Carlo Cardilli observe, "[t]he basic building block of Guatemala's approach to the spectrum is that all spectrum not currently assigned to [users]… can be requested by any person" (Spiller & Cardilli 1999). This inverts the standard, top-down administrative allocation process, where high level trade-offs between alternative uses for radio spectrum are made by government regulators.

The second key aspect is that *usufructory* rights are issued, entitling holders to exercise exclusive control over the use of the radio spectrum in question. This includes the right to change spectrum uses over time, and to subdivide and transfer rights, subject only to minimal technical limitations (designed to prevent interference), international agreements to which Guatemala is a signatory, and consistency with the general frequency allocations established by the International Telecommunications Union (ITU) for the Americas. This has the effect of delegating broad discretion to private parties in determining how radio spectrum is used, including the selection of services, technologies, and business models.

In the Guatemalan Civil Code the usufructory right carries the right to use and enjoy the property of another to the extent that such use and enjoyment does not destroy or diminish its essential substance.[12] Since electromagnetic waves are infinitely reusable and are not "destroyed or diminished" when employed, these rights are a close approximation of private property rights in

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[11] Portions of Guatel's assets, mostly wireline local exchange operations in rural areas, were not privatized and continue to operate under the name Guatel (NERC 1999).

[12] República de Guatemala. Código Civil, Libro II, De los Bienes, de la Propiedad y demás Derechos Reales, Título III, Usufructo, uso y habitación.

radio spectrum.[13] The 1996 law defines these rights as *TUFs – título de usufructo de frecuencia* – and specifically states that the *TUF* may be leased, sold, subdivided or consolidated for a limited period (fifteen years).[14] The *TUF* may be used as equity or collateral. The usufruct term can be extended for additional 15-year periods by a simple request (no payment by *TUF* owners).[15]

The distinction between a usufruct title and a standard wireless authorization is key. In other countries, wireless licenses (including those auctioned in the United States, United Kingdom, Europe, and Asia over the past decade) regulate the use of radio frequencies. Licensees are generally prohibited from redeploying frequencies from one service (or technology) to another as per economic incentives. Hence, a market for radio spectrum is excluded by regulatory restrictions. In contrast, Guatemala's reforms enable such a market to emerge.

3.2. KEY ELEMENTS OF SPECTRUM REFORM

The 1996 *Ley General de Telecomunicaciones* established foundational elements for a property regime, most (but not all) of which were subsequently implemented. First, an independent regulatory body was established, the Superintendent of Telecommunications (*SIT*). Under the previous state telecommunications monopoly, there were no private firms to regulate. The newly created body was conceived as an administrator to enforce specified rules. The broad political discretion embedded in the public interest standard was rejected in favor of specific mandates. Essentially, the *SIT* is empowered to respond to private claims for spectrum access (*TUFs*), and to adjudicate disputes over airwave rights. It may also engage in related activities, such as spectrum monitoring.

Nonetheless, the *SIT* is subject to political pressure, and this produces some consequences unanticipated in the law (see discussion in Section 7). The issue of how to shield dispute resolution from political pressures is a difficult one, with implications far beyond telecommunications policy. It is left for future research.

Second, existing commercial users were granted flexibility in the use of radio waves. These commercial users received *TUFs*, referred to as "regulated" spectrum

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[13] Ownership of spectrum itself was barred by Article 121 of the Guatemalan Constitution of 1985, which assigns the property of the radio waves to the State. The framers of the Constitution argued that the radio spectrum, along with water masses (underground or above), ocean and river shores, air space, subsurface (including minerals), natural gas and oil, was inherently scarce and, thus, "strategic." Previous Constitutions had also nationalized these resources.

[14] *Ley General de Telecomunicaciones*, Art. 58.

[15] *Ley General de Telecomunicaciones*, Art. 59. The government may refuse to renew a TUF only in the event that evidence is submitted by an accredited party that the spectrum was in no way used during the usufructory period, and "use" is not defined.

in the 1996 act. Two other general categories of users also were established. Government and amateur users received authorizations (*AUF*s), while international satellite operators received licenses. Ironically, while *TUF*s exist within "regulated" bands, they are some of the least regulated frequency bands in the world. These "regulated" bands may be employed according to market conditions so long as technical parameters associated with the *TUF* are met. The former state telecommunications monopoly, Guatel (now largely privatized under the name Telgua), was grandfathered with over 900 frequency rights, as were radio and television broadcasters and the erstwhile cellular monopolist, ComCel.

  Third, parties wishing to access frequencies are allowed to petition the *SIT* for the right to use any unoccupied bandwidth. The 1996 reform does not prohibit foreign entities from acquiring and using these frequencies. The process for providing access to spectrum is contained in Article 61 and has been implemented as follows:

(1) An interested party applies to the *SIT* for the right to use a frequency band under the terms of a *TUF*.

(2) The application is evaluated by the *SIT*, which deems it accepted, incomplete, or rejected. The *SIT* is required to answer within 3 days. Grounds for rejection include technical interference, violation of international agreements to which Guatemala is a signatory, or request of reserved or radio amateur bands. Reserved bands are for government use only.[16]

(3) If the application is accepted, public notice is issued. Parties objecting to the new use file formal complaints. Grounds for opposition are limited to technical interference and must be filed within five days of the public announcement.

(4) Complaints are adjudicated by the *SIT*, and the adjudication process cannot exceed 10 days.

(5) Other interested parties are allowed to file competing claims to requested spectrum rights.

(6) If no competing claims are filed, then the petitioner receives rights *gratis*.

(7) If competing claims are filed, the *SIT* must schedule an auction within 35 days of the close of the opposition period.[17]

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[16] The law stipulates that the government may at any moment request the SIT to transform reserved bands into regulated bands.

[17] *Ley General de Telecomunicaciones*, Art. 61.

A principal result of this law is observed in the *TUF* itself.[18] Instead of authorizing particular "radio stations," as in the U.S. license, the Guatemalan wireless operator explicitly controls the spectrum resource for a specified time period. The *TUF* is defined in a one-page form listing six basic variables:

(1)   frequency band

(2)   hours of operation

(3)   maximum power transmitted

(4)   maximum power emitted at the border of adjacent frequencies

(5)   geographic territory

(6)   duration of right (beginning and ending)

The back of the *TUF* contains spaces for endorsements, required whenever the instrument is transferred to a new owner.

Guatemala's 1996 telecommunications law also mandated elements that have been implemented less successfully. For example, the law requires the *SIT* to create a registry of all users of the communications spectrum, including government users, private holders of *TUF*s, and amateur radio operators, with the registry available to the public without charge.[19] The *SIT* is developing an online database, but it has not, as yet, been made available for public access. Interested parties may request in writing information about available spectrum bands, which the *SIT* will provide for a nominal fee.[20]

The *Ley General de Telecomunicaciones* also specifies the government's role in protecting the rights of *TUF* holders and other legal users of the spectrum. Article 53 of this law establishes the rights of *TUF* holders to file a formal complaint before the *SIT* in the event of interference caused by a third party.[21] While in most spectrum bands the dispute resolution process works effectively, the FM radio band hosts considerable "pirate radio" activity. For political reasons, however, the *SIT* has been reluctant to enforce FM band TUFs from interference, as discussed in Section 7.

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[18] A picture of the actual TUF form is found in Hazlett (2001:447).

[19] *Ley General de Telecomunicaciones*, Art. 23.

[20] The *SIT* charges 500 Quetzales, or approximately US $66.00, for this information. Pricing data provided to authors in correspondence with *SIT* representatives on November 21, 2005.

[21] *Ley General de Telecomunicaciones*, Art. 53.

4. EL SALVADOR'S REFORMS

4.1. THE 1996-97 STATUTES AND THEIR ANTECEDENTS

In 1996, El Salvador passed two significant telecommunications reform laws. One established a regulatory body, the General Superintendent of Electricity and Telecommunications (*SIGET*).[22] Another reformed telecommunications policy and privatized the state-run monopoly, Antel.[23] This law was revised approximately one year later, and the subsequent law, described herein, remains in effect.[24] Prior to the reform, wireline service was entirely controlled by Antel. The right to provide commercial mobile telephone service was granted to a private company, Telemovil, in 1991, and service was initiated in 1993. Competition in mobile telephony did not appear until after the 1996-97 statutes. Several key elements make this reform program similar to Guatemala's deregulation.

First, a wide array of license limitations were eliminated, with interference contours forming the constraints imposed on wireless operators. Second, requests to use unoccupied radio spectrum must be granted by the regulator. Hence, the regime permits market allocation of frequencies. Salvadoran property rights are not explicitly defined as privately owned, however; liberalization is achieved by a statutory provision permitting license holders full flexibility in the use of allocated frequencies. This results in a situation where, despite issuing wireless licenses similar to those in other countries, the licensee exercises broad control of assigned airwaves. The Salvadoran regime, while technically distinct from Guatemala's, yet yields a similar set of spectrum property rights.

4.2. KEY ELEMENTS OF SPECTRUM REFORM

El Salvador also established an independent regulatory body, the *SIGET*. Like the *SIT* in Guatemala, the *SIGET* in El Salvador has limited discretion. While the agency engages in spectrum monitoring and other activities to help detect and limit illegal use of the spectrum, its operations are largely passive, responding to complaints and petitions.

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[22] *Ley de Creación de la Superintendencia General de Electricidad y Telecomunicaciones (SIGET)*, Decreto Legislativo No. 808, 12 de Septiembre de 1996, Diario Oficial No. 189, Tomo 333 del 9 de Octubre de 1996 (El Salvador).

[23] *Ley de Telecomunicaciones,* Decreto Legislativo No. 807, 12 de Septiembre de 1996, Diario Oficial No. 189, Tomo 333 del 9 de Octubre de 1996 (El Salvador).

[24] *Ley de Telecomunicaciones*, Decreto Legislativo No. 142, 6 de Noviembre de 1997, Diario Oficial No. 218, Tomo 337 del 21 de Noviembre de 1997 (El Salvador).

Spectrum is divided into three general categories: official use, free use, and regulated (or commercial) use.[25] Official use refers to bandwidth reserved for government entities or set aside by international treaties. Parties must receive an authorization to use this spectrum. A small amount of spectrum is dedicated for "free" use by the public, although *SIGET* may require users to be licensed. As in Guatemala, the most liberal rules apply to "regulated" bands, which is where commercial services (such as mobile telephony) are provided. Parties operating in these bands received concessions. Existing commercial users rights were grandfathered.

New users of spectrum are accommodated much as in Guatemala. Interested parties, including foreigners, can petition the *SIGET* to receive a concession. The adjudication process is found in Articles 76-85 of the 1997 law:

(1) An interested party may petition the *SIGET* for the right to a concession.

(2) The *SIGET* must consider the application. Grounds for rejecting a petition are specific and limited, including: The spectrum is granted to another party and there is no compatibility in use. The spectrum requested does not require a concession for use (e.g., free use spectrum). The requesting party has an outstanding sanction related to the existing telecom law. The requesting party is not eligible to receive a concession under the existing law.

(3) Upon receipt of a request for concession, the *SIGET* must publish this request, and other parties have 20 days to respond.

(4) Opposing parties must receive a hearing within 10 days of their response.

(5) During the response period, *SIGET*'s Manager of Telecommunications must produce a technical evaluation of the request.

(6) In the event the Manager of Telecommunications provides a favorable report and there are no parties opposing the request, the concession is granted as requested. If the Manager of Telecommunications provides a favorable report and there are additional spectrum claimants, the *SIGET* must hold an auction within 60 days.[26]

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[25] *Ley de Telecomunicaciones*, Art. 12.

[26] *Ley de Telecomunicaciones*, Art. 76-85.

In contrast to Guatemala, in El Salvador all parties receiving a concession must pay an annual fee for use. The fee is based on the spectrum band in question, the amount of spectrum used, etc.[27] Further, El Salvador's telecommunications law does not require a spectrum registry. In either country, public agencies (and the regulatory agency itself) retain some power to reserve particular airwave rights for governmental use. This is not inconsistent with a general property regime, provided that the scope of such authority is limited, which it is due to the statutory reforms endowing non-governmental parties with explicit rights.

5. ADMINISTRATIVE RESULTS

5.1. GUATEMALA

Despite political pressures to protect incumbent interests in Guatemala, including government efforts to delay competition in mobile telephone markets while Guatel was being privatized (new entry would reduce bids for state assets), requested *TUF*s have generally been issued. All told, 3,985 *TUF*s have been awarded since the beginning of the reform process through June 2005, along with approximately 1,000 licenses for satellite and other uses, and 880 authorizations for government and amateur users. See Table 5.1 and Figure 5.1. Of the 3,985 *TUF*s issued following reform, 930 went directly to the former state telecommunications monopoly, 918 went directly to other incumbents, and 2,137 were awarded by auction.

Table 5.1. Spectrum Rights Issued by Guatemalan Government

Type of Right	TUFs (Frequency Use Titles)	Authorizations	Licenses
Approximate Number of Rights Issued	3,985	290 (government) 590 (amateurs)	1,000

Sources: Escalante (2005). Also, email correspondence with Mr. Escalante on July 6, 2005 and Sept. 12, 2005.

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[27] *Ley de Telecomunicaciones*, Art. 13. The fee is a base rate multiplied by the bandwidth, multiplied by a measure of the transmission power, multiplied by a service factor (based on location within the spectrum band).

Figure 5.1: TUFs Issued in Guatemala
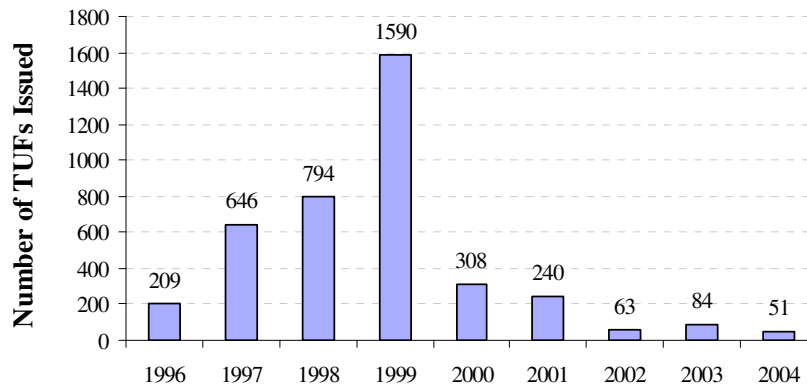
Source: Escalante (2005).

5.2. EL SALVADOR

Since its 1997 reform, El Salvador has granted 1,311 concessions, 80 authorizations, and 56 licenses. See Table 5.2. Of the 1,311 concessions granted, 152 were assigned via auctions.[28] The number of concessions in El Salvador is considerably smaller than the number of *TUF*s in Guatemala, though this is largely explained by the Salvadoran regulator's practice of grouping many frequencies into a single concession. For example, the 152 concessions that have been auctioned in El Salvador represent 564 distinct frequency bands. A single concession may grant rights to use several megahertz in the 800 MHz band, several megahertz in the 900 MHz band, etc. As a result, direct comparisons with other countries can be misleading. But, as demonstrated in Section 6, sufficient spectrum is available for the most highly valued services. Moreover, as in Guatemala, the issuance of licenses has proceeded without evident administrative confusion or corruption. This is despite an exceptionally large shift in the law and a dramatic transformation in the nature of the rights being issued.

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[28] Data provided to authors by SIGET representatives in email correspondence on September 14, 2005. Much of this data also is available on the agency's website under the title "Registro de Electricidad y Telecomunicaciones," at www.siget.gob.sv.

Table 5.2. Spectrum Rights Issued by Salvadoran Government

Type of Right	Concessions	Authorizations	Licenses
Approximate Number of Rights Issued	1,311	80	56

Source: Registry of the Superintendencia de Electricidad y Telecomunicaciones (SIGET), available at www.siget.gob.sv. Also, email correspondence with authors on August 29, 2005.

6. ECONOMIC RESULTS

6.1. HYPOTHESES

Spectrum is an input into the production of all wireless services. As such, the regulatory model used to allocate spectrum may yield significant consumer welfare implications. The analysis presented here concentrates on wireless telephone service, as this is the dominant market in terms of economic benefit,[29] and radio spectrum has considerable value at the margin (Hazlett and Muñoz 2004). Moreover, the regimes we are attempting to study were instituted in 1996 and 1997, just as mobile telephone service was beginning to emerge as an important, mass consumer market throughout Latin America (and elsewhere). This affords an opportunity to observe the results of policy changes in terms of their effects on consumers.

   We do not systematically examine the broadcasting industry. While Guatemala and El Salvador grant rights to broadcast frequencies that, in a technical sense, more closely resemble private property rights than in other countries, spectrum reforms have – as a practical matter – been largely confined to common carrier communications. This reflects a standard pattern in spectrum policy. In the United States, for instance, the intense political interest in broadcast media has been shown to drive non-market allocation methods (Hazlett 1998).

   Our general hypothesis is that, as compared to other countries in Latin America, the liberal radio spectrum allocation reforms in Guatemala and El Salvador increase the surplus that consumers gain from the use of mobile telephones. Specifically, we wish to test the propositions that liberally extending exclusive property rights to radio spectrum has resulted in:

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[29] Ofcom, the UK radio spectrum regulatory authority, produces estimates of the social value of wireless services by sector. These estimates place mobile telephone service as the most valuable sector, with broadcasting in second place. Both are well ahead of other categories. This ranking is likely to be skewed even more in the direction of mobile telephony in developing countries. (Ofcom 2005, Waverman et al. 2005)

    (1)   an increase in the spectrum available to mobile carriers,

    (2)   more intense competition between mobile carriers.

These policy outcomes will, if in evidence, imply output market results in the liberalized spectrum regimes, including

    (1)   lower retail prices for mobile phone service; and

    (2)   an increase in mobile phone service output.[30]

We note that propositions (3) and (4) are largely cross-checks on the more direct implications of liberalization, (1) and (2). That is because reforms that produce more generous resource inputs and greater competitiveness will, by microeconomic theory, produce consumer welfare gains. We also note, as above, that the issue of transactional efficiency is embedded in these predictions, as reforms that increased uncertainty over property rights or otherwise limited productive activities would lower consumer welfare gains as evidenced by lower prices and higher outputs.

The predicted increase in consumer welfare from radio spectrum liberalization stems from the logic put forward in Coase (1959), namely that decentralized decisions by spectrum owners will produce superior economic outcomes to administrative allocations. This is further developed in Hazlett & Muñoz (2004), which considers bandwidth as an input into the production of mobile phone services. Incremental bandwidth lowers the opportunity cost of delivering a phone call, ceteris paribus. In addition, given that capital (network infrastructure) and spectrum can be used as substitutes, incremental bandwidth in the market lowers fixed costs for entrants, potentially intensifying competition. Either effect tends to increase efficiency.

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[30] The opportunity cost of radio spectrum would be an issue if spectrum were fully employed. In fact, radio spectrum is characterized by widespread under-employment. See Hazlett (2001). The bandwidth variations observed in this study of wireless telephony do not displace alternative services of non-trivial value. It should also be noted that the assignment of liberal property rights does not lock-in spectrum to given applications. Since frequency rights holders are free to deploy other services, opportunity costs are internalized by mobile carriers. While excluded from our empirical inquiry, this tends to bias results against liberalization.

6.2. TEST METHODOLOGY

Our sample consists of 16 Latin American mobile phone markets,[31] with annual data from 2000 to 2004, yielding 80 observations.[32] We use three sets of regression models to examine propositions (1)–(4). The first set contains four standard OLS regressions (1.1)–(1.4). In each of them, the dependent variable of interest is regressed against country characteristics (per capita income, population, density, and a general "economic freedom" index) and the *Liberal* dummy, set to one for Guatemala or El Salvador, and zero otherwise. A different dependent variable is used to test each of the four propositions. Dependent and independent variables are listed in Table 6.1 and Table 6.2 respectively. All four of the regressions in the first set are structured in log-linear form since quantile-against-quantile plots show that this improves the relationship between the dependent and independent variables. Looking at the same plots, a squared density variable is also included and observed to increase R-squared. Generically, the estimated regressions are defined as:

$$\ln y_i = \beta_0 + \beta_1 \ln GDPPC_i + \beta_2 \ln Population_i + \beta_3 \ln Fraser_i + \beta_4 \ln Density_i + \beta_5 (\ln Density_i)^2 + \beta_6 Liberal_i + \varepsilon_i$$

Estimated parameters from regressions (1.1)–(1.4) indicate that liberal spectrum policies are positively related to increased spectrum deployment by mobile carriers and to increased competition (lower industry concentration) among them. Spectrum liberalization is also positively related to output in the mobile telephony sector (minutes of use) and with lower retail prices. All of these effects are statistically significant. Results are provided in Appendix 2.

However, the disturbances from three out of the four regressions are found to be heteroskedastic.[33] One method of addressing this, weighted OLS,[34] fails

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[31] Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, Venezuela. Costa Rica has a government monopoly mobile phone supplier, making pricing data problematic to interpret, and is thus excluded. The Caribbean nations also are excluded.

[32] Data sources are detailed in Appendix 1.

[33] Using White's test, the null hypothesis of homoskedasticity could be rejected for all four regressions but one. For the outlier (that with the dependent variable $\frac{MOU}{GDPPC}$), the supplementary Breusch-Pagan/Cook-Weisberg test shows that homoskedasticity can be rejected at the 10% significance level. White's test results are included in Appendix 2.

[34] We thank an anonymous referee for suggesting the weighted OLS method in Acton & Vogelsang (1992).

to solve the heteroskedasticity problem. Averaging, another option, is potentially useful because country-specific observations in the sample are taken from five consecutive years. These observations, not independent at the country level, may generate heteroskedastic disturbances. To test for this, a second set of four OLS regressions, (2.1)–(2.4), averages values for the dependent and independent variables (defined in Tables 6.1 and 6.2) over time for each country. Otherwise the structural forms of the regressions are the same as above. Averaging reduces sample size from 80 to 16.

Table 6.1: Dependent Variables Used in the Pooled OLS Regressions

Variable	Explanation
$\dfrac{Spectrum}{GDPPC}$	Spectrum deployed by cellular carriers in MHz per \$ thousand GDP per capita.
HHI	Hirschman-Herfindahl Index in cellular market based on carrier subscribership levels.
ARPM	Average revenue per minute of mobile telephone service (including pre-paid and post-paid subscribers).
$\dfrac{MOU}{GDPPC}$	Minutes of use for voice mobile telephone service, per \$ thousand GDP per capita. Reported as a blend of pre-paid and post-paid use, and then adjusted for overall population.

Table 6.2: Independent Variables Used in Pooled OLS Regressions

Variable	Explanation
GDPPC	Per-capita GDP, by country, PPP adjusted and in thousand 2000 international \$.
Population	In millions.
Fraser	An index value, 1-10, measures the general security of property rights.

Density	Population density of a country (in terms of number of people per square kilometer).
Liberal	=1 if Guatemala or El Salvador, =0 otherwise.

The second set of regression results (2.1–2.4) are consistent with those derived from the first, although the output and price effects of liberalization are statistically significant at the 10%, but not the 5% level, perhaps owing to the decline in degrees of freedom (see Appendix 2). The White and Breusch-Pagan/Cook-Weisberg tests, however, reveal that with country-level averaging, the null hypothesis of homoskedasticity cannot be rejected in any of the four regressions (see Appendix 2).

Our primary statistical results are derived from a third set of estimated equations. This set consists of four random effects regressions, (3.1)–(3.4), examining propositions (1)–(4).[35] The dependent variables remain as defined in Table 6.1. In each model, the dependent variable of interest is regressed onto the *Liberal* dummy, set to one for Guatemala or El Salvador, zero otherwise. The individual heterogeneities are defined and clustered[36] at the country level to indicate that country-level observations are not independent from each other. Also, the standard errors are heteroskedasticity robust.

The random effects approach helps to fully capture the effects of country characteristics and therefore isolate the implications of the value changes in the *Liberal* dummy. In the previous regressions, (1.1)–(1.4) and (2.1)–(2.4), we tried to explain the country heterogeneities with the set of variables presented in Table 6.2, excluding *Liberal*. However, the Breusch-Pagan/Lagrange Multiplier tests show that these explanatory variables are far from being sufficient to characterize country heterogeneities. (The null hypothesis that the residual variance of the country-specific disturbances are zero can be rejected with a test statistic of 156.62, which is distributed as chi-squared with one degree of freedom: p-value=0.000, when the dependent variable is $\ln \frac{Spectrum}{GDPPC}$). Therefore, the subsequent section reports the results from the random effects regressions (3.1)–(3.4) in detail. The Breusch-Pagan/Lagrange Multiplier test results for all of the third set regressions (3.1)–(3.4) are again provided in Appendix 2.

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[35] It should be noted that a fixed effects approach is not appropriate given that there exists no variation in the spectrum allocation regimes in Guatemala and El Salvador from 2000 to 2004.

[36] See Froot (1989) and Rogers (1993).

6.3. RESULTS

6.3.1. Spectrum

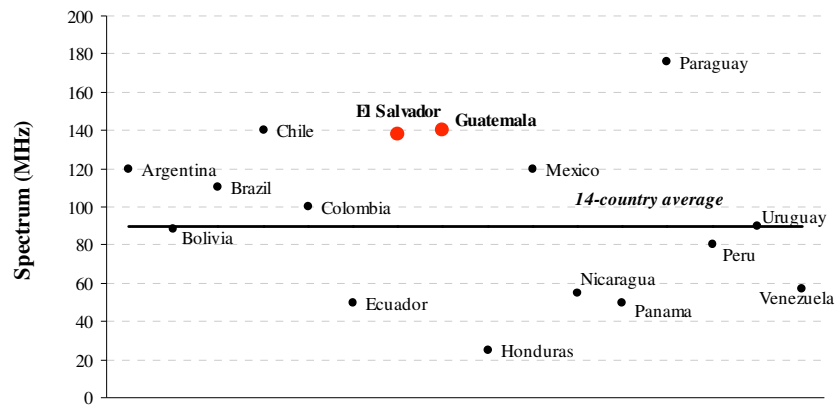**Figure 6.1: Radio Spectrum Deployment (in MHz)**

Figure 6.1 shows the spectrum deployment (in MHz) in the 16 Latin American countries constituting our sample. The 14-country average, excluding Guatemala and El Salvador, is 90.03 MHz. Guatemala and El Salvador are well above this average with spectrum deployments of 140 and 137.87 MHz, respectively. We cannot directly use a random effects regression model to test the effects of the spectrum liberalization in Guatemala and El Salvador on spectrum deployment because spectrum takes integer values in 65 out of the 80 observations. However, a two-sided Wilcoxon rank-sum test shows that the spectrum increase from the 14 countries to Guatemala and El Salvador is statistically significant (z=3.8320; p=0.0001).

As an alternative econometric approach, we divide the spectrum deployed in each country in the sample with GDP per capita (PPP adjusted and in constant 2000 international $), and then regress the normalized spectrum onto the *Liberal* dummy. This normalization gives more explanatory power to the *Liberal* independent variable and is reasonable, considering the positive correlation between spectrum and GDP per capita, as seen in Figure 6.2.

Figure 6.2: Log Spectrum Deployment (in MHz) versus Log GDP ($/capita)
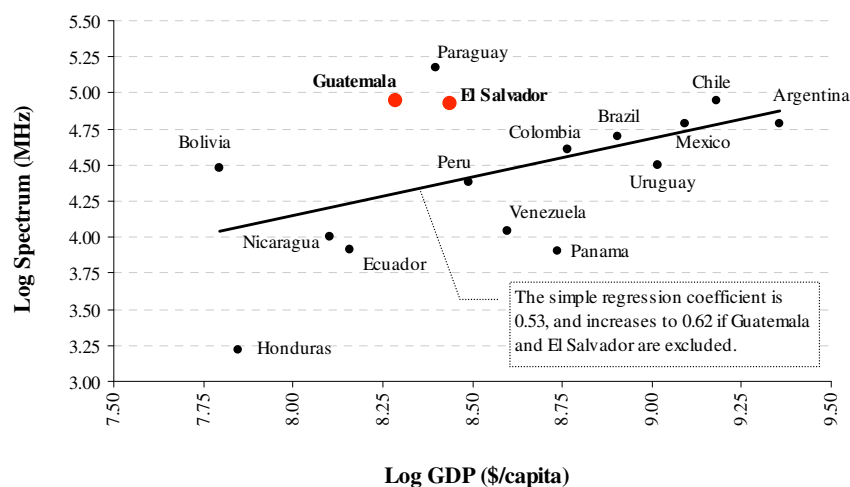
After normalizing spectrum on per capita GDP, we use the following regression model to examine the effects associated with the spectrum liberalization policies in Guatemala and El Salvador:

$$\ln(\frac{Spectrum}{GDPPC})_{ij} = \beta_1 \times Liberal + (\alpha + \mu_i) + \varepsilon_{ij},$$

$$i = 1,...,16 \quad j = 2000,...,2004 ,$$

where $(\frac{Spectrum}{GDPPC})_{ij}$ is defined to be the total radio spectrum (in MHz) available to mobile operators divided by per capita GDP (in $thousands/capita) in the ith country and in the jth year; μ_i represents the country-specific disturbances; ε_{ij} indicates the observation-specific disturbances. We initially run the regression on the complete 16-country sample, and then distinguish the effects of liberalization in Guatemala and El Salvador individually by excluding first El Salvador and then Guatemala from the sample. Table 6.3.1 contains regression results.

Table 6.3.1: Liberalization and Radio Spectrum (MHz)

Dep. Var: $\ln(\dfrac{Spectrum}{GDPPC})$	I Dummy (Guatemala + El Salvador)		II Dummy excluding El Salvador		III Dummy excluding Guatemala	
Liberalization **Coefficient**		**.7852**		**.8697**		**.7007**
(Std. Dev.)		(.1368)		(.1222)		(.1222)
z		5.74		7.12		5.73
[95% Conf. Interval]	[.5171	1.0533]	[.6302	1.1093]	[.4612	.9402]
Constant **Coefficient**		**2.6935**		**2.6935**		**2.6935**
(Std. Dev.)		(.1219)		(.1222)		(.1222)
z		22.10		22.04		22.04
[95% Conf. Interval]	[2.4546	2.9324]	[2.4540	2.9331]	[2.4540	2.9331]

We find the coefficient for *Liberal* to be statistically significant in all three regressions. Spectrum liberalization on average increases the bandwidth available to mobile networks by 16.02 MHz per $thousand GDP per capita, about double the mean allocation of 16.51. Figure 6.3 displays the allocated spectrum per $thousand GDP per capita for each country in the sample.[37] Coupled with the results from the second set of regressions (2.1-2.4), the evidence then supports the hypothesis that liberal property rules are associated with greater bandwidth being made available to the marketplace.

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[37] Given the reforms in our liberal sample, we measure spectrum allocated for mobile telecommunications as the bandwidth available to wireless phone carriers. In Guatemala, where no use-specific licenses are issued, this allows us to count the frequency space in the TUFs held by wireless operators.

Figure 6.3: Radio Spectrum Deployment per $ thousand GDP per capita
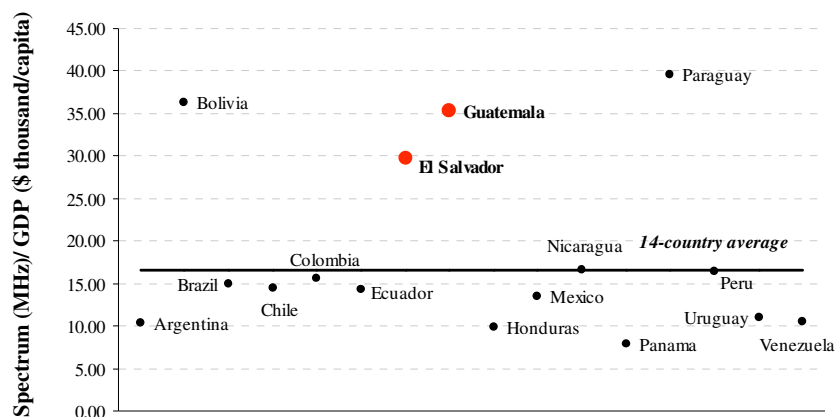
6.3.2. Competition

To evaluate the competitive effects of liberalization, we calculate Herfindahl-Hirschman indices (HHI) computed from shares of mobile telephone revenues. A decrease in HHI is here associated with an increase in competition. We use the following random effects regression model to investigate the effects of liberalization on HHI:

$$\ln(HHI)_{ij} = \beta_1 \times Liberal + (\alpha + \mu_i) + \varepsilon_{ij},$$

$$i = 1,...,16 \quad j = 2000,...,2004 .$$

We estimate the regression first on the full sample; then again, excluding El Salvador; and then once more, including El Salvador but excluding Guatemala. The results, contained in Table 6.3.2, show that the coefficient for *Liberal* is negative and statistically significant in all three cases. Figure 6.4 shows the HHI values for each country in the sample, as well as the 14-country average. Liberalization decreases the HHI, on average, from 4892 to 3381.

Table 6.3.2: Liberalization and HHI

Dep. Var.: ln(*HHI*)	I Dummy (Guatemala + El Salvador)		II Dummy excluding El Salvador		III Dummy excluding Guatemala	
Liberalization						
Coefficient	**-.3045**		**-.2904**		**-.3186**	
(Std. Dev.)	(.0895)		(.0891)		(.0891)	
z	-3.40		-3.26		-3.58	
[95% Conf. Interval]	[-.4798	-.1291]	[-.4650	-.1157]	[-.4932	-.1440]
Constant						
Coefficient	**8.4282**		**8.4282**		**8.4282**	
(Std. Dev.)	(.0889)		(.0891)		(.0891)	
z	94.85		94.60		94.60	
[95% Conf. Interval]	[8.2540	8.6024]	[8.2536	8.6028]	[8.2536	8.6028]

Figure 6.4: Herfindahl-Hirschman Index (HHI)
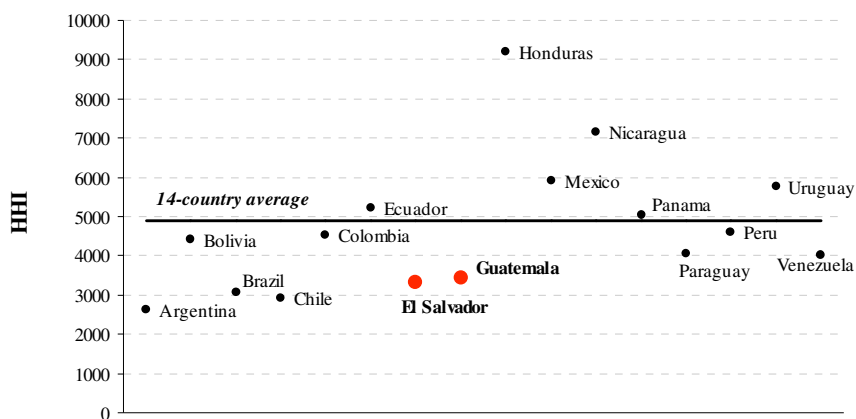
6.3.3. Price

We use the average revenue per minute (ARPM) as a proxy for retail price.[38] The ARPM measure helps simplify the complications associated with non-linear pricing, commonly used in mobile telephone markets. Looking at Figure 6.5, we can see that the ARPM in Guatemala is below the 14-country Latin American average whereas El Salvador's ARPM is slightly above average.

Figure 6.5: Average Revenue Per Minute (ARPM)
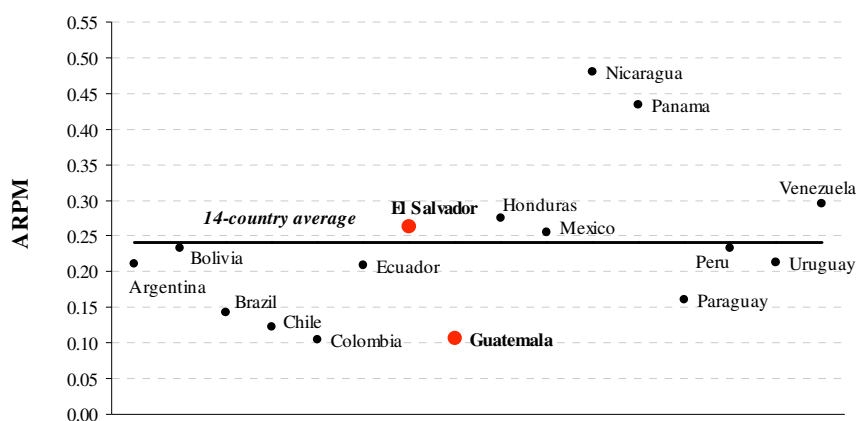
The random effects regression model is provided below and Table 6.3.3 contains the results.

$$\ln(ARPM)_{ij} = \beta_1 \times Liberal + (\alpha + \mu_i) + \varepsilon_{ij},$$
$$i = 1,...,16 \quad j = 2000,...,2004 .$$

When ARPM is regressed against the *Liberal* dummy using the full 16-country sample, liberalization in Guatemala and El Salvador is associated with a decrease in ARPM, but the decrease is not statistically significant. Excluding El Salvador from the sample, ARPM decreases by about 56% with the liberalization in Guatemala, and the effect is statistically significant. The same regression, when including El Salvador but excluding Guatemala, indicates that

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[38] The data used here report average revenues per month per subscriber for mobile voice service and exclude revenues for other services, such as text messaging, email, video, and gaming. We divide these figures by the minutes of use per month per subscriber to obtain the average revenues per minute.

ARPM increases with liberalization in El Salvador, but by a statistically insignificant magnitude.

Table 6.3.3: Liberalization and Average Revenue per Minute

| Dep. Var.: $\ln(ARPM)$	I Dummy (Guatemala + El Salvador)	II Dummy excluding El Salvador	III Dummy excluding Guatemala
Liberalization **Coefficient** (Std. Dev.) z [95% Conf. Interval]	-.2545 (.3551) -0.72 [-.9504 .4414]	-.7104 (.1178) -6.03 [-.9413, -.4794]	.2013 (.1178) 1.71 [-.0296, .4323]
Constant **Coefficient** (Std. Dev.) z [95% Conf. Interval]	-1.5417 (.1175) -13.12 [-1.7721 -1.3114]	-1.5417 (.1178) -13.08 [-1.7727 -1.3108]	-1.5417 (.1178) -13.08 [-1.7727 -1.3108]

6.3.4. Output

We define the output of the mobile telephone market as the total minutes of mobile phone use in a month (MOU) per person.[39] Figure 6.6 shows the MOU per person for 16 Latin American countries together with the 14-country average excluding Guatemala and El Salvador. Guatemala is above and El Salvador is below the 14-country average.
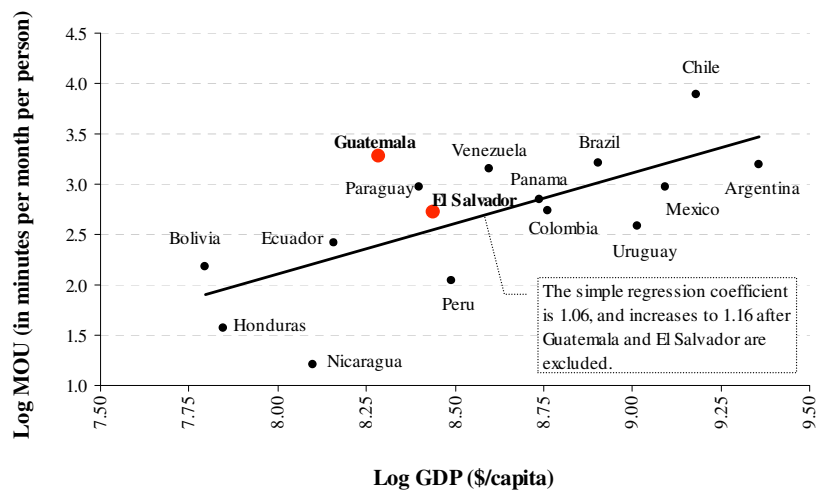
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[39] This is not MOU per subscriber, but per capita.

Figure 6.6: Minutes of Use (MOU) per person
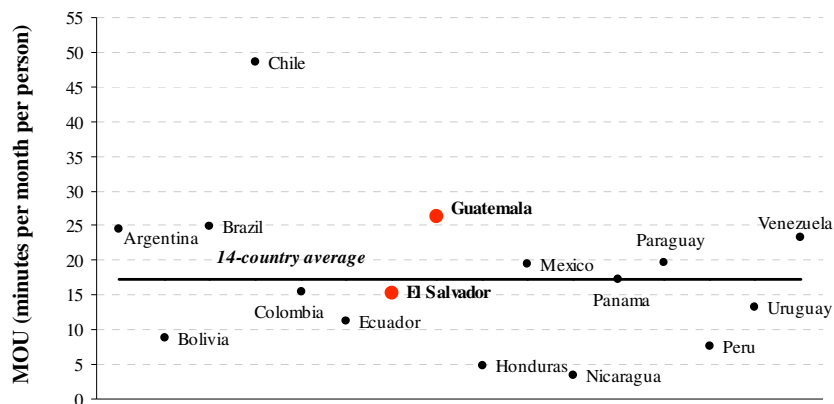
As Figure 6.7 demonstrates, however, there is a positive correlation between the MOU per person and GDP per capita.

Figure 6.7: Log Minutes of Use (minutes/person) versus Log GDP ($/capita)

Therefore, dividing the MOU per person by GDP per capita, we can see in Figure 6.8 that Guatemala is significantly and El Salvador is slightly above the 14-country average.

Figure 6.8: Minutes of Use (MOU) per person per $ thousand GDP per capita
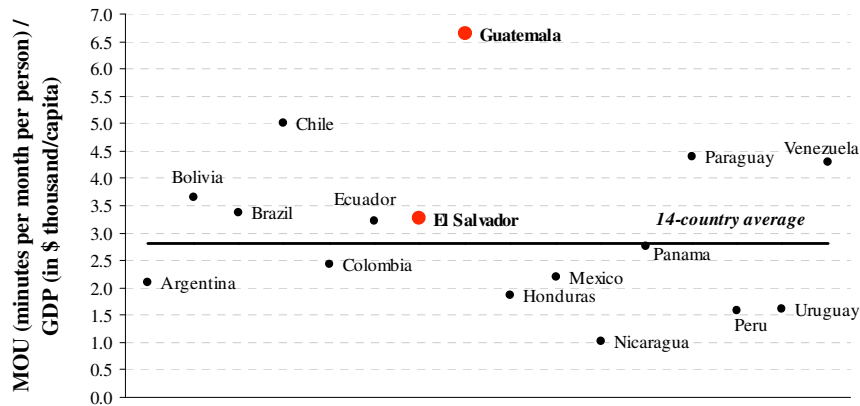
In estimates using the random effects regression model, radio spectrum liberalization in Guatemala and El Salvador is associated with an increase in the minutes of use (per person per $thousand GDP per capita), and the effect is statistically significant. The model is specified here, with results in Table 6.3.4:

$$\ln(\frac{MOU}{GDPPC})_{ij} = \beta_1 \times Liberal + (\alpha + \mu_i) + \varepsilon_{ij},$$
$$i = 1,...,16 \qquad j = 2000,...,2004.$$

Table 6.3.4: Liberalization and Minutes of Use

Dep. Var.: $\ln(\dfrac{MOU}{GDPPC})$	I Dummy (Guatemala + El Salvador)	II Dummy excluding El Salvador	III Dummy excluding Guatemala
Liberal			
Coefficient	**.6241**	**.9570**	**.2913**
(Std. Dev.)	(.2771)	(.1304)	(.1304)
z	2.25	7.34	2.23
[95% Conf. Interval]	[.0810 1.1672]	[.7014 1.2127]	[.0356 5469]
Constant			
Coefficient	**.8841**	**.8841**	**.8841**
(Std. Dev.)	(.1301)	(.1304)	(.1304)
z	6.80	6.78	6.78
[95% Conf. Interval]	[.6291 1.1390]	[.6284 1.1397]	[.6284 1.1397]

6.3.5. *Summary of Empirical Tests*

The empirical evidence gleaned from mobile telephone markets, while preliminary, broadly supports the Coasean conjecture that decentralized property rights were relatively efficient mechanisms for policing spectrum resource use. As summarized in Table 6.4, the liberalization dummy and dummies for each of the two countries individually are associated with more bandwidth being made available to market participants, and with a higher degree of competitiveness among mobile phone carriers, all of which are statistically significant. Retail prices appear lower for the combined dummy sample than elsewhere in Latin America, yet the difference is statistically insignificant except in the Guatemalan decrease. With respect to output, both liberal regimes are separately and jointly associated with statistically significant increases in mobile usage. Hence, the dominant pattern observed in these data is consistent with at least three and a half of the four empirical hypotheses.

Table 6.4. Summary of Econometric Results

Dependent Variable	Predicted Sign for *Liberal* Dummy	I Dummy (Guatemala + El Salvador)		II Dummy excluding El Salvador		III Dummy excluding Guatemala	
		Actual Sign for *Liberal* Dummy	Statistical Signif. (Y/N)	Actual Sign for *Liberal* Dummy	Statistical Signif. (Y/N)	Actual Sign for *Liberal* Dummy	Statistical Signif. (Y/N)
$\ln(\frac{Spectrum}{GDP})$	+	+	Y	+	Y	+	Y
$\ln(HHI)$	-	-	Y	-	Y	-	Y
$\ln(ARPM)$	-	-	N	-	Y	+	N
$\ln(\frac{MOU}{GDP})$	+	+	Y	+	Y	+	Y

7. TRANSACTION COSTS

With any policy reform, the possibility arises that transitional difficulties will dominate gains. This prospect is particularly important in wireless telecommunications for two reasons. First, the centralized spectrum allocation regime has been historically supported with arguments concerning the transactions costs of private ownership. Second, global markets for manufactured wireless equipment (handsets, base stations, and other cellular network infrastructure) exhibit pronounced economies of scale. Such economies may fundamentally impact the success of policy reforms, although it is not clear in which direction.[40] In any event, we here examine how the costs of allocating radio spectrum appear to be impacted, in both the private and public sectors, under the liberal spectrum regimes being evaluated.

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[40] Global standards may facilitate experimentation with liberal regimes in small economies, providing private market coordination without government regulation. Alternatively, small markets may not capture many of the advantages of free entry (due to liberalization) because scale economies are not available.

7.1. PRIVATE SECTOR

7.1.1. Guatemala

It has been shown that liberal regimes are relatively successful in assigning wireless property rights, and that liberalized mobile phone markets demonstrate a high degree of efficiency relative to other Latin American markets. These findings imply that transactions costs are not offsetting social gains. Here we focus on the issue of radio interference. The inability of private property rules to adequately police spectrum use, leading to a tragedy of the commons outcome, has traditionally been a stated concern of regulators.

In Guatemala, *TUF* holders may file a formal complaint to the *SIT*, accompanied by a technical report produced by an accredited expert, in response to radio interference.[41] The *SIT* then informs the party alleged to be creating the reported conflicts, with that party given ten days to file its own expert technical report. Following this reply, the *SIT* must issue a decision within ten days. If the accused has violated *TUF* rights, the party must cease the interfering activities and pay any fines imposed by the *SIT*, which range from $10,000 to $100,000,[42] within five days.[43]

Within the mobile telephony sector, there have been almost no problems with interference. For example, the largest mobile telephony provider, Telgua, reports little difficulty in coordinating use with other *TUF* holders and has encountered virtually no illegal use of their frequencies. On one occasion, however, Telgua was the cause of interference when, after the 1996 reform, it continued to use a point-to-point transmitter in a band for which it did not have a *TUF*. The *SIT* issued a $50,000 fine; Telgua paid the fine and ceased operations in the band.[44]

This episode illustrates how the resolution process is designed to work. The band that Telgua used illegally was reserved for governmental use. In 1999, the U.S. government intended to use these frequencies in conjunction with security during a visit by then-president Bill Clinton. Testing the band prior to the official event, U.S. authorities experienced interference and complained to the *SIT*, which promptly investigated and enjoined Telgua.

As elsewhere, broadcast spectrum in Guatemala receives special treatment. The relevant regulations were largely established in the Radio Communications

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[41] *Ley General de Telecomunicaciones*, Art. 53.

[42] *Ley General de Telecomunicaciones*, Art. 81.

[43] *Ley General de Telecomunicaciones*, Art. 84.

[44] Interview with Belisario Montepeque, Chief Counsel, Telgua. Guatemala City (June 8, 2005).

Law of 1966.[45] This law established the General Directorate for Broadcasting, which allocated spectrum until the telecommunications reform in 1996, and which was managed by the Guatemalan military. The General Directorate for Broadcasting was retained following the Telecommunications Law of 1996, although it now shares responsibility for spectrum regulation with the *SIT* and the Ministerio Público (Ministry of Justice).[46]

From 1997 to mid-2005, the *SIT* reports that it has received a total of 217 formal complaints of interference (Escalante 2005). See Figure 7.1. Of these, 181 cases (84 percent) pertain to the VHF band, and 158 of these (72.8 percent of all interference complaints) pertain to the FM radio bands. With the exception of only seven cases, the remaining interference complaints pertain to use of the UHF bands (29 complaints) (Escalante 2005). Not only are the reported cases concentrated in the FM radio band, some *TUF* holders with FM frequencies claim that the post-2002 decrease in the number of *SIT* complaints is a result of their lack of faith in the government's commitment to rights enforcement (Liu 2005).

Figure 7.1: Interference Complaints in Guatemala
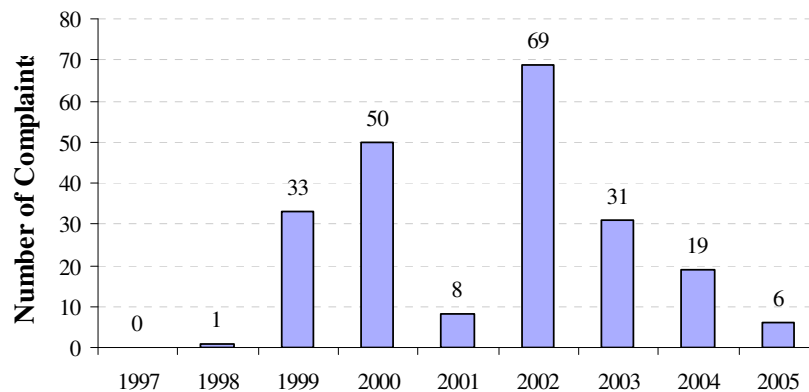
Source: Escalante (2005)

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[45] *Ley de Radiocomunicaciones*, Decreto-Ley Número 433, March 10, 1966.

[46] The Ministerio Público in Guatemala is the administrative home of prosecutors serving at the national level and includes the Procuraduría General, approximately equivalent to the U.S. Attorney General. In this sense, the Ministerio Público is similar to the U.S. Department of Justice.

According to the Guatemalan broadcasting trade association, illegal use of FM channels is widespread but is generally tolerated by the authorities.[47] Many of the illegal stations have been affiliated with religious organizations, including evangelical Christian churches. In early 2003, the Guatemalan National Radio Broadcast Chamber waged a media campaign against the "pirates" and filed a lawsuit demanding that 341 unauthorized stations be closed by the government for operating illegally.[48]

In 2004, the Ministerio Público announced that it intended to prosecute illegal users of spectrum; some unauthorized users responded by suing the government for the violation of their constitutional rights to private property and freedom of expression.[49] These arguments were accepted by some lower courts, but the highest court in Guatemala, the Corte de Constitucionalidad, heard two of these cases and overturned both, freeing the Ministerio Público to shut down users not possessing *TUFs*.[50] The decisions support property rights holders, even as many illegal users continue to operate.

Weak property rights enforcement is suggested by the highly political nature of broadcast content. Whereas standard regimes vest great discretion in regulators, and allow policy makers to thereby engage in rent-seeking via "public interest" spectrum allocations, Guatemalan law formally constrains regulators. This tends to lessen support for the standard pro-incumbent policies exhibited.

7.2. EL SALVADOR

In El Salvador, the process for resolving interference is not as well-defined as it is in Guatemala.[51] The 1997 law does not specify how rights holders may bring a complaint against illegal encroachment. However, the Act does establish the

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[47] Unless otherwise cited, the information pertaining to the Guatemalan broadcasting industry is based on an interview with Mario F. Valderramos, President, Guatemalan Chamber of Broadcasters, Guatemala City (June 1, 2005).

[48] "Community Radio Asks for Solidarity," (5/5/03); *http://www.fhrg.org/news/ghrc_march_2003.html*.

[49] See, Ref. Amparo 1377-2004, Juzgado de Primera Instancia Penal, Narcoactividad y Delitos contra el Ambiente, Coban, Alta Verapaz. January 31, 2005. This case involved a community radio station, Radio Libre, operating illegally at 90.7 FM. See also, Ref. Amparo 1376-2004, Juzgado de Primera Instancia Penal, Narcoactividad y Delitos contra el Ambiente, Coban, Alta Verapaz. January 31, 2005. This case involved another community radio station, Stereo Tiempo, operating illegally at 98.3 FM.

[50] See, Expediente No. 1987-2004, Corte de Constitucionalidad, Republica de Guatemala (Nov. 12, 2004). See also, Expediente No. 1664-2004, Corte de Constitucionalidad, Republica de Guatemala (March 27, 2005).

[51] See Art. 76-82.

SIGET's authority to regulate spectrum,[52] and specifies "less serious," "serious" and "very serious" violations.[53] The use of "regulated" (i.e., commercial) or official spectrum bands without the relevant authorization is considered a "serious" infraction, with substantial fines assessed on a per-day (of violation) basis.

As in Guatemala, El Salvador experiences little or no illegal interference problems involving mobile telephony. Moreover, *SIGET* reports that illegal use of spectrum is rare in all bands.[54] The lack of illegal use in the broadcasting bands is corroborated by representatives from that industry.[55] This contrasts with the pre-democracy period. In a peace accord signed in 1990, guerrillas were given licenses to frequencies that they previously had used illegally. In subsequent years, some illegal broadcast users again emerged.

7.3. PUBLIC SECTOR

To investigate whether transaction costs incurred in the public sector are substantially increased due to spectrum reforms, we use telecom regulatory agency personnel levels as a cost proxy. Hence, we test the prediction that Guatemala and El Salvador have significantly greater spectrum agency workers than other countries, adjusting for GDP. These data are available as per World Bank surveys (Wallsten et al., 2004).

A scatter diagram is plotted in Fig. 7.2. Guatemala and El Salvador have fewer regulatory employees per GDP size than other countries for which data are available in the survey (these countries extend beyond Latin America). This simple analysis suggests that transaction costs in the public sector are not increased by the switch to a liberal spectrum regime. This supports the evidence presented above, consistent with the view that the administrative process of rights definition has – with an interesting exception in the case of Guatemala's governmental support for illegal FM radio broadcasters – worked relatively smoothly under liberal spectrum reforms in Guatemala and El Salvador.

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[52] *Ley de Telecomunicaciones y su Reglamento*, Art. 50.

[53] *Ley de Telecomunicaciones y su Reglamento*, Art. 33.

[54] Interview with Victor Artiga, Director of Telecommunications, SIGET, in San Salvador, El Salvador (Feb. 7, 2005).

[55] Interview with Ana Maria Urrutia de Lara, Executive Director, Broadcasters Association, San Salvador, El Salvador (Feb. 7, 2005).

Figure 7.2: Number of Regulators vs. GDP
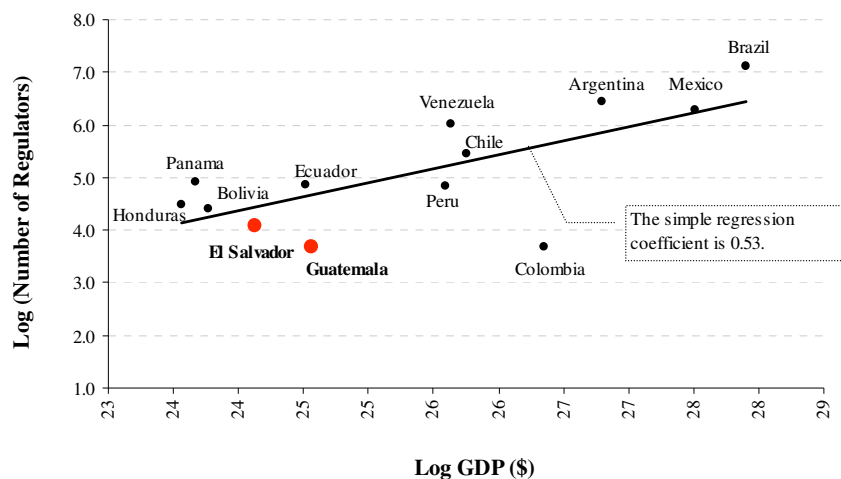
8. CONCLUSION

Ronald Coase's normative conclusion that private property rights in spectrum would yield incentives for efficient use has been widely embraced by economists (Rosston et al., 2001). Yet, while many countries use auctions to assign wireless licenses, administrative fiat remains the standard mechanism to allocate radio spectrum itself.

  The experience in Guatemala and El Salvador provides an important natural experiment of Coase's policy prescription. Liberal reforms in these countries a decade ago have permitted market mechanisms to distribute bandwidth across wireless services, technologies and operators. Performance indicators from the dominant industry within the sector, mobile telephony, suggest that economic benefits have obtained.

  As with other real world case studies, the data we draw on are limited. The relatively small economies of Guatemala and El Salvador are unlikely to deploy highly differentiated networks or technologies no matter how liberal their policy regimes. Scale economies make the purchase of technology and network infrastructure in global markets highly advantageous. Global technology standards may help or hinder the case for private property rights in spectrum, but they strongly assist our analysis in one important respect. Because wireless

networks in liberal regimes are built with inputs supplied on world markets, the services produced are directly comparable.

We find that private spectrum rights have been adopted without substantial administrative impediments and that property rights are defined and enforced at reasonable cost. Most generally, we find that private spectrum rights yield wireless phone markets that perform relatively efficiently, in terms of prices and outputs, suggesting consumer welfare gains from liberalization. Most pointedly, the liberal spectrum regimes make a relatively abundant quantity of bandwidth available to wireless phone networks. This relaxes the input constraint imposed via centralized allocation regimes, promoting greater competition among carriers and more productive employment of radio spectrum, the economic result anticipated by Coase.

We also find shifting political allegiances of policy makers (in Guatemala), leading to rights enforcement problems within the FM radio band. This suggests that where property rights are more secure in statutory law, regulators will be led to withdraw political support (and regulatory protections) offered elsewhere.

Guatemala and El Salvador offer relatively challenging venues for the policy experiment conducted, with relatively low incomes, small populations, and poor ratings in terms of "economic freedom." Larger countries, which may capture higher returns to scale in entrepreneurial use of spectrum, as well as countries with better developed capital markets and judicial systems, may experience greater benefits from Coasean spectrum reforms. Research on the political dynamics enabling such further experimentation could prove highly beneficial for lawyers, economists, technologists, and policy makers.

Appendix 1: Description of Data and Sources

The following 16 Latin American countries were considered in this analysis: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, and Venezuela. Costa Rica was excluded because it featured a state monopoly provider of mobile telephony throughout the sample period, which makes it difficult to interpret price data given the potential for cross-subsidization of services.

The Dependent and Independent Variables are:

ARPM: average revenue per minute of mobile telephone service. Source: "Latin America Mobile Data," Pyramid Research, Cambridge, MA (2005). The data are averaged across pre-paid and post-paid subscribers.

GDPPC: the per-capita GDP, by country, PPP adjusted and in 2000 international $. Source: World Development Indicators 2006, World Bank: http://web.worldbank.org/WBSITE/EXTERNAL/DATASTATISTICS/0,,menuPK:23 2599~pagePK:64133170~piPK:64133498~theSitePK:239419,00.html

HHI: the Hirschman-Herfindahl Index score based on subscriber data. Source: "Latin America Mobile Data," Pyramid Research, Cambridge, MA (2005).

MOU: Total minutes of use for voice mobile telephone service. Source: "Latin America Mobile Data," Pyramid Research, Cambridge, MA (2005). MOU per subscriber reported as a blend of pre-paid and post-paid use for, and then multiplied by the number of mobile subscribers (Source: World Development Indicators 2006, World Bank: http://web.worldbank.org/WBSITE/EXTERNAL/DATASTATISTICS/0,,menuPK:23 2599~pagePK:64133170~piPK:64133498~theSitePK:239419,00.html

POPULATION: Source: World Development Indicators 2006, World Bank: http://web.worldbank.org/WBSITE/EXTERNAL/DATASTATISTICS/0,,menuPK:23 2599~pagePK:64133170~piPK:64133498~theSitePK:239419,00.html

SPECTRUM: the amount of spectrum within a country that is available for mobile telephony service. Source: Country regulator websites.

DENSITY: the population density of a country (in terms of number of people per square kilometer). Source: World Telecom Indicators 2005, ITU, Geneva, Switzerland: http://www.itu.int/publications/template.aspx?lang=e&menu=main&media=download&t arget=/publications/EBookshop.htmlhttp://www.itu.int/publications/template.aspx?lang =e&menu=main&media=download&target=/publications/EBookshop.html

FRASER INDEX: an index value, 1-10, measures the general security of property rights. Source: "Economic Freedom of the World Data," 2006, The Fraser Institute. Available at http://www.freetheworld.com/2006/2006Dataset.xls

Appendix 2: OLS Regressions

Regression 1.1: Results

$\ln \dfrac{Spectrum}{GDPPC}$	Coefficient (Std. Error)	t	P>t	Confidence Interval	
ln *GDPPC*	-0.5008 (0.0838)	-5.98	0.000	-0.6678	-0.3337
ln *Fraser*	0.2133 (0.3241)	0.66	0.513	-0.4327	0.8593
ln *Population*	0.0886 (0.0346)	2.56	0.012	0.0197	0.1576
ln *Density*	-1.0210 (0.2886)	-3.54	0.001	-1.5961	-0.4459
(ln *Density*)^2	0.0868 (0.0420)	2.06	0.043	0.0030	0.1706
Liberal	1.2683 (0.1959)	6.47[56]	0.000	0.8778	1.6587
Constant	5.2771 (0.8616)	6.12	0.000	3.5599	6.9943

N=80; R-squared=0.7065

White's test for H_o: homoskedasticity:
chi2(25) = 76.58
Prob > chi2 = 0.0000

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[56] With robust standard errors, t statistic increases to 12.35 (p-value=0.000).

Regression 1.2: Results

ln *HHI*	Coefficient (Std. Error)	t	P>t	Confidence Interval	
ln *GDPPC*	-0.3484 (0.0678)	-5.14	0.000	-0.4835	-0.2133
ln *Fraser*	0.4822 (0.2621)	1.84	0.070	-0.0402	1.0045
ln *Population*	-0.0495 (0.0280)	-1.77	0.081	-0.1053	0.0062
ln *Density*	0.7651 (0.2334)	3.28	0.002	0.3001	1.2302
(ln *Density*)^2	-0.0692 (0.0340)	-2.04	0.045	-0.1370	-0.0015
Liberal	-0.8173 (0.1584)	-5.16[57]	0.000	-1.1330	-0.5015
Constant	6.5385 (0.6968)	9.38	0.000	5.1498	7.9271

N=80; R-squared=0.6253

White's test for H$_o$: homoskedasticity:
chi2(25) = 48.45
Prob > chi2 = 0.0033

---

[57] With robust standard errors, t statistic decreases to -8.43 (p-value=0.000).

Regression 1.3: Results

ln *ARPM*	Coefficient (Std. Error)	t	P>t	Confidence Interval	
ln *GDPPC*	-0.1414 (0.1205)	-1.17	0.244	-0.3815	0.0987
ln *Fraser*	0.4310 (0.4659)	0.93	0.358	-0.4975	1.3595
ln *Population*	-0.1242 (0.0497)	-2.50	0.015	-0.2233	-0.0251
ln *Density*	-0.5139 (0.4148)	-1.24	0.219	-1.3406	0.3127
(ln *Density*)^2	0.1224 (0.0604)	2.03	0.046	0.0020	0.2429
Liberal	-1.4176 (0.2816)	-5.03[58]	0.000	-1.9788	-0.8564
Constant	-1.4118 (1.2384)	-1.14	0.258	-3.8800	1.0563

N=80; R-squared=0.3907

White's test for H_o: homoskedasticity:
chi2(25) = 54.98
Prob > chi2 = 0.0005

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[58] With robust standard errors, t statistic decreases to -9.84 (p-value=0.000).

Regression 1.4: Results

$\ln\dfrac{MOU}{GDPPC}$	Coefficient (Std. Error)	t	P>t	Confidence Interval	
ln *GDPPC*	0.1054 (0.1613)	0.65	0.516	-0.2162	0.4269
ln *Fraser*	-0.8209 (0.6240)	-1.32	0.192	-2.0645	0.4227
ln *Population*	0.0210 (0.0666)	0.31	0.754	-0.1117	0.1537
ln *Density*	-0.1459 (0.5555)	-0.26	0.794	-1.2530	0.9613
(ln *Density*)^2	-0.0290 (0.0809)	-0.36	0.721	-0.1904	0.1323
Liberal	1.5014 (0.3771)	3.98[59]	0.000	0.7498	2.2531
Constant	2.9444 (1.6587)	1.78	0.080	-0.3614	6.2502

N=80; R-squared=0.2623

White's test for H_o: homoskedasticity:
chi2(25) = 28.55
Prob > chi2 = 0.2832
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
(H_o:homoskedasticity):
chi2(1) = 3.70
Prob > chi2 = 0.0543

---

[59] With robust standard errors, t statistic increases to 5.60 (p-value=0.000).

Regression 2.1: Results

$\ln \dfrac{Spectrum}{GDPPC}$	Coefficient (Std. Error)	t	P>t	Confidence Interval	
ln *GDPPC*	-0.5041 (0.2402)	-2.10	0.065	-1.0475	0.0392
ln *Fraser*	0.3008 (1.0013)	0.30	0.771	-1.9643	2.5659
ln *Population*	0.0920 (0.0997)	0.92	0.380	-1.1336	0.3175
ln *Density*	-1.0047 (0.8235)	-1.22	0.253	-2.8677	0.8583
(ln *Density*)^2	0.0846 (0.1200)	0.70	0.499	-0.1868	0.3560
Liberal	1.2667 (0.5562)	2.28[60]	0.049	0.0084	2.5250
Constant	5.0843 (2.5950)	1.96	0.082	-0.7860	10.9545

N=16; R-squared=0.7075

White's test for H_o: homoskedasticity:
chi2(25) = 16.00
Prob > chi2 = 0.3821
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
(H_o:homoskedasticity):
chi2(1) = 0.06
Prob > chi2 = 0.8000

---

[60] With robust standard errors, t statistic increases to 4.33(p-value=0.002). With clustering instead of averaging, the coefficient for *Liberal* equals 1.2683 with a t statistic of 5.40 (p-value=0.000).

Regression 2.2: Results

ln *HHI*	Coefficient (Std. Error)	t	P>t	Confidence Interval	
ln *GDPPC*	-0.3418 (0.1396)	-2.45	0.037	-0.6575	-0.0261
ln *Fraser*	0.4215 (0.5818)	0.72	0.487	-0.8946	1.7376
ln *Population*	-0.0508 (0.0579)	-0.88	0.403	-0.1819	0.0802
ln *Density*	0.7420 (0.4785)	1.55	0.155	-0.3404	1.8245
(ln *Density*)^2	-0.0650 (0.0697)	-0.93	0.376	-0.2226	0.0927
Liberal	-0.8366 (0.3232)	-2.59[61]	0.029	-1.5677	-0.1055
Constant	6.6706 (1.5078)	4.42	0.002	3.2598	10.0813

N=16; R-squared=0.7655

White's test for H_o: homoskedasticity:
chi2(25) = 16.00
Prob > chi2 = 0.3821
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
(H_o:homoskedasticity):
chi2(1) = 0.00
Prob > chi2 = 0.9931

---

[61] With robust standard errors, t statistic decreases to -3.98 (p-value=0.003). With clustering instead of averaging, the coefficient for *Liberal* equals -0.8173 with a t statistic of -5.02 (p-value=0.000).

Regression 2.3: Results

ln *ARPM*	Coefficient (Std. Error)	t	P>t	Confidence Interval	
ln *GDPPC*	-0.1204 (0.2848)	-0.42	0.682	-0.7646	0.5239
ln *Fraser*	0.1123 (1.1872)	0.09	0.927	-2.5733	2.7980
ln *Population*	-0.1353 (0.1182)	-1.14	0.282	-0.4028	0.1321
ln *Density*	-0.5746 (0.9765)	-0.59	0.571	-2.7835	1.6343
(ln *Density*)^2	0.1323 (0.1422)	0.93	0.377	-0.1895	0.4541
Liberal	-1.4351 (0.6595)	-2.18[62]	0.058	-2.9270	0.0568
Constant	-0.7418 (3.0768)	-0.24	0.815	-7.7020	6.2183

N=16; R-squared=0.4867

White's test for H_o: homoskedasticity:
chi2(25) = 16.00
Prob > chi2 = 0.3821
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
(H_o:homoskedasticity):
chi2(1) = 0.44
Prob > chi2 = 0.5087

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[62] With robust standard errors, t statistic decreases to -5.10 (p-value=0.001). With clustering instead of averaging, the coefficient for *Liberal* equals -1.4176 with a t statistic of -6.38 (p-value=0.000).

Regression 2.4: Results

$\ln \dfrac{MOU}{GDPPC}$	Coefficient (Std. Error)	t	P>t	Confidence Interval	
ln *GDPPC*	0.0912 (0.3540)	0.26	0.803	-0.7096	0.8919
ln *Fraser*	-0.9971 (1.4757)	-0.68	0.516	-4.3354	2.3412
ln *Population*	0.0116 (0.1469)	0.08	0.939	-0.3208	0.3440
ln *Density*	-0.1431 (1.2137)	-0.12	0.909	-2.8887	2.6026
(ln *Density*)^2	-0.0334 (0.1768)	-0.19	0.854	-0.4333	0.3666
Liberal	1.5742 (0.8198)	1.92[63]	0.087	-0.2803	3.4286
Constant	3.3559 (3.8244)	0.88	0.403	-5.2956	12.0073

N=16; R-squared=0.3943

White's test for H_o: homoskedasticity:
chi2(25) = 16.00
Prob > chi2 = 0.3821
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity (H_o:homoskedasticity):
chi2(1) = 0.83
Prob > chi2 = 0.3636

---

[63] With robust standard errors, t statistic increases to 6.61 (p-value=0.000). With clustering instead of averaging, the coefficient for *Liberal* equals 1.5014 with a t statistic of 7.56 (p-value=0.000).

Regression 3.1: Breusch-Pagan/Lagrange Multiplier Test Results

Breusch-Pagan / Lagrange Multiplier test for random effects (H_o:var(country)=0):
chi2(1) = 156.62
Prob > chi2 = 0.0000

Regression 3.2: Breusch-Pagan/Lagrange Multiplier Test Results

Breusch-Pagan / Lagrange Multiplier test for random effects (H_o:var(country)=0):
chi2(1) = 24.40
Prob > chi2 = 0.0000

Regression 3.3: Breusch-Pagan/Lagrange Multiplier Test Results

Breusch-Pagan / Lagrange Multiplier test for random effects (H_o:var(country)=0):
chi2(1) = 57.58
Prob > chi2 = 0.0000

Regression 3.4: Breusch-Pagan/Lagrange Multiplier Test Results

Breusch-Pagan / Lagrange Multiplier test for random effects (H_o:var(country)=0):
chi2(1) = 36.65
Prob > chi2 = 0.0000

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