TOPICS ON THE ECONOMICS OF INTERNATIONAL TELECOMMUNICATIONS

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Abstract

This thesis comprises three essays of the economics of international telecommunications.

The first of the essays is concerned with the modeling of international telephone demand. Standard models of international telecommunications demand have exclusively focused on modeling the total demand for telephone minutes and ignored call durations as a separate dimension of calling behavior. Yet, average call durations and total volume of telephone traffic have developed in opposite directions over the past decade, suggesting that it is important to clarify the relationship between call duration and total traffic volume. This essay extends traditional telephone demand analysis to show how to handle call durations in the Point-to-Point telephone demand model, and presents estimation results using data of telephone traffic between the US and 42 countries.

The remainder of this thesis analyzes the regulatory history of the Proportionate Return Requirement (PRR) and its effect on the US telephone markets and industry.

The second essay is an institutional analysis of the PRR in the context of United States' regulation of international telephony. The main conclusion is that the actual effect of the PRR is not in line with its regulatory objectives, and that the PRR is not needed to prevent "whipsawing" of US carriers by foreign monopolists. The FCC's justifications of the PRR are found to be largely based on an erroneous interpretation of historic case law.

The third essay, finally, attempts to provide an insight into the nature of economic distortions created by the PRR. It develops a competition model of an international telecommunications market with two types of carriers, facilities-based and resale carriers. The model is used to analyze and simulate the effect of the proportionate return requirement (PRR) on the existence and properties of equilibria in the country where the PRR is implemented. In addition, this model analyzes the discriminatory effect of the PRR on resellers, and the extent to which facilities-based carriers can use the advantage of receiving incoming traffic to increase their market share at the expense of resellers in the end-user market.

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Chapter 1

Introduction

During the past 25 years, telecommunications has turned from a heavily regulated essential services industry with a public utility character to one of the fastest growing and most radically changing industries. It has become a key to industrial change and is forever altering the ways people interact and conduct business. The international segment of this industry, with its traditionally high profit margins and heavy use of cutting-edge technology, has been at the forefront of this development.

As technology and industry structure are rapidly changing, so are the tasks and objectives of applied economics and business research on the telecommunications industry and its regulation. Although the findings of much of the current research may be of little interest 20 years from now, they help to guide future ways to conduct business, facilitate a smooth transition towards a competitive business environment, and advance economic methodology for future telecommunications research.

This dissertation is comprised of three essays that address issues of such current and future relevance to businesses, regulators, and researchers of the international telecommunications industry. Chapter 2 is a study of telecommunications demand, which extends the traditional analysis of demand for *total telephone minutes* to analyzing the *structure* of telephone demand, that is, the tradeoff between the number of telephone calls and their duration. In particular, it develops an empirical model to explore how this demand structure has adjusted due to technological change, and changes of telephone carriers' calling charge schedules.

The main theme of both Chapters 3 and 4 relates to the Proportionate Return Requirement (PRR), a regulation that governs international telephone traffic on a significant number of international routes, typically between countries with a competitive telecom market and countries with traditional telecom monopolies. The analysis of this regulation is conducted from two different angles.

Chapter 3 traces the historical and institutional background of the PRR. It shows that the regulatory process leading to the implementation of this important regulation is inconsistent, and sheds some serious doubts on its appropriateness for achieving the regulators' objectives. In addition, this chapter reveals the dangers and difficulties of the regulatory rulemaking process by which international telecommunications is currently regulated, and which may also be applied for future regulation of advanced telecommunication services.

Finally, Chapter 4 develops a competition model to analyze the impact of the PRR on the telecommunications market structure in the country where it is implemented. It establishes, analytically and by simulations, how the PRR affects the profits and market shares of telecommunications carriers and resale carriers, and the welfare of the telephone end user. The chapter concludes with some policy recommendations regarding the future regulatory framework for international telephone services.

Chapter 2

Call Lengths and International Telecommunications Demand

2.1 Introduction

In the literature on telecommunications demand analysis, demand for international telephone services has received relatively little attention. One of the reasons is that international telephone service was often considered as a special type of long distance service, with essentially the same features. Only as late as at the mid-1980s have researchers started to develop theoretical and empirical frameworks that specifically captured the unique characteristics of international telephony.

One aspect in which international telephone markets differ from domestic long distance markets is that international outgoing traffic and the respective return traffic may be subject to significantly different market conditions. For example, in 1988 the calling charge for a call from Turkey to the United States was more than twice the charge applicable in the opposite direction.

At the same time, Turkey's per-capita GDP amounted only to 8 percent of the American GDP. Asymmetric market conditions are more likely to be prevalent in international than in domestic long distance markets. They typically result in imbalanced traffic patterns and give rise to arbitrage, both of which significantly complicate demand analysis.

Second, international telecommunications has been a starting point and prime target for competitive service providers and new types of telephone service concepts, including Internet Telephony, callback, International Simple Resale, Pure ("switchless") resale, corporate private networks, and refiling. As a result, collection charges[1] have declined more rapidly in international than in domestic long distance markets, and the average growth of international telephone traffic has by far exceeded that of domestic traffic.

A third distinctive feature of international telephone markets is the extent to which carriers levy call connection charges. In the United States, connection charges were traditionally applied to all long distance calls, including domestic and international calls. They were phased out for domestic long distance calls in 1988, but remained in effect in international call markets throughout most of the 1990s, although in gradually decreasing magnitude. By 1998, most facilities-based carriers had phased out also the call connection charges on international calls, however, significant connection charges remain in effect with US international resellers, as well as with a number of

[1]The term "collection charge" is used throughout this paper for the per-minute price of a telephone call.

non-US carriers.

Finally, calling patterns in international telephone markets have conspicuously shifted over the past decade, from longer average duration of calls to shorter average call duration. A similar shift is observable also in US domestic long distance demand; however, it appears by far not as pronounced as in the international call market. Moreover, average call durations significantly vary between different inter-country routes.

While previous empirical research on international telecommunications demand has developed methods to investigate the implications of asymmetric market conditions on international call demand, it has so far neglected the joint analysis average call duration and total calling volume. Relatedly, there has been no research that focused on measuring the effect of call set-up charges on telephone demand and calling patterns.

The objective of this research is therefore to explain the variations of calling patterns and to analyze the role of call durations and call set-up charges in telephone demand analysis.

An investigation of international telephone demand along these new dimensions would be useful for telecommunications policy analysis, as it theoretically improves and refines previous empirical demand models and thus allows for a more accurate assessment of the effect of pricing policies on use, capacity, revenues and total welfare. This paper will contribute to such improvement by extending the traditional telephone demand model to incorporate the aspect of varying call durations and set-up charges. Section 2.2 further motivates this research by providing background information on trends in international telephone calling patterns and reviews the related academic literature. Section 2.3 develops two alternative demand models that both explicitly take call durations into account, and clarifies the assumptions under which these models are valid. Section 2.4 presents the empirical results of estimating both demand specifications with and contrasts them with previous studies. Section 2.5 summarizes and concludes. A detailed description of data and data sources is included in Appendix A.

2.2 Trends in International Telecommunications and Related Literature

2.2.1 Focus and Limitations of International Telephone Demand Analysis

Throughout the past decades, international telecommunications has arguably been one of the fastest growing market segments of the telecommunications industry. It has provided the essential infrastructure for international trade, tourism and migration, It has driven and been driven by globalization of businesses, technological and regulatory change.

Yet, relatively little research has been conducted to understand the structure of international telecommunications demand. Early research in this area, conducted by Lago (1970), and Rea and Lage (1978), simultaneously analyzed the demand for telephone service together with two of its closet

Table 2.1. Average annual traffic growth 1988-1996 of telephone traffic between the United States and selected countries, outgoing from and incoming into the U.S.

country	*from US*	*into US*	*country*	*from US*	*into US*
Australia	19.72%	12.46%	India	37.64%	10.13%
Chile	43.51%	34.95%	Ireland	13.68%	14.98%
Egypt	18.65%	11.03%	Japan	15.04%	13.31%
France	14.99%	8.66%	Netherlands	18.74%	10.07%
Germany	10.08%	8.36%	New Zealand	20.80%	14.35%
Hong Kong	31.88%	9.09%	Spain	15.00%	14.29%
Italy	12.79%	8.90%	Turkey	14.88%	17.89%
Iceland	6.59%	10.64%	U.K.	11.77%	8.55%

Source: Compiled from Statistics of Communications Common Carriers

substitutes, telegram and telex services. Besides collection charges of these services, they found a number of statistically significant determinants of telephone demand, including household income, trade and number of main lines. Later studies, including Larson, Lehman and Weisman (1986), Appelbe et al. (1988), Acton and Vogelsang (1992), Garín-Muñoz and Pérez-Amaral (1996, 1998, 1999), develop and use point-to-point models of telecommunications demand in order to include reciprocal calling effects as important determinants of demand. Acton and Vogelsang (1992) focus on call externalities and investigate whether incoming traffic is a substitute or a complement for outgoing traffic. Hackl and Westlund (1995), finally, allow for time-varying regression coefficients to estimate trajectories of price elasticities over time.

At the center of attention of all previous studies is the aggregated total demand for international telephone service[2] in a given country. The total number of telephone minutes as a quantity measure of telephone demand has for obvious reasons been strictly preferred to another readily available quantity measure, that is, the total number of telephone calls. After all, the total number of call minutes appears to be a more instructive measure of information generated and transmitted during on any inter country relation than the actual number of calls made.

Yet, simply ignoring the total number of calls as an output measure may result in the loss of valuable information. During the period 1988 to 1996, the total number of telephone calls has increased at a higher rate than the total number of call minutes on most international routes. In other words, while the total number of call minutes increased on all routes in this period of time (Table 2.1), the average *call duration* decreased significantly on most routes (Table 2.2).

Comparing the average percentage change of outgoing traffic versus incoming traffic, it appears that the total amount of US outbound traffic has grown faster than the inbound traffic on most routes. In the case of average call durations, there is no such clearly recognizable pattern.

Average call durations vary widely between different countries. Among the routes displayed in Table 2.3, average call durations range from 2.76 minutes on the inbound route from India, to 8.34 minutes on the inbound route from Iceland. In the outbound direction, the shortest duration in the

[2] Expressed as the total number of call minutes.

Table 2.2. Average annual change of average call durations 1988-1996 of telephone traffic between the United States and selected countries, outgoing from and incoming into the U.S.

country	*from US*	*into US*	*country*	*from US*	*into US*
Australia	-2.80%	1.16%	India	-0.59%	-6.67%
Chile	-2.84%	-5.95%	Ireland	-3.75%	-7.49%
Egypt	-5.13%	-7.07%	Japan	-3.58%	0.58%
France	-4.62%	-6.28%	Netherlands	-3.98%	-4.25%
Germany	-5.56%	-0.72%	New Zealand	-4.98%	-1.78%
Hong Kong	-3.07%	-1.71%	Spain	-4.65%	-3.66%
Italy	-4.23%	-3.36%	Turkey	-5.54%	-1.49%
Iceland	-7.27%	-4.49%	U.K.	-3.20%	-1.71%

Source: Compiled from Common Carriers

sample is 4.47 minutes on the route to Hong Kong, the longest is 7.72 minutes on the route to Ireland. On most, but not all routes, the average telephone call in the outbound direction is longer than the average call in the inbound direction. The difference between outbound call durations and inbound call durations tends to be greater on routes to the less developed countries than on those to developed countries.

Finally, focusing only on routes between the United States and industrialized countries, Figure 2.1 shows a plot of relative (outbound over inbound) total telephone minutes (outbound over inbound) against relative call durations (outbound over inbound). The traffic volume ratios turn out to be greater than the duration ratios on any given route of the sample. However, there is otherwise again no pattern indicating a strong correlation between the ratios of total traffic volumes and the ratios of average call durations.

Table 2.3. Average call durations of telephone traffic (in minutes) between the United States and selected countries in 1995, outgoing from and incoming into the U.S.

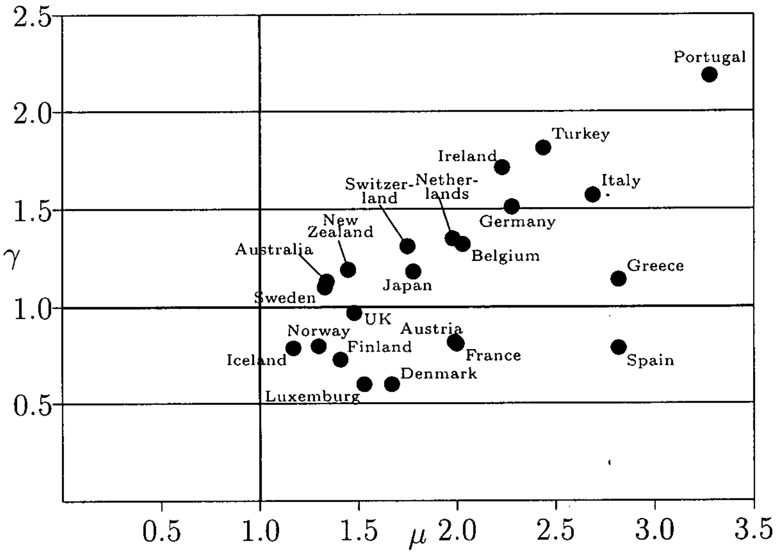
country	*from US*	*into US*	*country*	*from US*	*into US*
Australia	5.25	4.63	India	6.84	2.76
Chile	7.07	3.59	Ireland	7.72	4.52
Egypt	7.33	3.72	Japan	5.77	4.89
France	5.14	6.35	Netherlands	4.87	3.61
Germany	6.09	4.04	New Zealand	4.91	4.14
Hong Kong	4.47	3.72	Spain	5.78	7.31
Italy	5.59	3.56	Turkey	5.79	3.19
Iceland	6.58	8.34	U.K.	5.37	5.52

Source: Compiled from Statistics of Communications Common Carriers

For example, an approximately balanced traffic volume in outbound and inbound direction of a given route does not imply that the average duration of telephone calls in both directions will be approximately equal. Rather, calls may on average be longer, equal or shorter on the outbound versus the inbound direction.

The traditional analysis of international telecommunications demand, with its focus on total traffic volumes as the main object of analysis, has as of today not made use of information that allow to gain deeper insights into the *structure* of international telephone traffic and its characteristics. The evidence suggests that determinants of international telecommunications demand do not affect average call durations in the same way as they effect total traffic volume. Rather, the relationship between these two output measures of telephone service is far from obvious. A closer investigation into the

Figure 2.1. Ratios of outgoing over incoming total traffic volume versus outgoing over incoming average call duration on routes between the United States and selected OECD countries, 1995



Note: γ=average duration of U.S. outgoing calls/average duration of U.S. incoming calls; μ=total minutes of U.S. outgoing traffic/total minutes of U.S. incoming traffic
Source: Compiled from Statistics of Communications Common Carriers

structure of telecommunications demand could be valuable for a number of reasons. First, it may provide a deeper understanding of the mechanisms that drive telecommunications demand. Second, to the extent that the initiation of each telephone call utilizes network capacity, telephone carriers should be interested in learning more about how to forecast both total traffic volume and the number of calls. Third, it needs to be investigated whether including additional information into the econometric demand model will improve the efficiency of estimators, and thus improve the quality of demand models.

2.2.2 Determinants of Call Duration

Previous studies of aggregate international telephone demand have been relatively consistent in their selection of relevant determinants of demand, such as price, number of main lines, population, disposable income, trade, export and imports, tourism, or migration. Consequently, the effect of these determinants on international telephone traffic is empirically widely understood.

In the context of analyzing both average call durations and total traffic volume, however, it is a priori unclear how these determinants can affect call durations and total traffic differently, such that an increase of one of the determinants over time would result in a shift of total traffic volumes and call durations in different directions, or such that differences of these determinants across countries affect volumes and durations in a different way. For example, a decrease in collection charges or increasing international trade flows should have a positive effect on both average call duration and total traffic volume.

The underlying reasons for the observed traffic patterns may be found in a combination of technological and economic developments that have traditionally not been accounted for in studies of international telecommunications demand. Factors that may effect call durations and total traffic volume in opposite directions include certain technological developments in terminal equipment, telecommunications service innovation, decreasing connection charges relative to marginal 'per minute' calling charges, calling behaviors that try to capture arbitrage opportunities, telecommunications network quality, and changes of communications patterns due to cultural factors.

The development of terminal equipment and telecommunications service innovation. Technological change in the terminal equipment market and the development of innovative telecommunications services may contribute to the reduction of call durations in a number of ways. Telefax, for example, allows transmitting complex text and graphical information via telephone lines. The transmission of an equivalent amount of information by means of conversation would arguably take significantly more time. Moreover, telefax transmissions are often preceded by an additional brief telephone conversation. Hence, telephone users can transmit the amount of information of a long telephone call by making two shorter calls: one telephone conversation and one telefax transmission. Similarly, electronic mail is often a more efficient means of communicating factual complex information than verbal telephone conversation. To the extent that the communicating parties supplement their telephone conversations by exchanging electronic documents, e-mail is likely to be a contributing factor to an overall reduction of average call durations.

Another possible explanation for decreasing call durations is the growing use of corporate private communications networks. Multinational corporations typically establish private communications networks on routes with high data and telephone traffic volumes. To the extent that the duration of international business calls and data transmission exceed the average duration of international telephone calls, the transfer of corporate communications to private networks will effectively result in a reduction of average call durations on public telephone networks.[3]

On the call-receiving end of an inter-country relation, the use of voice mail, answering machines, and call waiting services may have an impact on call durations. Without voice mail, the attempt to establish a telephone connection will result in an uncompleted and unmeasured call, if the call recipient is away from the phone. With voice mail, it results in a telephone call that lasts only for the duration of voice box "greeting", plus the time it takes the caller to leave a voice mail. The call recipient may then return the call, or the caller will start another attempt at a later point in time. Similarly, a call waiting service at the call-receiving end of a connection eliminates the possibility of getting a busy signal. The call recipient is likely to answer an incoming call "on the other line", but only to agree with the caller upon who is calling back, and when. Hence, a higher penetration of voice mail and call waiting services will result in more and on average shorter telephone calls.

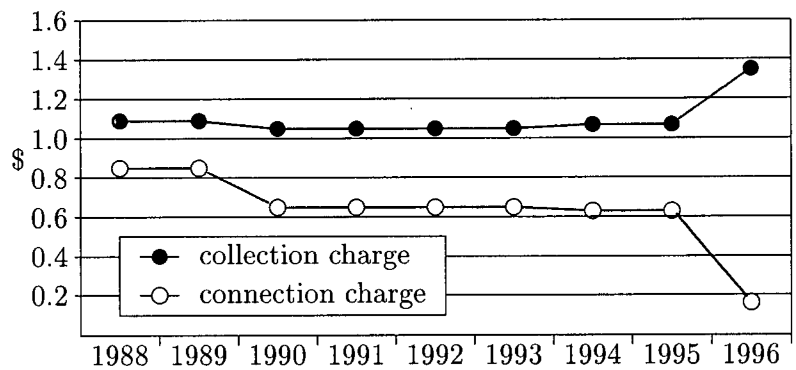
Finally, service innovations such as call forwarding an cellular phones will increase the availability of call recipients, but may also result in shorter

[3]A similar effect is due to the use of resale carriers by multinational corporations. Note however, that the data sample used in this study is restricted to the period 1988 to 1996. During this period, resale services were prohibited on most international routes.

calls, since the call recipient is more likely to be in a situation where it is inconvenient to hold a long conversation. Moreover, even if mobile telephones are unattended, the mobile phone is likely to be attached to a voice mail or call forwarding system.

Call connection charges. Some international telephone carriers, including carriers in the United States, have traditionally applied a pricing structure with a fixed connection charge per call, and a marginal charge per minute of call duration. Figure 2.2 shows the development of AT&T's average peak load connection charge and marginal per minute charge for calls from the United States to The Netherlands. It represents a typical trend for international

Figure 2.2. AT&T Collection charges and connection charges for telephone calls from the United States to The Netherlands, 1988-1996



Source: Compiled from Statistics of Communications Common Carriers

connection charges of US carriers throughout the late 1980s and 1990s. In 1988, connection charges were commonly set close to the level of the marginal charges. In subsequent years, AT&T gradually reduced connection charges relative to marginal charges, and phased them out in 1997. Other major carriers, such as MCI and Sprint, adopted similar pricing policies. By reducing connection charges relative to marginal charges, carriers provide the end users with economic incentives to change their calling behavior[4].

Arbitrage and callback. Differences in international telephone charges invite arbitrage and therefore influence the communication traffic patterns on international routes. Arbitrage opportunities, arising between high charge and low charge countries are commonly exploited in three ways. The party in the country with the higher calling charge can initiate the connection by making a short "call me back" call, and has the other party return the call. Second, the telephone call can be initiated at the end of the last call, through a mutual agreement about the time to call, and about what party is next to call. Third, the call initiating party can involve a callback carrier[5].

All three methods of arbitrage will have an influence on the structure of telephone traffic patterns, i.e., the duration and frequency of incoming and outgoing calls[6].

[4]For example, if price connection charges are lowered and marginal charges are increased such that the *average charge* remains constant, then one would expect the end users to reduce call duration and increase number of calls they make.

[5]There are a number of ways in which a call involving a callback carrier can be initiated. The most common form requires the calling person to dial the number of the operator and hang up after a few rings, without the call having been answered. The callback carrier will then initiate a call in the reverse direction, after which it establishes the connection to the actual call recipient.

[6]See Acton and Vogelsang (1992) for a more detailed discussion of the effect of arbitrage on telephone demand.

Technical Network Failures. A reduction of technical network failures will reduce involuntary interruptions of telephone calls and the subsequent need to redial. It will therefore result in an increase of average call duration, while total call volume should *ceteris paribus* remain approximately constant. Significant improvement of network quality are likely to be noticeable on routes from and to developing countries, rather than on routes between developed countries, where telecommunications networks are highly digitalized and networks quality measures are usually stagnating at high levels. The problem with technical network failures is that they are empirically hard to measure. Indicators that are to some extent reflect the technical failure rate in networks are the Answer Seizure Ratio[7] (ASR), and the Percentage of Network Digitalization. However, both measures are confounded with other effects, such as the presence of voice mail boxes on the receiving end of a call, the use of callback services, or limited network capacity.

Cultural Differences in Communications Patterns. Finally, even with all of the above conditions being equal on all inter country relations and over time, differences in communications patterns due to cultural factors may lead to variations of calling patterns. As the communications behavior of both conversation partners determine number and duration of telephone calls between them, cultural factors on both sides of an inter country relation will shape calling patterns of both incoming and outgoing calls.

[7]The percentage of calls that seize an international circuit and are unanswered at the terminating side. Quite obviously, the ASR is low on routes where many calls seize the international network, but are not answered due to technical failures in the network.

2.3 Theoretical Framework

In his monograph on telecommunications demand analysis, Taylor (1980) considers both call number of calls and call duration in his discussion on how information is produced via telephone calls: *"Suppose that a person is weighing making three-minute calls to a relative in the middle and at the end of a month or a six-minute call at the end of the month...the former would be more expensive, but could be of greater value because the information conveyed is more current."* In this view, therefore, the amount of information the agents derive from telephone calls not only depends on total number of minutes of outgoing and incoming calls, but also on the frequency and the duration of calls.

While it has hence been recognized that call duration matters, there has been no systematic method developed for handling it, neither conceptually, nor empirically. The two alternative models developed in this section build up on work of Larson, Lehman and Weiss (1986) and Acton and Vogelsang (1992), incorporating work of Cesario (1976), McConnell (1992), and Larson (1993). They extend the existing conceptual framework for Point-to-Point demand models by specifying alternative empirical models of telecommunications demand incorporating both call durations and total calling volume in a point-to-point market.

2.3.1 The Classical International Telecommunications Demand Model: Point-to-Point Demand without Connection Charges

Consider a country pair telephone market with a home country, h, and a foreign country, f, and one economic agent in each country with access to the telephone network. Both agents are assumed to derive utility from information, I, and from a composite good, z, that is, $u = u(I, z)$. Following Larson et al (1986), the agents in h and f do not only derive information from calls they initiate, but also from calls they receive. Hence we can write $I^h = I^h(t^h, t^f)$ and $I^f = I^f(t^f, t^h)$, where t^h and t^f are the total call minutes initiated by the agents in country h and f, respectively. The utility maximization problem of the agent in h can then be written as

$$\begin{aligned} &\max_{t^h, z^h} \quad u^h(I^h(t^h, t^f), z^h) \\ &s.t. \qquad y^h = p_t^h t^h + p_z^h z^h \end{aligned} \tag{2.1}$$

where p_t^h is the call charge , p_z^h is the price of the composite good , and y^h is the income of the agent in h. Under the standard assumptions on the curvature of the utility function in t^h and z^h, the solution to this optimization problem then takes the form of the demand equation $t^{h*} = f(p_t^h, p_z^h, y^h, t^f)$. Similarly, the foreign agent's demand equation is given by $t^{f*} = f(p_t^f, p_z^f, y^f, t^h)$. The

Nash equilibrium therefore satisfies the equation system

$$
\begin{aligned}
t^{h*} &= f(p_t^h, p_z^h, y^h, t^{f*}) \\
t^{f*} &= f(p_t^f, p_z^f, y^f, t^{h*})
\end{aligned}
\tag{2.2}
$$

The agent's choice variable is the total number of calls, i.e., the product of number of calls and call duration, $t^h = x^h \cdot d^h$. An agent is commonly assumed to be indifferent between any combination of call number and average call length that results in a given total number of call minutes. Hence, an exogenous increase of the average call duration would not change the agent's choice of the total number of call minutes.

$$
\frac{dt^{h*}}{dd^h} = \frac{\partial x^h}{\partial d^h}\, d^h + x^h = 0 \tag{2.3}
$$

that is, the agent would decrease the optimal choice of number of calls to compensate for an increase of average call duration

$$
\frac{\partial x^h}{\partial d^h} = -\frac{x^h}{d^h} \tag{2.4}
$$

A common assumption in all of the previous literature on international telecommunications is that calling charges are exogenous. This assumption is also adopted for this study and can be justified on two accounts. First, in many of the countries included in the data set regulators still maintain some oversight over calling charges. The second reason is that even where regulators do not maintain such oversight, transmission capacities for international telephone services by far exceed actual demand. Supply can therefore be considered as perfectly elastic in the relevant range, making it unnecessary to deal with the estimation of the supply curve.

2.3.2 Point-to-Point Demand with Connection Charges

The model described in the previous section serves as the basis for most of the recent empirical models of international telecommunications demand, such as Larsson et al. (1986) and Acton and Vogelsang (1992), and Garin-Muñoz and Perez-Amaral (1998, 1999). There has been little concern about the validity of this approach, in particular with respect to its implicit assumption that agents are indifferent between different combinations of call duration and number of calls, as long as the total number of call minutes remains the same (Equations (2.3) and (2.4)).

The most natural way of modeling a setting as described by Taylor would be by using a dynamic framework. Such an approach would however exceed the limitation given by the data set that is available for this study. Instead, this research generalizes the static framework of Section 2.3.1 in order to encompass call durations.

Let $I^h = I^h(x^h, d^h, x^f, d^f)$ and $I^f = I^f(x^f, d^f, x^h, d^h)$ be the information, from which agents in h and f derive utility. x^h is the number of telephone calls initiated by the agent in h, and d^h is the average duration of each of these telephone calls. Similarly, x^f and d^f are the number and average duration of telephone calls initiated by the agent in f, respectively. The budget constraint of the agent in h is given by

$$y^h = x^h(p_x + p_d d^h) + p_z z \tag{2.5}$$

where p_x is the connection charge, p_d is the (marginal) per-minute charge of a telephone call, and p_z is the price of the composite good. This budget constraint is non-linear, which makes this model different from standard models of consumer theory. Information can only be generated when neither call frequency, nor call duration are zero. Without any call duration, there is no information generated by making a call,

$$\frac{\partial I^h(x^h, 0, x^f, d^f)}{\partial x^h} = 0 \tag{2.6}$$

and without making a connection, no information can be derived from longer call durations,

$$\frac{\partial I^h(0, d^h, x^f, d^f)}{\partial d^h} = 0 \tag{2.7}$$

It is therefore reasonable to exclude the possibility of boundary solutions. In order to ensure an interior solution for the agents' utility maximization problem, it is important to assume that the utility function $u^h(I(x^h, d^h, x^f, d^f), z)$ is such that the curvature of the indifference curves in (x^h, d^h) is greater than that of the budget constraint, as shown in Figure 2.3. Interior solutions occur

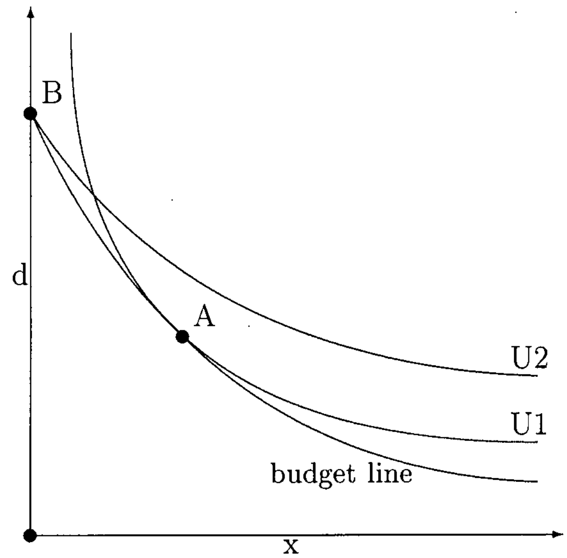


Figure 2.3. The nonlinear budget constraint

with indifference curves that are shaped like U1. Without the restriction on the utility function, the concave shape of the budget constraint could lead to solutions at (B). This is the case when the utility function is shaped like U2. However, since the shape of the utility function is assumed to be such that boundary solutions cannot occur, only interior solutions (A) are relevant.

2.3.3 The Case of Exogenous Call Duration

A simple way to introduce call durations in the standard framework is to consider a model where average call durations are exogenous. One could conjecture, for example, that average call durations are exclusively dictated by specific (exogenously determined) cultural traits, whereas the number of calls reflects economic optimization behavior. The utility maximization problem of the agent in h is then

$$\begin{aligned} &\max_{x^h, z^h} \quad u^h(I^h(x^h, d^h, x^f, d^f), z^h) \\ &s.t. \qquad\quad y^h = x^h(p_x^h + p_d^h d^h) + p_z^h z^h \end{aligned} \tag{2.8}$$

Hence, when call duration are exogenous, the agent's choice variable is the number of calls, leading to the fundamental demand equation

$$x^{h*} = f^h(p_x^h + p_d^h d^h, p_z^h, d^h, y^h, x^f, d^f)$$

Similarly, the foreign agent's demand equation is given by

$$x^{f*} = f^f(p_x^f + p_d^f d^f, p_z^f, d^f, y^f, x^h, d^h)$$

Note that if call duration is exogenous but not constant, it must be included in the specification of the demand equation. The call duration enters the demand equation in two ways, once directly and once through the price of a call, $p_x^h + p_d^h d^h$. Hence, when call duration exogenously increases, there are two additive effects.

$$\frac{dx^{h*}}{dd^h} = p_d^h \frac{\partial x^{h*}}{\partial (p_x^h + p_d^h d^h)} + \frac{\partial x^{h*}}{\partial d^h} \tag{2.9}$$

The first term is the price effect of longer call durations. As the call duration increases, the price per call goes up, resulting in a lower call demand.

The second term is a pure utility effect. Longer call durations increase the marginal utility of a call, and in turn increase the demand for calls. The sign of the total effect is however ambiguous. The demand for total call minutes can be written as

$$t^{h*}(p_x^h + p_d^h d^h, p_z^h, d^h, y^h, x^f, d^f) = d^h x^{h*}(p_x^h + p_d^h d^h, p_z^h, d^h, y^h, x^f, d^f) \quad (2.10)$$

The change of demand for total call minutes with an exogenous change of the call duration is non-zero

$$\frac{dt^{h*}}{dd^h} = x^{h*} + d^h p_d^h \frac{\partial x^{h*}}{\partial(p_x^h + p_d^h d^h)} + d^h \frac{\partial x^{h*}}{\partial d^h} \quad (2.11)$$

The Nash equilibrium outcome satisfies the following system of equations

$$\begin{aligned} x^{h*} &= f^h(p_x^h + p_d^h d^h, p_z^h, d^h, y^h, x^{f*}, d^f) \\ x^{f*} &= f^f(p_x^f + p_d^f d^f, p_z^f, d^f, y^f, x^{h*}, d^h) \end{aligned} \quad (2.12)$$

2.3.4 The Case of Endogenous Call Duration

Now consider the model when call duration is endogenous. Call duration then becomes one of the agent's choice variables, along with the number of calls and the quantity of the composite good. Hence, the agent's utility optimization problem is

$$\begin{array}{ll} \max_{x^h, d^h, z^h} & u^h(I^h(x^h, d^h, x^f, d^f), z^h) \\ s.t. & y^h = x^h(p_x^h + p_d^h d^h) + p_z^h z^h \end{array} \tag{2.13}$$

The resulting indirect utility function can be written as $V(p_x^f, p_d^f, p_z^f, y^h, x^h, d^h)$. The nonlinear budget constraint complicates the derivation of the demand system in this case. It can be easily verified, that Roy's identity holds in the case of the demand for number of calls,

$$x^{h*} = \frac{-V_{p_x}^h}{V_y^h} \tag{2.14}$$

The demand function for call duration is given by[8]

$$d^{h*} = \frac{V_{p_d}^h}{V_{p_x}^h} \tag{2.15}$$

While Equation 2.15 represents a standard Marshallian demand function in the sense that it expresses demand as a function of exogenous parameters, it does not relate the marginal utility of call durations to the marginal utility of income. However, this property is held by the demand function for the

[8]A standard way of deriving equation 2.14 is by using the envelope theorem. Due to the envelope theorem, $V_{p_x}^h = -\lambda x$ and $V_y^h = \lambda$, and hence $V_{p_x}^h / V_y^h = -x$. The envelope theorem holds regardless of the specific form of the budget constraint. Therefore, $V_{p_d}^h = -\lambda dx$. Dividing by $V_{p_x}^h = -\lambda x$ yields the following expression for the optimal call duration.

total number of call minutes,

$$t^{h*} = x^{h*}d^{h*} = \frac{-V^h_{p_x}}{V^h_y}\frac{V^h_{p_d}}{V^h_{p_x}} = \frac{V^h_{p_d}}{V^h_y} \tag{2.16}$$

Hence, a complete demand system for the agent in the home country is given by

$$\begin{aligned} x^{h*} &= f^h(p^h_x, p^h_d, p^h_z, y^h, x^{f*}, d^f) \\ t^{h*} &= g^h(p^h_x, p^h_d, p^h_z, y^h, x^{f*}, d^f) \end{aligned} \tag{2.17}$$

Again, with the respective demand equations for the foreign country, the equilibrium outcome of the complete point-to-point system is given by

$$\begin{aligned} x^{h*} &= f^h(p^h_x, p^h_d, p^h_z, y^h, x^{f*}, d^f) \\ d^{h*} &= g^h(p^h_x, p^h_d, p^h_z, y^h, x^{f*}, d^f) \\ x^{f*} &= f^f(p^f_x, p^f_d, p^f_z, y^f, x^{h*}, d^h) \\ d^{f*} &= g^f(p^f_x, p^f_d, p^f_z, y^f, x^{h*}, d^h) \end{aligned} \tag{2.18}$$

2.3.5 Price Elasticities of Call Duration

The question arising from the previous analysis of Section 2.3.4 in the context of demand analysis is, whether the non-linear budget constraint alters standard economic results regarding the signs of demand elasticities. To derive demand elasticities in this case, consider again the utility maximization problem of Equation 2.13. Dropping the country superscript, and assuming additive separability of the utility function of the form[9]

$$U = I(x, d) + z \tag{2.19}$$

and

$$p_z = 1 \tag{2.20}$$

the Lagrangian to Equation 2.13 can be written as

$$L = I(x, d) + z + \lambda(y - p_x x - p_d x d - z) \tag{2.21}$$

The first order conditions can be derived as

$$\begin{aligned} &I_x - \lambda(p_x + p_d d) = 0 \\ &I_d - \lambda p_d x = 0 \\ &p_x x + p_d d x + z = y \\ &\lambda = 1 \end{aligned} \tag{2.22}$$

[9]This restriction is needed for reasons of tractability. An obvious feature of this specific form is that it implies a zero income elasticity. As explained below, the assumption of a zero income elasticity poses no empirical problem in the context of the data set used for this study.

Total differentiation and arranging the equations in matrix form yields

$$\begin{pmatrix} 0 & p_x + p_d d & p_d x & 1 \\ p_x + p_d d & I_{xx} & I_{xd} - \lambda p_d & 0 \\ p_d x & I_{dx} - \lambda p_d & I_{dd} & 0 \\ 1 & 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} -d\lambda \\ dx \\ dd \\ dz \end{pmatrix} = \begin{pmatrix} dy - x dp_x - dx dp_d \\ \lambda dp_x + \lambda d dp_d \\ \lambda x dp_d \\ 0 \end{pmatrix} \tag{2.23}$$

Hence, using Cramer's Rule and substituting $\lambda = 1$, the total differentials of x and d, respectively, are

$$dx = -\frac{I_{dd}}{|I|}(dp_x + dp_d d) + \frac{I_{xd} - p_d}{|I|} x dp_d \tag{2.24}$$

$$dd = \frac{I_{xd} - p_d}{|I|}(dp_x + dp_d d) - \frac{I_{xx}}{|I|} x dp_d \tag{2.25}$$

where I is the bordered Hessian matrix of Equation 2.23. The second order conditions of utility maximization require $|I| < 0$. Hence, the "own"-price elasticity of the number of calls can be signed as follows

$$\frac{dx}{dp_x} = -\frac{I_{dd}}{|I|} < 0 \tag{2.26}$$

As it would be the case in the standard two goods model[10], the "own" price elasticity of number of calls is negative. The sign of the other price and cross

[10] I.e., where the budget constraint is $y = p_1 x_1 + p_2 x_2 + z$.

price elasticities, however, remain ambiguous[11][12],

$$\frac{dd}{dp_d} = d\frac{I_{dx} - p_d}{|I|} - x\frac{I_{xx}}{|I|} \tag{2.27}$$

$$\frac{dx}{dp_d} = -d\frac{I_{dd}}{|I|} + x\frac{I_{xd} - p_d}{|I|} \tag{2.28}$$

$$\frac{dd}{dp_x} = \frac{I_{xd} - p_d}{|I|} \tag{2.29}$$

unless more structure is imposed on the Information function.

One way of imposing additional structure on the Information function is to assume that the agent ultimately cares only about the *total number of call minutes* and is indifferent between combinations of x and d that result in the same product $t = xd$[13]. Both price elasticities of the total number of call minutes can then be assumed as negative, $\frac{d(xd)}{dp_x} < 0$ and $\frac{d(xd)}{dp_d} < 0$.

It turns out that

$$\frac{d(xd)}{dp_x} = d\frac{dx}{dp_x} + x\frac{dd}{dp_x} = -d\frac{I_{dd}}{|I|} + x\frac{I_{xd} - p_d}{|I|} = \frac{dx}{dp_d} \tag{2.30}$$

Therefore, $\frac{d(xd)}{dp_x} < 0$ implies $\frac{dx}{dp_d} < 0$, and hence, under the assumption that the agent maximizes over total call minutes, the cross-price elasticity of number of calls would be negative. The own and cross-price elasticities of duration

[11]This is due to the fact that the expression $I_{xd} - p_d$ cannot be signed.

[12]Recall that in the standard two goods case all elasticities can be signed: both own price elasticities would be negative, whereas the cross price elasticities would be positive.

[13]Note that this is one of underlying assumptions of the "standard" model of Section 2.3.1.

still remain ambiguous.

2.4 Empirical Model, Estimation, and Results

In order to estimate an empirical specification based on models of Section 2.3.4 and Section 2.3.3, this paper employs a data set that has not been used in previously published demand studies. The question hence arising is, to what extent are the results of this study driven by the data, and to what extent are they influenced by the extended theoretical framework on which the empirical specification is based. This empirical section proceeds in two steps. The following subsection will report empirical results of estimating standard international telephone demand models with the current data. It will interpret the results and compare them to results of previous demand studies. The subsequent subsections, then, will estimate and analyze empirical specifications based on the new theoretical frameworks, based on the assumption of exogenous call durations (Section 2.3.3) and endogenous call duration (Section 2.3.4).

2.4.1 Standard Empirical Specifications

Empirical models based on the framework of Section 2.3.1 and on previous work by, for example, Larson, Lehman and Weisman (1986), and Garín-Muñoz and Pérez-Amaral (1999), are subject to the assumption that neither call durations nor connection charges are relevant in the context of telecommunications demand analysis. Hence, a typical empirical specification of the "standard" demand model takes the following double-logarithmic form:

$$\begin{aligned}\ln T_{it}^{h} &= \beta_0 + \beta_1 \ln P_{it}^{h} + \beta_2 \ln T_{it}^{f} + \beta_3 \ln GDP_{it}^{f} + \beta_4 \ln TRADE_{it} \\ &+ \beta_5 \ln TOUR_{it}^{h} + \beta_6 \ln TOUR_{it}^{f} + \beta_7 \ln IM_{it}^{h} \qquad (2.31) \\ &+ \beta_8 \ln ML_{t}^{h} + \beta_9 \ln ML_{it}^{f} + \beta_{10} \ln POP_{it}^{f} + \epsilon_{it}^{h}\end{aligned}$$

$$\begin{aligned}\ln T_{it}^{f} &= \delta_0 + \delta_1 \ln P_{it}^{f} + \delta_2 \ln T_{it}^{h} + \delta_3 \ln GDP_{it}^{f} + \beta_4 \ln TRADE_{it} \\ &+ \delta_5 \ln TOUR_{it}^{f} + \delta_6 \ln TOUR_{it}^{h} + \delta_7 \ln IM_{it}^{h} \qquad (2.32) \\ &+ \delta_8 \ln ML_{it}^{f} + \delta_9 \ln ML_{t}^{h} + \delta_{10} \ln POP_{it}^{f} + \epsilon_{it}^{f}\end{aligned}$$

where h again stands for home country, in this particular case the United States, and f stands for foreign country. The variables are defined as follows:

T_{it}^h	Total number of call minutes from the US to country i in year t
P_{it}^h	Charge for a (marginal) minute of a telephone call from the US to country i in year t[14]
GDP_{it}^f	GDP of country i in year t , deflated by the CPI
$TRADE_{it}$	Total trade volume between the US to country i in year t
$TOUR_{it}^h$	Number of US tourists to country i in year t
$TOUR_{it}^f$	Number tourists from country i in year t to the US
IM_{it}^h	Six-year stock of immigrants from country i to the US in year t[15]
ML_t^h	Number of main lines per inhabitant in the US, in year t[16]
ML_{it}^f	Number of main lines per inhabitant in country i and year t
POP_{it}^f	Number of Inhabitants of country i and year t[17]

Equation 2.31 represents the demand for total telephone minutes from the US to various countries, whereas Equation 2.32 describes the telephone demand in the reverse direction. The subscripts i, j, and t are country subscripts,

[14]The definition of P_{it}^h is also used by Acton and Vogelsang (1992). Alternatively, Garín-Muñoz and Pérez-Amaral 1999 (among others) use the price of a three minute call.

[15]only migration *into* the US is included as an explanatory variable, whereas migration in the reverse direction is considered negligible.

[16]The number of main lines per inhabitant ("telephone penetration") can be regarded as a proxy for the availability of advanced communications technology and services in a country's telephone system. Low penetration rates typically coincide with a low standard of technology and service availability. But also in countries with high penetration rates, further increases in penetration rates may indicate the use of telephone lines for advanced telecommunications applications, such as telefax, call waiting, credit card confirmation and debit card payment in retail. For an interpretation of the telephone penetration measure, see also OECD (1999).

[17]The number of inhabitants is used as an indicator of market size.

$i = 1..48$, $j = 1..23$[18], and t is the year subscript, $t = 1988 \dots 1996$.

The variables of Equation 2.32 are defined analogously. For a detailed description of the data and data sources, see Appendix A. Some previous studies have included the GDP of the call originating country and the GDP of the destination countries as proxies for income. Others[19] have not included any measure for income at all. A particular empirical problem with including GDP in the empirical specification arises from nature of the panel data commonly used to estimate telephone Point-to-Point models. These panel data typically comprise observations of one call originating country and many destination countries. The overall GDP of the call originating country is not a useful proxy for income, because it provides no information about the relative income levels of telephone users of different outgoing routes. The lack of cross-sectional variation in the data is particularly problematic where a data sets contains short time series for a large number of cross sections, as it is the case here. The same is also true with all other non-route specific explanatory variables, such as total population, main line penetration, and fax machines in the call originating country.

Moreover, GDP, total population and main line penetration are highly correlated, such that including all three of them simultaneously will lead to multicollinearity. To deal with the problem of multicollinearity, the empirical specifications used in this study will omit GDP and total population as

[18]The country index in Equation 2.32 runs only to 23, since observations for P^f_{jt} were not available for all 48 countries.

[19]See Table 2.4.

explanatory variables[20].

Due to data restrictions, most previous studies of international telecommunications have not succeeded estimating the equation for incoming and outgoing traffic as a simultaneous equation system. Rather, they focused on estimating only one of the equations, or looked at both equations separately. Table 2.4 summarizes a number of previous demand studies and their results. Estimated price elasticities ranged from -0.32 to -1.9. Previous findings on income elasticities are somewhat more inconsistent, they range from 1.39 to 2.66[21].

Table 2.4. Price and Income elasticities of international telephone demand as reported by selected studies

Study	*Routes*	*Price Elastic.*	*Income Elastic.*	*Years of Data*
Lago(1970)	23 routes to/from US	-1.249	-	1962-64
Rea and Lage (1978)	37 routes to/from US	-1.7 to -1.9	1.92 to 2.66	1964-74
Acton and Vogelsang(1992)	17 routes to/from US	-0.36	1.39	1979-86
Garín-Muñoz and Pérez-Amaral(1997)	27 routes to/from Spain	-0.69	-	1981-91
Garín-Muñoz and Pérez-Amaral(1999)	24 routes to/from Spain	-0.32	-	1981-91

Source: Referenced Papers

[20]The variables to be omitted were chosen by successively eliminating those variables that were not significantly different from zero.

[21]Note that the elasticities at the high end of this range were estimated based on data from the 1960s and early 1970s, when international charges were considerably higher and international traffic volumes were lower than in the 1990s.

Table 2.5 shows the estimation results for US outbound demand, for two different estimation techniques. The first column reports the results using an empirical specification that assumes the presence of fixed route specific effects (fixed effects model)[22].

Two important issues that also need to be addressed in the context of telecommunications panel data are the simultaneity between outgoing traffic[23] and incoming traffic[24], and the potential presence of autocorrelation. Since the available data are typically not rich enough to estimate both relations simultaneously, previous empirical research has either ignored the problem of simultaneity altogether, or employed instrumental variable regression techniques.

Garín-Muñoz and Pérez-Amaral (1999), for example, use the one period lagged incoming traffic variable as instrument for the incoming traffic. This approach is valid, as long as the error terms are not serially correlated. In the presence of autocorrelation, however, the lagged variables are still cor-

[22]The results of the fixed effects estimation were compared and tested against a random effects model. Since the sample of routes used for this study is not exhaustive, i.e., represents only a subset of all US outbound routes, the random effects model can be a more appropriate choice of model than the fixed effects model, if the model is meant to allow for inferences regarding the entire set of international routes. However, if the route specific errors of the random model are correlated with other regressors, then the random effect model will produce inconsistent estimates. A Hausman test can be used to check the appropriateness of the random effects model. (for details about the random effects model and about how to test for the appropriateness of the random effects model versus the fixed effects model, see, for example, Kennedy (1996)). In the present case, the Hausman test statistic is 77.04, which is significant compared to the critical value of $\chi^2_{10} = 18.307$. Hence, the GLS for the random effect model is inconsistent, and the OLS is the preferred estimator.

[23]Represented by the variable T^h_{it}.

[24]Represented by the variable T^f_{it}.

Table 2.5. Estimation results for standard model of international telephone demand for traffic originating in the United States, using 1988-96 data

Dep var: lnT^h_{it} regressor	OLS F.E.	FGLS AR(1)	regressor	OLS F.E.	FGLS AR(1)
lnP^h_{it}	-0.647*	-0.441*	$lnIM^h_{it}$	0.036*	0.031*
	(-8.283)	(-7.586)		(2.382)	(2.060)
lnT^f_{it}	0.167*	0.168*	$lnML^h_t$	1.428*	2.069*
	(4.410)	(4.348)		(4.477)	(7.215)
$lnGDP^f_{it}$	-0.872	0.019	$lnML^f_{it}$	0.437*	0.431*
	(-1.281)	(0.220)		(7.636)	(7.685)
$lnTRADE_{it}$	-0.042	-0.036	$lnPOP^f_{it}$	0.762*	0.606*
	(-1.428)	(-1.685)		(3.913)	(3.908)
$lnTOUR^h_{it}$	0.004	0.004	*constant*	3.331	6.148*
	(0.094)	(0.124)		(0.781)	(2.664)
$lnTOUR^f_{it}$	0.160*	0.076*			
	(4.119)	(2.728)			
obs	338	330	R^2	0.990	-
rho	-	0.522			

related with the contemporaneous error term, their use as instrument is not appropriate.

In the context of this study, a test for autocorrelation suggests that the error terms are autocorrelated of the order one, making the use of lagged variable instrument inappropriate. There are two possible alternatives to the lagged variable instrument. One is P^f_{it}, the calling charges in countries f. In fact, P^f_{it} is the only regressor in Equation 2.32 that was not also included in Equation 2.31. The problem with this instrument is that the relevant data are not available for the full set of observation, and including this instrument will significantly reduce the degrees of freedom in the estimation. The second alternative is the *number* of incoming telephone calls, C_{it}^{f}. By definition, the number of incoming calls is correlated with the total number of incoming call minutes. Moreover, under the underlying assumption of this model type, that is, the number of calls do not need to be considered for estimating telephone demand, the number of incoming calls will be uncorrelated with the error terms, and can therefore serve as an instrument for the total traffic volume.

Using either instrument, or both instruments in an instrumental variable regression, and performing a Hausman test, indicates that the incoming traffic does not need to be considered as endogenous in this model[25].

The second column of Table 2.5 presents the Feasible Generalized Least Squares (FGLS) results under the assumption of first order autocorrelation. Although fixed effects specification reported in the first column is unbiased in the presence of autocorrelation, greater efficiency of the model that accounts for autocorrelated disturbances suggests that the latter is preferred among all the empirical models discussed in this section.

With the elasticity of -0.441, the first order effect of a price change on outgoing telephone traffic is highly significant and in the range of previous findings. Moreover, all estimates have shown to be relatively robust across different empirical specifications. The total volume of incoming traffic is positive and significant, which supports the hypothesis that the reciprocal

[25]The χ^2 statistic in the case of including C_{it}^{f} and P_{it}^{f} as instruments is 2.99 and below the critical value of $\chi_2^2 = 5.991$. Hence, the OLS remains a consistent estimator in this context.

calling effect is positive, and that it dominates the call substitution effect[26]. Other significant and positive variables are, the number of incoming tourists, immigration, the market sizes of the call receiving countries at the ends of a given relation, and the main line penetration at both ends of a given inter country relation.

Not significant are GDP of the call receiving countries, trade and outgoing tourism. Some of these effects may however have been picked up by the correction for route specific effects in the regression.

Table 2.6 reports the results of estimating the respective models for the incoming traffic, whereby, due to the lack of data, fixed route effects could not be accounted for. In the OLS regression, the hypothesis of first order autocorrelated residuals could not be rejected. Moreover, the results of a Hausman test performed on IV and OLS estimates suggested that the total volume of incoming traffic could not be considered as exogenous. OLS estimates are therefore both inconsistent and inefficient. The columns of Table 2.6 show the coefficient estimates of the model with a correction for first order autocorrelation[27] and the results of the instrumental variable regression, using C_{it}^h and P_{it}^h as instruments for T_{it}^h.

It is important to note that the reliability of a cross comparison between

[26]For a detailed description of these effects, see Larson, Lehman and Weisman (1986), Acton and Vogelsang (1992), and Garín-Muñoz and Pérez-Amaral (1999).

[27]Due to the endogeneity problem, these estimates are still inconsistent.

Table 2.6. Estimation results for standard model of international telephone demand for traffic with destination United States, using 1988-96 data

Dep var: lnT^h_{it} regressor	FGLS AR(1)	IV	regressor	FGLS AR(1)	IV
lnP^f_{it}	-0.162*	-0.262*	$lnIM^h_{it}$	-0.073*	-0.127*
	(-3.464)	(-5.472)		(-2.503)	(-5.775)
lnT^h_{it}	0.704*	0.701*	$lnML^f_{it}$	0.299*	0.389*
	(12.908)	(15.767)		(2.929)	(4.479)
$lnGDP^f_{it}$	-0.196*	-0.424*	$lnML^h_t$	-1.327*	-1.951*
	(-2.836)	(-6.776)		(-3.622)	(-5.815)
$lnTRADE_{it}$	0.014	0.047*	$lnPOP^f_{it}$	0.138*	0.314*
	(0.614)	(2.008)		(2.301)	(6.119)
$lnTOUR^f_{it}$	-0.353*	0.448*	$constant$	3.399*	5.222*
	(-7.889)	(11.058)		(3.788)	(6.426)
$lnTOUR^h_{it}$	-0.013	-0.042*			
	(-0.505)	(-2.141)			
obs	197	186	R^2	-	0.9863
rho	0.556	-			

the results for outbound demand estimation[28] and inbound demand estimation[29] is only limited. For one, the empirical models are different: in the former case they include fixed effects, whereas in the latter they do not. More importantly, the characteristics of countries routes included in the estimations are different. The inbound results include exclusively observations from OECD countries, whereas the outbound demand estimations are based on observations from routes to both OECD and non-OECD countries.

The total effect, or long run equilibrium effect, of a price change on outgoing telephone traffic can be computed by computing a closed form solution

[28]See Table 2.5.
[29]See Table 2.6.

for T^h_{it} from the system of equations 2.31 and 2.32. The total effect of a price change on the total traffic volume can then be computed from

$$\frac{\partial \ln T^h_{it}}{\partial \ln P^h_{it}} = \frac{\beta_1}{1-\beta_2\delta_2} \tag{2.33}$$

$$\frac{\partial \ln T^f_{it}}{\partial \ln P^f_{it}} = \frac{\delta_1}{1-\delta_2\beta_2} \tag{2.34}$$

Hence, with the estimated coefficients of -0.441 and -0.262 for outgoing and incoming traffic, respectively[30], total price elasticities are -0.500 and -0.296. While the elasticity estimate for incoming traffic is slightly below the most recent published findings (compare to table 2.4), the estimate of the price elasticity of outgoing call demand is well within the range of demand studies conducted throughout the previous decade.

2.4.2 Models with Exogenous Call Duration

The empirical specification of Equations 2.31 and 2.32 change when the call duration is included as an exogenous variable. From Equation 2.12, the appropriate respective empirical specification becomes

$$\begin{aligned} \ln C^h_{it} &= \beta_0 + \beta_1 \ln PC^h_{it} + +\beta_2 \ln PM^h_{it} + \beta_3 \ln C^f_{it} + \beta_4 \ln D^h_{it} \\ &+ \beta_5 \ln D^f_{it} + \beta_6 \ln GDP^f_{it} + \beta_7 \ln TRADE_{it} + \beta_8 \ln TOUR^h_{it} \end{aligned} \tag{2.35}$$

[30]Given the incomparability of results, this should be merely regarded as a demonstration exercise.

$$
\begin{aligned}
&+ \quad \beta_9 \ln TOUR^f_{it} + \beta_{10} \ln IM^h_{it} + \beta_{11} \ln ML^h_t + \beta_{12} \ln ML^f_{it} \\
&+ \quad \beta_{13} \ln POP^f_{it} + \beta_{14} \ln FAX^h_t + \beta_{15} \ln FAX^f_{it} + \epsilon^h_{it}
\end{aligned}
$$

$$
\begin{aligned}
\ln C^f_{it} \quad &= \quad \delta_0 + \delta_1 \ln PC^f_{it} + \delta_2 \ln PM^f_{it} \delta_3 \ln C^h_{it} + \delta_4 \ln D^h_{it} \\
&+ \quad \delta_5 \ln D^f_{it} + \delta_6 \ln GDP^f_{it} + \delta_7 \ln TRADE_{it} + \delta_8 \ln TOUR^f_{it} \qquad (2.36) \\
&+ \quad \delta_9 \ln TOUR^h_{it} + \delta_{10} \ln IM^h_{it} + \delta_{11} \ln ML^f_{it} + \delta_{12} \ln ML^h_t \\
&+ \quad \delta_{13} \ln POP^f_{it} + \delta_{14} \ln FAX^f_{it} + \delta_{15} \ln FAX^h_t + \epsilon^f_{it}
\end{aligned}
$$

where the newly introduced variables are defined as follows

PC^h_{it}	Connection charge for a call from the US to country i in year t, deflated by the CPI
PM^h_{it}	Marginal, per minute Charge for a call from the US to country i in year t
C^h_{it}	Number of calls from the US to country i in year t
D^h_{it}	Average duration of calls from the US to country i in year t
FAX^h_t	Estimated number of fax machines in the US in year t
FAX^f_{it}	Estimated number of fax machines in country i and year t[31]

and all other variables are defined analogously as in the context of Section 2.4.1.

[31]Fax machines are included in this specification as they may contribute to explaining the variation of call durations.

The empirical strategy for estimating Equation 2.35 is also analogous to that of Section 2.4.1. Table 2.7 reports the empirical results for the fixed effect model and the model with correction for first order autocorrelation[32]. In the context of this model, the Hausman specification test indicates that the random effects model is incorrectly specified (at $\chi^2_{15} = 280.31$). Again, the Hausman specification test is also used to test whether C^f_{it} can be considered as exogenous. The OLS is compared to the instrumental variable estimator with P^f_{it} and all exogenous variables of Equation 2.35 as instruments. As observed with the previous models, the hypothesis that C^f_{it} is endogenous is rejected[33].

As expected, the price elasticities with respect to both connection charge and marginal calling charge are negative and highly significant. The coefficient on call duration is negative and highly significant, indicating that users substitute the number of calls with call duration, or, in the context of Equation 2.9, the price effect of the duration change dominates the utility effect. The coefficient on call durations of incoming calls, however, is insignificant. The effect of an increase of incoming calls on outgoing calls is positive and significant, confirming the presence of positive reciprocal effect also with respect to *number of calls.* Analogous to the previous model, the coefficients

[32]As specified in Equation 2.12, the dependent variable is C^h_{it}. T^h_{it} is deterministically dependent on C^h_{it} in this specification (see Equation 2.10), such that the estimation of T^h_{it} yields equivalent parameter estimates, except of the coefficient on D^h_{it}, which then is estimated to be $\beta_4 = 0.572$ ($t = 4.329$) and $\beta_4 = 0.350$ ($t = 3.308$) for the fixed effects model and the model with correction for autocorrelation, respectively.

[33]At $\chi^2_{12} = 1.99$.

Table 2.7. Estimation results for model of international telephone demand for calls originating in the United States, with exogenous call durations, using 1988-96 data

Dep var: lnC_{it}^h regressor	OLS F.E.	FGLS AR(1)	regressor	OLS F.E.	FGLS AR(1)
$lnPC_{it}^h$	-0.037*	-0.039*	$lnTOUR_{it}^h$	0.057	0.018
	(-2.175)	(-3.577)		(1.359)	(0.597)
$lnPM_{it}^h$	-0.587*	-0.346*	$lnTOUR_{it}^f$	0.024	0.019
	(-6.391)	(-5.103)		(0.562)	(0.683)
lnC_{it}^f	0.132	0.123*	$lnML_t^h$	0.593	1.277*
	(1.749)	(2.112)		(1.294)	(3.423)
lnD_{it}^h	-0.428*	-0.650*	$lnML_{ti}^f$	0.591*	0.559*
	(-3.241)	(-6.153)		(7.460)	(8.206)
lnD_{it}^f	0.071	0.757	$lnFAX_t^h$	0.161*	0.142*
	(0.770)	(1.071)		(3.810)	(4.128)
$lnGDP_{it}^f$	0.049	0.036	$lnFAX_{it}^f$	-0.014	-0.016
	(0.664)	(0.650)		(-0.499)	(-0.694)
$lnIM_{it}^h$	0.044*	0.052*	$lnPOP_{it}^f$	0.701*	0.595*
	(2.463)	(3.058)		(3.568)	(3.892)
$lnTRADE_{it}$	-0.034	-0.011	*constant*	0.013	3.498
	(-1.189)	(-0.555)		(0.004)	(1.589)
obs	266	266	R^2	0.956	-
rho	-	0.533			

F.E. = Fixed Effects

on tourism (both directions), GDP of the call destination country, and trade are all insignificant, whereas significant positive effects were found for the mainline penetration of both countries, immigration, and destination country market size. The number of fax machines in the US was found to have a significant positive effect, while that in the call destination countries had no significant effect.

2.4.3 Models with Endogenous Call Duration

The final set of empirical models is based on the theoretical framework of Section 2.3.3. When call durations are assumed to be endogenous, the empirical specification for demand in country h becomes

$$\begin{aligned}
\ln C_{it}^h &= \beta_0^h + \beta_1^h \ln PC_{it}^h + \beta_2^h \ln PM_{it}^h + \beta_3^h \ln C_{it}^f + \beta_4^h \ln D_{it}^f \\
&+ \beta_5^h \ln GDP_{it}^f + \beta_6^h \ln TRADE_{it} + \beta_7^h \ln TOUR_{it}^h \qquad (2.37) \\
&+ \beta_8^h \ln TOUR_{it}^f + \beta_9^h \ln IM_{it}^h + \beta_{10}^h \ln ML_t^h + \beta_{11}^h \ln ML_t^f \\
&+ \beta_{12}^h \ln POP_{it}^f + \beta_{13}^h \ln FAX_t^h + \beta_{14}^h \ln FAX_{it}^f + \epsilon_{it}^h
\end{aligned}$$

$$\begin{aligned}
\ln D_{it}^h &= \delta_0^h + \delta_1^h \ln PC_{it}^h + \delta_2^h \ln PM_{it}^h + \delta_3^h \ln C_{it}^f + \delta_4^h \ln D_{it}^f \\
&+ \delta_5^h \ln GDP_{it}^f + \delta_6^h \ln TRADE_{it} + \delta_7^h \ln TOUR_{it}^h \qquad (2.38) \\
&+ \delta_8^h \ln TOUR_{it}^f + \delta_9^h \ln IM_{it}^h + \delta_{10}^h \ln ML_t^h + \delta_{11}^h \ln ML_t^f \\
&+ \delta_{12}^h \ln POP_{it}^f + \delta_{13}^h \ln FAX_t^h + \delta_{14}^h \ln FAX_{it}^f + \nu_{it}^h
\end{aligned}$$

An equivalent set of equations can be specified for incoming traffic, but is omitted at this point.

Equations 2.37 and 2.38 are directly based on the system of equations 2.17. A structural equation specification would not be feasible in this case, because both equations contain the same set of exogenous variables. Including C_{it}^h on the right hand side of equation 2.38 and D_{it}^h on the right-hand-side of equation 2.37, respectively, would hence leave both equations unidentified.

Therefore, under the assumption that the number and duration of incoming calls is exogenous to the above system, the equations would have no direct or indirect interaction. Where simultaneous Equations 2.37 and 2.38 do not interact, there may still be a relation between the error terms, and using the Seemingly Unrelated Regression (SUR) technique may improve the efficiency of estimation.

Note however that because the set of right hand variables in both equations is the same, no gains can be realized from the SUR technique, as it becomes identical to OLS.

The crucial assumption here is, of course, that there is no simultaneous equation bias due to an interaction between incoming and outgoing traffic. For the previous models, results showed the effect of incoming traffic could in deed be considered exogenous when estimating the demand for US outgoing telephone traffic, and OLS produced consistent estimators. The further estimation strategy for this model will have to rely on the assumption that what was true in the standard models and in the models with exogenous call duration is still true here[34].

The two dependent variables, C_{it}^h and D_{it}^h determine the total number of call minutes, T_{it}^h, in a non-stochastic fashion. In order to fully identify the

[34]This assumption is needed because, first, the number of observations is not sufficient to estimate more complex specifications, second, instruments used in previous regressions will also be endogenous in this model, and third, error terms are autocorrelated such that the variables cannot be instrumented with their own lags. Hence, there are no appropriate instruments available to empirically test the assumption that OLS is consistent.

demand system of C_{it}^h, D_{it}^h, and T_{it}^h, one needs to estimate only two of the three relevant demand equations. For the ease of comparison to previous results, Table 2.8 reports the OLS estimates and the FGLS estimates under the assumption of first order autocorrelated disturbances for all three equations.

Although the results of the two estimation techniques are qualitatively similar, the estimation with correction for autocorrelation is preferred, as it is more efficient than OLS.

The main estimates of interest, that is, the coefficients on the price variables, are highly significant in all regressions. Consistent with the framework of Section 2.3.5, the "own" price elasticity of calls[35] is negative (Equation 2.26). As expected, the cross price elasticity of duration[36] was found to be positive, whereas the remaining elasticities are both negative[37].

The total effect of a price change on demand can be computed from

$$\begin{pmatrix} \frac{\partial \ln C_{it}^h}{\partial \ln PC_{it}^h} & \frac{\partial \ln C_{it}^h}{\partial \ln PM_{it}^h} \\ \frac{\partial \ln D_{it}^h}{\partial \ln PC_{it}^h} & \frac{\partial \ln D_{it}^h}{\partial \ln PM_{it}^h} \\ \frac{\partial \ln C_{it}^f}{\partial \ln PC_{it}^f} & \frac{\partial \ln C_{it}^f}{\partial \ln PM_{it}^f} \\ \frac{\partial \ln D_{it}^f}{\partial \ln PC_{it}^f} & \frac{\partial \ln D_{it}^f}{\partial \ln PM_{it}^f} \end{pmatrix} = \begin{pmatrix} 1 & 0 & -\beta_3^h & -\beta_4^h \\ 0 & 1 & -\delta_3^h & -\delta_4^h \\ -\beta_3^f & -\beta_4^f & 0 & 1 \\ -\delta_3^f & -\delta_4^f & 0 & 1 \end{pmatrix}^{-1} \begin{pmatrix} \beta_1^h & \beta_2^h \\ \delta_1^h & \delta_2^h \\ \beta_1^f & \beta_2^f \\ \delta_1^f & \delta_2^f \end{pmatrix} \tag{2.39}$$

Assuming that outgoing traffic and incoming traffic are symmetrical[38], the

[35] That is, the coefficient on $\ln PC_{it}^h$ in the regression of C_{it}^h.

[36] that is, the coefficient on $\ln PC_{it}^h$ in the regression of D_{it}^h

[37] Recall that this framework provided that the signs of these elasticities was ambiguous.

[38] That is, $\beta_i^h = \beta_i^f$ and $\delta_i^h = \delta_i^f$ for $i = 3, 4$.

Table 2.8. Estimation results for model of international telephone demand for calls originating in the United States, with endogenous call durations, using 1988-96 data

regressor		OLS F.E.			FGLS AR(1)	
dep. var.	$\ln C_{it}^h$	$\ln D_{it}^h$	$\ln T_{it}^h$	$\ln C_{it}^h$	$\ln D_{it}^h$	$\ln T_{it}^h$
$\ln PC_{it}^h$	-0.052*	0.029*	-0.023	-0.051*	0.022*	-0.033*
	(-3.046)	(3.279)	(-1.359)	(-4.426)	(3.331)	(-2.951)
$\ln PM_{it}^h$	-0.474*	-0.159*	-0.633*	-0.327*	-0.105*	-0.373*
	(-5.326)	(-3.474)	(-7.149)	(-4.443)	(-2.615)	(-5.246)
$\ln C_{it}^f$	0.076	-0.029	-	0.125*	0.000	-
	(1.576)	(-1.161)	-	(1.971)	0.004	-
$\ln D_{it}^f$	-0.010	0.029	-0.028	0.039	0.061	-0.025
	(-0.138)	(0.800)	(-0.478)	(0.508)	(1.472)	(-0.586)
$\ln T_{it}^f$	-	-	0.047	-	-	0.122*
	-	-	(0.981)	-	-	(2.055)
$\ln GDP_{it}^f$	0.073	-0.059	0.014	0.067	-0.051	0.020
	(0.986)	(-1.545)	(0.189)	(1.106)	(-1.532)	(0.394)
$\ln TRADE_{it}$	-0.014	-0.001	-0.015	-0.023	0.014	-0.006
	(-0.477)	(-0.066)	(-0.513)	(-1.033)	(1.155)	(-0.309)
$\ln TOUR_{it}^h$	0.043	-0.010	0.033	0.026	-0.011	0.017
	(1.022)	(-0.447)	(0.795)	(0.767)	(-0.628)	(0.559)
$\ln TOUR_{it}^f$	0.069	-0.000	0.069	0.021	-0.003	0.017
	(1.691)	(-0.000)	(1.696)	(0.705)	(-0.020)	(0.610)
$\ln IM_{it}^h$	0.037*	-0.008	0.028	0.055*	-0.007	0.050*
	(2.102)	(-0.966)	(1.610)	(3.070)	(-0.768)	(2.911)
$\ln ML_t^h$	0.947*	-0.838*	0.108	1.728*	-0.895*	0.958*
	(2.173)	(-3.727)	(0.251)	(4.478)	(-4.365)	(2.620)
$\ln ML_{it}^f$	0.501*	0.127*	0.629*	0.514*	0.089*	0.587*
	(7.521)	(3.698)	(9.468)	(7.148)	(2.364)	(8.504)
$\ln POP_{it}^f$	0.652*	0.058	0.710*	0.554*	0.072	0.624*
	(3.329)	(0.579)	(3.642)	(3.356)	(0.812)	(4.006)
$\ln FAX_t^h$	0.267*	-0.114*	0.152*	0.199*	-0.090*	0.111*
	(8.331)	(-6.928)	(4.775)	(5.584)	(-4.761)	(3.283)
$\ln FAX_{it}^f$	-0.043*	0.019	-0.023	-0.017	0.000	-0.016
	(-2.109)	(1.853)	(-1.158)	(-0.662)	(0.013)	(-0.687)
constant	-1.540	4.444*	2.903	1.423	3.119*	4.472*
	(-0.428)	(2.359)	(0.811)	(0.603)	(2.461)	(2.007)
obs	298	298	298	266	266	266
R^2	0.952	0.810	0.923	-	-	-
rho	-	-	-	0.463	0.337	0.531

F.E. = Fixed Effects

long run elasticities are then

$$\begin{pmatrix} \frac{\partial \ln C_{it}^h}{\partial \ln PC_{it}^h} & \frac{\partial \ln C_{it}^h}{\partial \ln PM_{it}^h} \\ \frac{\partial \ln D_{it}^h}{\partial \ln PC_{it}^h} & \frac{\partial \ln D_{it}^h}{\partial \ln PM_{it}^h} \end{pmatrix} = \begin{pmatrix} -0.057 & -0.379 \\ 0.023 & -0.112 \end{pmatrix} \tag{2.40}$$

All coefficients on main line penetration (in the US and in the call receiving countries) and on the number of US fax machines are significant. The effect of the number of Fax machines is positive on the number of calls and on total call minutes, but negative on call durations. Also significant and positive is the effect of incoming number of calls on outgoing number of calls, and the effect of incoming total call minutes on outgoing total call minutes. Market size and Immigration have a positive significant effect on number of calls and total call minutes, but no significant effect on call duration.

All remaining variables, including GDP of the call receiving countries, Trade, and Tourism, have no significant effect. However, some of these effects could have been picked up by the complete set of dummy variables included in the estimation[39].

2.4.4 Discussion

In the light of the empirical results, there are three basic issues that call for a more detailed discussion. The first issue concerns the comparison of

[39] 9 of 41 dummy variables included in the estimation of total traffic volume are significant. In the estimation of call duration, only 2 out of 42 variables turned out to be significant. Omitting the insignificant variables would increase the significance most estimates, but qualitatively not alter the results.

the different model specifications. Is it necessary to consider call durations in telecommunications demand analysis, and if yes, should call durations be considered as exogenous or endogenous? Second, the results need to be tied to the discussion about the causes of decreasing call durations. Which are the factors that cause the variation of calling patterns? Finally, what are the main implications of this research for the telephone service providers with respect to pricing of international telephone services?

Model Comparison. Given the data limitations in this study, the conclusions drawn with respect to the different model specifications must remain subject to future investigation. However, the empirical results clearly support the relevance of the extensions to the standard telecommunications demand model presented in this paper. The result that call duration is significant when used as an (exogenous) explanatory variable for the total minutes of telephone traffic (Equation 2.35) is not surprising. After all, total minutes of telephone traffic is the product of number of calls and call duration.

More interestingly, however, are the results of the more general model - the model with endogenous call duration. Estimating the demand for call duration indicates that the key coefficients of Equation 2.37, that is, the coefficients on the price variables, are significantly different from zero. One can therefore conclude, that call duration should be considered as endogenous[40].

The difference between the specification with endogenous call durations

[40]On the other hand, if the coefficients of Equation 2.37 were insignificant, then the hypothesis of endogenous call durations would have to be refuted in favor of the exogenous duration hypothesis.

and the standard empirical specification is that the endogenous specification involves including the connection price, PC_{it}^h, and incoming call durations, D_{it}^f, as relevant parameters, whereas the standard model does not. When estimated, the coefficient on the former parameter is significant but small, the coefficient on the latter parameter is not significantly different from zero. Hence, the standard demand model is misspecified to the extent that it omits the connection charge as a relevant variable.

The good news for traditional "standard" demand modeling, on the other hand, is that the error of misspecification can be considered as small, because the coefficient on the connection charge variable, if included, is small.

Determinants of Call Duration. The empirical results shown in Table 2.8 support several explanations for the observed traffic patterns. One of the central observations of Section 2.2 was that total telephone traffic increases throughout the period of observation, whereas call durations decreases. Hence, the variables of interest are those where the coefficients in the demand equation for *call duration* significantly differ from those in the demand equation for *total minutes of traffic.*

The variable with the greatest influence in this context is ML_t^h, the main line penetration in the United States. The elasticity of main line penetration in the duration equation is -0.895, versus 0.958 in the total traffic equation. Main line penetration has a significant and strong negative effect on call duration, but a strong positive effect on total traffic volume. The respective coefficients on the foreign countries' main line penetration, ML_{it}^f, do not indicate a negative relationship with call duration. Yet, the coefficients are significant and small (0.089) in the case of call duration, and significant and large (0.587) in the case of total call volume. With main line penetration interpreted as a proxy for the availability of advanced communications technology and services (see footnote 16), this result empirically supports the hypothesis that changes of traffic patterns are to a large extent due to technological change and service innovation.

A more specific indicator for the development of terminal equipment technology, the coefficient on FAX_t^h is estimated to be -0.09 in the duration equation, but 0.11 in the total traffic equation.

Another significant, albeit smaller effect is due to the pricing of international telephone services. The gradual decline of connection charges in the period of observation had a significant negative effect (-0.022) effect on call duration, yet a significant positive effect (-0.033) on total traffic volume.

The effect of incoming traffic volume on total outgoing traffic volume is positive and significant, whereas the effect of incoming traffic on call duration is not significantly different from zero. Moreover, the duration of incoming calls has no significant effect on the duration of outgoing calls. Together, these results are consistent with the hypothesis of arbitrage, although it may also be partly due to a combination of other effects, such as call substitution and call stimulation.

The two remaining reasons for changing calling patterns discussed in section 2.2.2 are *Technical Network Failures*, and *Cultural Differences.* None of these explanations are supported by the empirical results. The impact of technical network failures could not be assessed, since no appropriate measures for this effect were available. Finally, the majority of dummy variables included in the estimation was not significantly different from zero[41], indicating that there were no significant route specific effects on most routes. The existence of *cultural differences* in calling patterns would have been reflected in such route specific effects, and can therefore be refuted.

Implications for Pricing of Telephone Services. The changes of calling patterns described and analyzed in this paper are of interest in the context of pricing of telecommunications services. Call dial ups utilize costly network capacity. Shorter call durations result in shorter (charged) calls relative to (uncharged) dial-up time, and will therefore increase the per minute cost of a call. The shorter the call duration, the greater the relative importance of including their assessment for the purpose of demand forecasting and capacity planning.

An noteworthy aspect of this analysis is that it allows for a comparison between the consumers' price sensitivity to changes in connection charges, and their price sensitivity to changes in marginal calling charges. An average telephone call, that is, a telephone with mean duration (7.16 minutes), mean connection charge ($1.03) and mean marginal charge ($1.10), costs $8.91. A one percent increase of the total charge for such a call, solely by adjustment of the connection charge, would result in a decrease of the long-run demand

[41] See footnote 39.

for telephone calls by 0.49 percent. The same increase of the total charge, solely by adjustment of the marginal charge, would result in a decrease of long-run demand by for calls 0.44 percent. While the difference between these elasticities is small, the results indicates that there is empirically no evidence that users ignore connection charges, or that they are less sensitive to changes of connection charges than to changes of marginal charges.

In a market where service providers possess market power, connection charges are a useful tool to extract additional rents from users, if demand is less elastic with respect to changes of the connection charge than with respect to changes of the marginal charges. In the reverse, if telephone users are more sensitive to connection than to marginal charges, the usefulness of connection charges as a pricing tool is questionable. The estimates presented here empirically support the latter proposition. They help explaining, why service providers have gradually phased out connection charges on international routes.

In the past two years, connection charges have had a renaissance with resale carriers. Their pricing schedule often includes a low, close to cost-level marginal charge, and a comparably high connection charge.[42] The implications of this demand study for the resale market may however be limited. First, the market conditions have considerably changed since 1996, the last year of the observation period. Second, users of resale services may exhibit

[42]For example, in 2000, Canadian resale carriers offered calls to Europe for as low as US$0.054, with a call connection charge of $3.00.

different demand characteristics than users of facilities-based carriers. Third, charges of resale carriers are considerably different from those of those included in this study, that is, the typical connection charge of a resale carrier is far above the sample maximum of the dataset used for this study, while the typical marginal charge is far below the sample minimum. However, given the availability of appropriate disaggregated data, the methodology employed in this study can also provide the basis for an empirical investigation of telephone resale service pricing.

2.5 Summary and Conclusion

The paper extends traditional telephone demand analysis introducing the aspect of call durations into the Point-to-Point demand model framework. It develops the theoretical foundations and explores the implications for the cases of two alternative assumptions, the assumption that call average call durations are determined exogenously, and the assumption that telephone users simultaneously choose the number of calls they make and the average durations of these calls.

The empirical results derived from these extended frameworks provide a number of insights into the *structure* of international telephone calling patterns. First, the results confirm the hypothesis that users regard call durations as a decision variable for their choice of international telephone service use. The findings do not support the hypothesis that telephone users only value total minutes of traffic conversation, no matter what the average call duration is.

Second, the results explain the observation that during the past decade call durations have significantly decreased on international routes, whereas both total traffic volume and the number of telephone calls have increased. The reasons for this shift in calling patterns can be found in both technological and economic factors. A large part of it can be attributed technological change and service innovation in the telecommunications industry and in the terminal equipment market. To a lesser extent, the gradual phasing out of connection charges for international telephone calls has also contributed to the decrease. The hypothesis that cultural factors or arbitrage behavior contributed to the shift of calling patterns was not be supported by the data.

The analysis of call duration is important for telecommunications network planning, as the decrease of average call duration increases the significance of (unbilled) dial up time relative to the (billed) telephone conversation time. The framework presented in this paper can also be applied to assess the implications of currently popular pricing schedules with high connection charges and low marginal charges on telephone users' calling behavior.

Chapter 3

The Proportionate Return Requirement: Regulatory Overkill in International Telecommunications

3.1 Introduction

The Proportionate Return Requirement (PRR) is a regulatory rule that governs interconnection agreements between international telecommunications carriers. It stipulates that the incoming telephone traffic will be allocated among operators according to their respective share of the outgoing traffic. The PRR has been implemented in the United States as one of the three major features of the International Settlements Policy (ISP), a set of competitive safeguards with the objective of restricting the market power of foreign monopolists in the competitive US international telecommunications market.

The WTO Agreement on Basic Telecommunications Services (WTO 1997) has triggered a recent policy debate about the need for competitive safeguards in international telecommunications. Some analysts argued that the WTO Agreement would lead to more competition, undercutting monopolists' market power and thus making competitive safeguards superfluous. Others argued that the economic cost of such safeguards would outweigh their economic benefits.

The US Federal Communications Commission (FCC), on the other hand, holds that as long as a foreign carrier has market power in its home market, it will be able to exercise this market power to the detriment of US carriers and consumers, if competitive safeguards are not in effect. The FCC has therefore decided to continue applying the ISP on those international routes, where the foreign correspondent carrier possesses market power, while at the same time eliminating the ISP on routes between US carriers and competitive foreign carriers. As a result, the ISP is no longer in effect on a number of routes to countries with pro-competitive telecommunications policies, which together account for a significant portion of international traffic volumes and revenues. For the remainder of the routes, the FCC has in principle reasserted its settlement policy (FCC 1999b). Large US carriers have shared this view and pleaded in favor of competitive safeguards on routes to non-liberalized countries (AT&T 1998, Sprint 1998).

The objective of this paper is neither to dispute the need for competitive safeguards in general, nor to dispute the need to prevent whipsawing of competitive US carrier by foreign monopolists. Rather, this paper is specifically concerned with the *cumulative* effect of regulations introduced under the ISP. It will show that the FCC's policy of requiring proportionate allocation of return traffic is flawed on two accounts. First, the FCC's arguments for the PRR are partly based on an erroneous interpretation of historic case law. Contrary to FCC claims, the PRR is not needed over and above other regulations to prevent whipsawing. Second, the PRR distorts output decisions and price decisions in markets for outgoing and incoming international traffic to the detriment of US carriers. Foreign monopolists, on the other hand, may benefit from the PRR. On international routes where competitive or near competitive conditions on US outbound call markets prevail, the PRR has a negative effect on total US welfare.

The remainder of this paper is organized as follows. Section 3.2 gives an overview of the institutional characteristics and regulation of international telecommunications and discusses previous literature on international interconnection. Section 3.3 provides a historic perspective on the PRR in the United States, and critically assesses the justification of this policy. The FCC has adjusted its regulation of international telecommunications in recent years to account for global trends of liberalization and growing competition. These adjustments are reviewed in section 3.4. Section 3.5 discusses the effect of the PRR on the market conduct of international carriers, and its welfare implications. Section 3.6 summarizes and concludes. A glossary of acronyms in included in Appendix B.

3.2 Institutional Characteristics and Regulation of International Interconnection

The PRR is a policy that was specifically designed to regulate telecommunications markets in which interconnection arrangements are based on the Accounting Rate System[1]. Under the Accounting Rate System, the key economic parameter of any international interconnection agreement is the settlement rate, a call termination charge paid by the operator in the call-originating country to the operator in the country of the call destination[2]. Settlement rates are usually set to the same level in both directions.

Settlement rates are determined through bilateral negotiations between international carriers. They therefore reflect the prevailing market conditions and policy objectives in each country as well as the relative bargaining position of the carriers involved. Within the general framework of the Accounting Rate System, operators are autonomous in negotiating the specifics of their operating agreements. Yet, a number of factors limit the operators' autonomy. First, the ITU recommendations themselves recognize that settlement rates in each direction of the same relation should be approximately

[1]The Accounting Rate System is a set of international regulations for inter-carrier operating agreements with the status of an international treaty. For a detailed discussion, see for example Ploman (1982), CCITT (1988), and OECD (1994). While the principles put forward by these regulations are general, the regulations note that operating agreements should take into consideration the relevant ITU recommendations, specifically the series D1 to D.195.

[2]Another term commonly used in this context is the term *Accounting Rate.* An Accounting Rate is the sum of the two settlement rates on a given relation, intended to reflect the total per minute cost of an international call from origin to destination.

symmetric, and that accounting rates should be cost based[3]. Second, many countries lack a clear distinction between operator, regulator and government. To the extent that governments can influence the bargaining process between operators, decisions are often subject to vested interests outside the operators' organizations, or even outside the telecommunications industry[4]. Third, even in countries with a clear institutional separation, national regulators may choose to intervene in the bargaining process.

The ISP is an example of such an interventionist policy[5]. The ISP is specifically concerned with the asymmetry of bargaining power between competitive US carriers on one side, and monopolistic carriers on the other side of a relation. With the objective to prevent the US carriers from being "whipsawed"[6] by foreign monopolists, it imposes three restrictions on inter-carrier bargaining outcomes: the Uniform Settlements Rule, the Even Splitting Rule and the Proportionate Return Requirement. The Uniform Settlements Rule

[3]For details on the ITU recommendations, refer to the ITU-D series of recommendations, in particular D.140, D.150, D.151, and D155 (ITU 1999).

[4]Many countries, in particular developing countries, use international telephone calls to generate "tax" revenues, which are used to build up the telecommunications infrastructure. The carriers of some developing countries derive up to 50% of their annual profits from international settlement payments. Others divert international settlement payments into the countries' general budget. For this and more information see www.itu.org.

[5]The UK government historically used a set of competitive safeguards to regulate international telecommunications markets, but abolished these safeguards in 1996, arguing that the gains form open competitive markets outweigh the risk that such radical deregulation might give too much bargaining power to monopolies in other countries. The British regulator however reserved the right to intervene subsequently, if it finds that anti-competitive behavior between market participants is occurring. (Tyler and Bednarczyk 1998). Canada adopted a similar policy in 1998. (CRTC 1998).

[6]The FCC defines "whipsawing" as "playing U.S. carriers against each other to the disadvantage of U.S. carriers and U.S. ratepayers" See, for example, FCC (1999b) at 8.

requires that the conditions of an interconnection agreement that a foreign carrier offers to one US carrier must also be available to all other US carriers. Under the Even Splitting Rule, the accounting rate is evenly split between the carriers, i.e., US carriers must receive the same settlement rate for terminating inbound traffic that they pay to the foreign carrier for terminating US outbound traffic.

The Proportionate Return Requirement states that US carriers are allowed to accept incoming traffic only in the proportion of their market share of outgoing traffic. Faced with a soaring deficit in US settlement payment balance[7] and with settlement rates that by far exceed the cost of international calls, the FCC has also become increasingly concerned with the absolute level of settlement rates.

This concern resulted in the implementation of an additional restriction, which stipulates upper bounds ('benchmarks') for settlement rates. Under the Benchmark Restriction, US carriers are required to negotiate settlement rates at or below a level prescribed by the FCC.[8]

With their ISP, the US arguably has implemented the most 'heavy handed' international telecommunications policy among all countries with competitive telecommunications environments. The FCC itself acknowledged some

[7]The US net settlement payments amounted to $5.5 billion in 1997 (FCC 1999a).

[8]See FCC 1997c. Additionally, two supplements to the ISP provide that settlement rates have to be made publicly available (FCC 1990), and that US international carriers are prohibited from accepting "special concessions", defined as "any arrangement that affects traffic or revenue flow to or from the United States that is offered exclusively by a foreign carrier or administration to a particular carrier and not also to similarly situated US international carriers authorized to service a particular route", see FCC (1997a).

of the anti-competitive effects of this approach (FCC 1996b at 7-19), but largely maintained its policy arguing that the benefits from limiting "whipsawing" would clearly outweigh its economic cost. Analysts and researchers, on the other hand, have criticized the ISP on a number of grounds. One major point of criticism is that the benchmark requirement applies not only to US carriers but also to their correspondent foreign carriers. By unilaterally imposing benchmark rates, the FCC appears to have exceeded the boundaries of its jurisdiction (Tyler and Bednarczyk 1998), and violated fair trade principles (Frieden 1998).

More fundamental objections are raised by two theoretical studies. O'Brian (1988) finds that, contrary to common intuition, the Uniform Settlements Rule may in fact be the precise cause of the "whipsawing" problem, rather than its remedy. Hakim and Lu (1993) show that the Even Splitting Rule raises the collection charges when settlement rates are high. Both studies indicate that the Uniform Settlements and Even Splitting components of the ISP may not only cause some limited economic distortions, but also directly violate their very policy objectives.

The effect of the PRR has so far received little attention by researchers. Galbi (1998) analyzes the effects of the PRR on facilities-based carriers' outputs and total welfare in a general equilibrium framework. Scanlan (1998) assesses the effect of callback services in a country-pair market where proportionate return is stipulated. Using stylized accounts of international settlement payments, he finds that, contrary to common beliefs, a callback service may benefit the monopolist in the country where callback is offered, and harm the carriers in the country from where the service is operated.

3.3 The Regulatory History of the Proportionate Return Requirement

In order to analyze the economic effect of the PRR, it is important to understand why this policy rule was developed and how it relates to the body of FCC regulations regarding international telecommunications. Although PRR was formally codified as a policy rule only in 1991 (FCC 1990, FCC 1991, FCC 1996b), proportionate return rules have been part of international interconnection agreements between foreign carriers and US record carriers at least since the 1950s[9]. The FCC made clear that it viewed the 1990 ruling not as a new policy, but rather as the affirmation of a "longstanding U.S. regulatory policy," which had always been "imbedded" in the ISP (FCC 1996b at 24).

This view is questionable. Although it is true that FCC has repeatedly stated concerns about foreign monopolists' market power over competitive US carriers over the past 60 years, it has by no means consistently applied

[9]In the FCC's terminology, a record carrier is a telecommunications carrier that specializes in the transmission of documentary information, such as telegraphs, telegrams and telex. Record carriers traditionally used terrestrial (cable) or radio circuits for the transmission of information. Unlike in international public switched voice communications markets, which were exclusively served by AT&T until the mid 80s, the FCC has always allowed some degree of competition in markets for international record services.

the PRR as a policy tool to limit this market power. Rather, the PRR has developed as a generally accepted feature of international interconnection agreements, which the Commission considered to be compatible with, but not essential for, its regulatory objectives on the majority of international routes.

3.3.1 The Role of Proportionate Return in the Early Case Law

The first and arguably most frequently cited FCC proceeding in the context of international telecommunications is the Mackay Radio case of 1936 (FCC 1936). Mackay Radio had filed an application to operate a direct radio circuit between New York and Oslo, a route already served by several cable carriers and one radio carrier, RCA Communications.

The interconnection agreement proposed by Mackay was essentially equivalent to the agreement already in effect between RCA and the Norwegian Telecommunications Administration, encompassing an equal division of tolls between the two sides (FCC 1936 at 595). Nevertheless, the Commission denied Mackay's application, because it viewed the proposed contract as "contrary to the public interest" (FCC 1936 at 600). It argued that previous interconnection agreements between US cable operators and the Norwegian Telecommunications Administration had granted more favorable terms to the US side than to the Norwegian side. The proposed radio circuit, which effectively replaced an existing cable circuit, contemplated merely equal terms. The resulting loss of the US cable operators' contractual advantage over the Norwegian carrier was one of the FCC's major reasons for refusing to grant the operating permission.

It is important to note that the application was denied despite a number of clauses in the proposed interconnection agreement that tried to address the potential concern over the possibility of "whipsawing"[10]. The Commission's ruling in the Mackay Radio case was therefore not mainly aimed at limiting market power of foreign monopolists over US carriers, as is frequently implied (for example, FCC 1986), but largely an attempt to preserve the US carriers' contractual advantages over a foreign carrier[11].

The FCC continued to deny any applications for radio circuits to countries already served by other radiotelegraph carriers until the outbreak of WWII (FCC 1951 at 696). This policy was abandoned as a wartime measure after 1939, when the Commission started to grant all applications for new circuits and later even adopted a policy of requiring parallel circuits to all overseas points. Therefore, by the beginning of the 1950s, many (but not all) foreign

[10]Besides the provision to share tolls equally, the contract provided a proportionate return clause (FCC 1936 at 597) as well as a uniform settlement clause (Id. at 998). In other words, the proposed contract contained all elements that the FCC later deemed to be sufficient to prevent US carriers from being whipsawed (see, for example, FCC 1996c). However, at the time of the Mackay proceeding the FCC concluded: "the contract provides no safeguard against the exaction of terms from other American carriers less favorable to the American carriers and more favorable to the Norwegian Administration" (FCC 1936 at 598).

[11]Another major concern was the "wasteful and uneconomic duplication" of transmission capacity, associated with the new circuit.

points were served by two radio carriers and several cable carriers.

Proportionate return clauses were not necessarily part of interconnection agreements, nor did the FCC require them. Foreign carriers turned US-bound traffic to a US radio carrier[12] providing service to their respective country. If there was more than one radio carrier, then "such administrations divide(d) the traffic at their disposal among all United States radio carriers with which they communicate" (FCC 1955 at 1342). Consequently, the US carriers' market shares on the inbound routes were by no means proportional to their outbound market shares. Western Union, for example, transmitted 31% of all Portugal-bound traffic, but only 14% of the return traffic in 1953 (FCC (1955) at 1352).

In 1951 and 1955 the FCC granted Mackay's application to operate circuits to The Netherlands and Portugal, although the proposed interconnection agreement was essentially identical to the one proposed for the New York - Oslo route[13]. In its decision the Commission explicitly addressed the proposed proportionate return clause, and stated: "Since we have found competition by direct radio circuits to be beneficial, we feel that competing carriers ... should be permitted to share proportionately such inbound traffic

[12]This is because most foreign telecommunications administrations received less financial return from cable than from radio transmission, (see, for example, Id. at 732).

[13]The Commission's gives a number of reasons for arriving at a different decision than in the Oslo case. One is that traffic volumes had increased, implying the need for additional capacity (FCC 1951 at 732). Second, the FCC argued that starting with WWII it had abandoned its strict "single circuit" policy on many routes (Id at 733). Finally, the FCC pointed out the generally positive experience with competition on parallel radio circuits (FCC 1955 at 1340).

and the revenues therefrom...." (FCC 1955 at 1340) This statement is instructive of the Commission's views at the time. It indicates that, first, the proportionate return clause was permitted, rather than required. Second, the proportionate return clause was seen as beneficial only in the context of competition between radio circuit carriers, but not in the context of preventing foreign carriers from "playing-off" US carriers against each other.

By 1983, only a total of 15 out of 217 countries with direct interconnection to the US allocated traffic according to a proportionate return scheme (FCC 1983), and there is no indication that the FCC required this scheme to be part of the interconnection agreements[14].

3.3.2 Proportionate Return and the Uniform Settlements Policy

After the FCC opened international telephony to competition in 1985, US carriers requested a clarification of the FCC's position on competitive safeguards in the case of telephony. In response to this request, the FCC released the Implementation and Scope of the Uniform Settlement Policy (USP) (FCC 1986), in which it essentially implemented two rules, the Uniform Settlements Rule, the Even Splitting Rule[15]. The FCC stated: "The policy ... limits the ability of a PTT to whipsaw US carriers" (FCC 1986 at 54).

[14]One reason that proportionate return schemes were stipulated by only a small portion of foreign carriers was that their networks were not sufficiently developed to apply such schemes in practice. In any case, the point made here is that in 1983 proportionate return was not a very significant issue.

[15]See Section 3.2, supra.

The underlying economic rationale of the USP is based on the assertion that, *without* competitive safeguards, foreign carriers would play competing US carriers off against each other. They could threaten to divert traffic from one carrier to its rivals and force US carriers to pay a higher settlement rate for their outbound traffic than they receive for switching inbound traffic. Alternatively, even if the settlement rate were equal on inbound and outbound routes, the foreign carrier could negotiate different settlement rates with different US carriers, and then send US bound traffic predominantly via the route with the lower settlement rate. This scheme would increase the foreign carriers revenues from settlement payments to the disadvantage of the US industry as a whole.

The approach taken in the USP is not to remove the threat, but to prohibit US carriers from making concessions. The Commission believed that the USP would entirely eliminate the possibility of "whipsawing"[16]. There was no need to prohibit traffic diversion, since the foreign monopolist would be left without incentive to prefer one carrier to another for routing US-bound traffic. It therefore seems logically consistent that the FCC introduced the USP as a sufficient set of competitive safeguards and refrained from also including the PRR in this new set of regulations. As we shall see, the FCC did not maintain this initially correct approach, but later added the PRR to the set of safeguards despite the fact that it was superfluous.

[16]Note however O'Brian's objections to this view, O'Brian (1988).

3.3.3 The Sprint and TLD cases

Although the PRR had not been included in the 1986 USP regulation, the FCC subsequently decided to apply this principle in a number of individual cases.

In 1988, Sprint filed an application for a direct interconnection agreement with Germany's monopolist DBP (FCC 1988a). The agreement principally complied with the USP, however, it raised concerns among competitors and the FCC, because DBP allowed Sprint to provide service to end-users as well as to resale carriers via the same gateway[17]. On the other hand, DBP refused to enter into direct interconnection agreements with small carriers, i.e., carriers with a market share below 13%. The FCC concluded that DBP's position effectively put Sprint into a competitive advantage over its resale carrier customers[18], and reacted by establishing a number of regulatory measures that were aimed at creating a "level playing field" for Sprint and the small carriers. The FCC ruled that "...unless US Sprint proposes to route a proportionate share of inbound traffic to the domestic network of its carrier customers, we would expect the carrier rate to recognize the principle of proportionate return traffic, by providing a commensurate reduction in the price the carrier customer must pay to route its FRG-bound IMTS traffic through US Sprintś switch" (FCC 1988a at 22).

[17]In this context, the term *resale carriers* refers to pure (swtichless) resale carriers, which do not operate leased lines. International Simple Resale, or resale via leased lines, was prohibited with Germany at the time of this case.

[18]Note that these resale carriers were Sprint's customers on the wholesale market, but at the same time also its competitors on the retail (end-user) market.

The Commission's ruling in the Sprint case suggests that, first, the Commission did not apply the PRR in order to limit DBP's market power over Sprint, but to limit Sprint's market power over its resale carrier customers. Second, this PRR exclusively concerns the market shares of Sprint's customer carriers on Sprint's circuits, not the market share of the incumbent, AT&T. Third, the PRR would be applied only if Sprint's advantage from receiving inbound traffic were not reflected in its wholesale prices. Conversely, if wholesale prices had been competitive (and reflected the facilities-based carriers' advantage from receiving inbound traffic), then the PRR would not have been imposed. The PRR is therefore in this case neither a policy tool to regulate international interconnection agreements, nor a safeguard against "whipsawing" [19].

In 1992, the FCC had to reevaluate the service authorization of TLD (Telefonica Larga Distancia de Puerto Rico), when TLD was privatized and the majority of assets were sold to a wholly owned subsidiary of Telefonica (Spain) (FCC 1992). The Commission endorsed the Puerto Rican government's privatization efforts and recognized Telefonica as the only qualified buyer for TLD. Authorization was therefore granted despite the FCC's reciprocity policy[20]. However, the Commission imposed a number of competitive

[19]The PRR was discussed and applied again in the case of FTC Communications, Inc., FCC (1989), where the PRR was applied essentially for the same reasons as in the Sprint case.

[20]Under the reciprocity policy, the FCC grants service authorization to a foreign carrier only if US carriers can obtain equivalent authorizations in the respective foreign carrier's home country. At the time of the ruling, Spain's telecommunications market was not open to foreign investment.

safeguards, including the PRR, in order to ensure that Telefonica would not abuse its double-role as foreign monopolist and US carrier to discriminate against its competitors.

3.3.4 The Codification of the Proportionate Return Requirement

In both the Sprint and the TLD case the Commission imposed the PRR under exceptional circumstances. The proceedings to both cases carefully and clearly lay out the particularities of each case and why it was applied as a competitive safeguard above and beyond the USP. It therefore comes as a surprise that the FCC adopted an explicit and general PRR in 1991[21]. This policy applied to all international routes and was implemented in a complimentary fashion to the previously adopted set of international telecom regulations[22]. The Commission justified the PRR Decision with its "longstanding US regulatory policy that US carriers should be afforded nondiscriminatory treatment in their traffic relation with a given country".

This justification is flawed in a subtle yet important detail. It is true that the FCC had a longstanding policy to prevent "whipsawing", that is,

[21] FCC (1991), hereafter referred to as PRR Decision. In addition, carriers would have to certify that "they had not bargained for, nor received any indication that they would receive, more than their proportionate share of return traffic" (FCC 1990). A Proportionate Return Requirement had already been suggested in 1988, when the Commission solicited comments concerning the development of an "ideal" regulatory regime for international telecommunications. This proceeding was however closed without ever adopting the PRR. (FCC 1988b at 66, and FCC 1996a).

[22] This set of regulations had meanwhile been renamed the International Settlements Policy.

discriminatory treatment of US carriers to the disadvantage of US carriers and ratepayers. However, as pointed out above, the PRR generally does not prevent "whipsawing" over and above the rules implemented under the USP. The allocation of return traffic per se (that is, which one of the carriers receives the return traffic) does not affect the total US welfare[23], since settlement rates must be uniform across carriers. Rather, it only the profits of individual carriers. The PRR therefore effectively requires adherence to some notion of fairness among carriers, a notion that the Commission had previously never defined or applied in this form. It is therefore incorrect to endorse the PRR as the "continuation of an existing policy" (FCC 1993b).

Another frequently offered justification is that the proportionate return principle had been consistently applied and thus been "imbedded" in the ISP by reason of practice. Again, this justification is flawed. The cases in which the PRR had previously been applied were singular and not generalizable. They referred to particular market settings in which either no competitive resale market existed, or where particular foreign ownership interests prevailed (FCC 1988). Also, as pointed out above, the implementation of the PRR under the 1990 ruling differs significantly from the implementation under the Sprint model case. The Commission never indicated why it concluded that the reasoning in the Sprint and FTC cases applies to all other routes, or why the rules of implementation were changed[24].

[23]Defined as the sum of consumer and producer surplus.

[24]The Commission uses the above justifications also in the case of Atlantic Tele-Network Inc. (ATN), when ATN seeks permission to depart from the proportionate return princi-

To make the confusion complete, the Commission codified the PRR again in its 1996 Flexibility Order. The FCC states: "In this Report and Order we also codify our Proportionate Return Policy", although the PRR had already formally been codified in 1991[25]. The repeated codification of the very same policy is not only an interesting detail of the regulatory process that shaped the ISP, but also indicates some confusion in the FCC's rulemaking process.

3.3.5 Conclusion

The PRR has been called one of the cornerstones of the ISP (FCC 1996b). Yet, the Commission has provided surprisingly little and weak argumentative support for this important policy. The historic case law, on which the PRR decision is based, was largely misread and wrongly applied. The Commission failed to recognize that the PRR is superfluous as a competitive safeguard over and above the already existing safeguards. Instead, it appears that in implementing the PRR, the FCC confused the notion of economic welfare with the notion of fairness and equal treatment for US carriers.

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ple on the route to its monopoly telecommunications subsidiary, Guyana Telephone and Telegraph. The case is practically analogous to the TLD case, and the FCC's refusal to grant the deviation from the PRR may be justified. Paradoxically, the FCC decides the case by defending the its general PRR policy with the usual flawed reasoning, rather than by pointing out the particularities of the setting on the US - Guyana route that in fact justified the application of the proportionate return principle in this particular case. (FCC 1996a).

[25]FCC (1996b) at 4. In its justification, the commission refers to TLC and ATN cases and points out that the PRR had "long been a cornerstone of our ISP", but fails to refer to the PRR Proposal or PRR Order.

3.4 The Proportionate Return Requirement and the Emergence of Competition

3.4.1 Competitive and Regulatory Challenges to the Accounting Rate System

As international markets become increasingly liberalized and competitive, the portion of international traffic that is routed under traditional interconnection arrangements is declining, and with it the portion of US traffic that is subject to ISP and PRR. Technological and regulatory change have been the two major factors driving the emergence of competition and challenged the role of the Accounting Rate System as the dominant framework for interconnection (Tyler and Bednarczyk 1998, Frieden 1998).

Technological change has brought about six "alternative modes of operation"[26], in which interconnection arrangements substantially differ from the Accounting Rate System. Alternative modes of operation usually utilize economically inefficient ways to route traffic[27]. Their commercial success mainly stems from the fact that they bypass the Accounting Rate System, thus avoiding the payment of Settlement Rates that often by far exceed the real cost of international interconnection[28]. International Simple Resale

[26]For a description of these alternative modes, see, for example, Frieden (1998), Taylor and Bednarczyk (1998), Levine (1998) and Scanlan (1996).

[27]Alternative modes of operation evolved in a regulatory niche as services that could be offered exclusively to closed user groups, such as multinational companies. Starting in the mid-1990s, an increasing number of pro-competitive countries have allowed providers of these services to switch *any* type of traffic.

[28]Callback operators are often named in this context, however, they do not constitute an alternative mode of operation since they do not bypass the Accounting Rate System. Rather, Callback operators offer an arbitrage service within the Accounting Rate System.

(ISR)[29], International Alliances, and Foreign Points of Presence are three alternative modes that are subject to regulatory approval and have been a driving force of competition in liberalized markets. Refile (Hubbing), Internet Telephony, and International Business Networks[30], on the other hand, are service concepts that allow consumers and carriers to bypass the Public Switched Network without prior regulatory approval. They have therefore been instrumental to imposing competitive pressures on regulators and operators in non-liberalized countries.

The second factor that has had a profound impact on the liberalization of telecom markets is the WTO Basic Telecommunications Services Agreement. The 88 signatory countries, led by the United States, have committed in varying degrees to open their markets to competition, to allow non-discriminatory access to foreign operators, and to remove the regulations that limited services provision under alternative modes of operation. As a result, flexible arrangements rather than the framework of the Accounting Rate System will shape future interconnection agreements between operators of these countries.

The Accounting Rate System has also increasingly become subjected to

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While callback operators put significant pressure on established telecoms to lower collection charges and cost levels, they do not constitute a challenge to the Accounting Rate System per se.

[29]International Simple Resale involves the use of a private line (with a connection to the public switched network at one or both ends) for the provision of commercial international telephone services.

[30]At the beginning of the 1990s, international businesses started to route their inter-branch voice communications via leased line data networks, and thereby considerably reducing its use of international PSTN services.

heavy criticism by academics[31], and by regulators of countries with a large net payment deficit[32]. Responding to these various pressures and criticisms, a number of multinational organizations including the ITU and OECD have been working on a reform of the Accounting Rate System.

3.4.2 Regulatory Adjustments of the ISP

The liberalization and growing competition in various national and international markets during the past decade has raised concerns about adverse economic effects of the ISP on emerging competitive environments. One of the most prominent concerns is that the PRR may impede competitive behavior in outbound and inbound markets.

The FCC recognizes three ways in which this may happen. First, the PRR may generally deter U.S. terminating carriers from offering innovative pricing and supply arrangements. Second, it may constitute a barrier to entry. When

[31] It has been well understood that the structure of the Accounting Rate System, in conjunction with above cost settlement rates, creates economically inefficient incentives, by limiting the operators' incentive to lower collection charges, and by limiting net recipients' incentives to promote output growth. (See, for example, Tyler and Bednarczyk (1998), p. 802).

[32] See footnote 9, supra. Other major deficit countries are, for example, Switzerland, Australia and Japan (ITU 1998b). A number of economic studies have tried to establish a theoretical and empirical link between the inefficiencies due to the Accounting Rate System and international traffic imbalances. Ergas and Paterson (1991) identified the Accounting Rate System as the major cause of these imbalances. Chong and Mullins (1991), on the other hand, empirically showed that traffic imbalances may be related to long-term economic factors, rather than price-related factors. Domestic regulatory policies, not the Accounting Rate System per se, are the underlying determinants of traffic imbalances. Yun, Choi and Ahn (1996) developed a Cournot competition model to show how differences in demand, technology and market structure affect Accounting Rates as well as traffic and payment imbalances. They demonstrated that in some cases, high Accounting Rates might even have the role of reducing traffic imbalances.

entrants start serving a route, they have no past record of outbound traffic and thus no credits for the lucrative inbound traffic. For an initial period after entry, therefore, the new carrier will face a competitive disadvantage (FCC 1998a). Also, most foreign carriers will not start sending a US carrier the lucrative return traffic until that US carrier's outbound traffic volume reaches a certain threshold. Third, the Commission points out that inbound and outbound markets have different attributes, and that carriers differ in their effectiveness in serving these attributes[33].

These and other concerns led to a series of regulatory adjustments of the ISP[34]. The main premise of the adjustments was that the US regulator did not intend to generally relax its regulatory oversight in international markets[35]. Rather, it decided to selectively allow for flexible interconnection arrangements where it perceived no potential for abuse of market power by

[33]FCC (1996b). Another basic concern, raised by AT&T, is the enforceability of this policy. If foreign monopolists wanted to favor one US carrier over another, they could do this without formally violating the PRR, for example, by sending the favored carrier higher proportions of non-peak hour traffic, more valuable operator-handled calls, or by sending calls that can be terminated in the US over short distances. (FCC 1998a, AT&T 1998 at footnote 12 and Sprint 1998 p.4).

[34]In addition to the specific concerns associated to the PRR, the Commission also recognizes a number of economic distortions caused by the Uniform Settlements Rule and the even splitting rule. (FCC 1996b at 18). For example, the ISP could reduce a carrier's incentive to bargain for the lowest possible settlement rate. Due to the Uniform Settlement Rule, the carrier will be unable to achieve a cost advantage over its competitors, no matter how aggressively it negotiates. Moreover, under the ISP, settlement rates have to be made public, thus revealing a significant part of the carriers' cost structure to their competitors and inhibiting competition. The objective of the regulatory adjustments was to eliminate economic distortions associated with the ISP, while at the same time fostering competition and thereby imposing downward pressure on settlement rates. (FCC 1996b at 17)

[35]The FCC approach sharply differs from the one adopted in other pro-competitive countries, such as Britain and Australia. See also footnote 3, supra.

foreign carriers, and to continue enforcing the ISP on all other routes. In pursuit of this policy, the FCC developed a set of rules that define market conditions under which the ISP will be waived. These rules have been continuously fine-tuned and adapted to the various technological and regulatory developments that have challenged the Accounting Rate System and the regulatory framework surrounding it. Three regulatory decisions in this series of adjustments are directly concerned with the ISP.

The Flexibility Order (FCC 1996b) permitted interconnection arrangements that deviated from the ISP between US carriers and any foreign correspondent in of countries that satisfied the 'ECO'[36] test. For countries that failed to pass the test, a deviation from the ISP was permitted only if "the US carrier can demonstrate that deviation from the ISP will promote market-oriented pricing and competition, while precluding abuse of market power by the foreign correspondent."[37] (FCC 1995 at 2)

In 1997 the Commission revised the Flexibility Order in order to bring the ISP in accordance with the open market commitments made under the WTO Agreement. The ECO test was abandoned and replaced by a "presumption

[36]The "Effective Competitive Opportunities" (ECO) test attempts to determine the degree of competitiveness of a county's telecommunications industry, taking into consideration a number of regulatory and market conditions in a given country, including the degree of liberalization, the existence of non-discriminatory entry conditions, the existence of an effective regulatory framework and appropriate competitive safeguards, see FCC (1996) at footnote 65, or FCC (1995).

[37]The FCC however continued to (1) impose a filing and publication requirement; (2) maintain the right to intervene in arrangements affecting more than 25% of inbound or outbound traffic, if these contained 'unreasonable discriminatory terms and conditions'. (FCC 1996b).

in favor of alternative settlement arrangements on routes servicing WTO Members", which could however "be rebutted with a showing that there are no multiple facilities-based competitors operating in the foreign market for international services" [38].

Finally, a further set of regulatory rulings was released on May 6, 1999 as part of the FCC's 1998 biennial review of regulations[39]. In the Biennial Review Order the FCC abolished the Flexibility Order and provided that the ISP will be revoked in two circumstances: (1) for settlement arrangements between US carriers and foreign carriers that lack market power[40]; and (2) on routes where US carriers are able to terminate at least 50% of the their US billed traffic in the foreign market at settlement rates that are at least 25% below the applicable benchmark settlement rate[41],[42].

[38]FCC(1997a) at 20.

[39]FCC(1999b), in the following referred to as Biennial Review Order.

[40]The FCC presumes that "a carrier that possesses less than 50% market share in a foreign market lacks the ability to exercise market power in that market" (FCC 1999b at 39).

[41]This includes all rates for terminating traffic, including rates of International Simple Resale (ISR, resale of services via private leased lines) and settlement rates. The FCC's ISR restrictions obviously became superfluous under circumstances where the ISP no longer applies. (FCC 1999b) Under these restrictions, carriers may engage in ISR on routes to WTO signatory countries only where "settlement rates for at least 50% of the settled, U.S. billed traffic on the route are at or below the appropriate benchmark or where the foreign market offers equivalent resale opportunities". For service to non-WTO signatory countries, ISR is authorized only "where 50% of the traffic is settled at benchmark rates and where the foreign market offers equivalent resale opportunities" (FCC 1999b at 15). Hence there are routes where the FCC allows ISR, while at the same enforcing the ISP. On such routes, facilities-based carriers have the choice of negotiating an ISR agreement with the foreign correspondent carrier and routing its traffic via ISR, or of carrying traffic under a traditional settlement arrangement that is subject to the ISP. It is a peculiar feature of the ISP that it maintains a distinction between ISR and "traditional settlement arrangements" even where this distinction has become blurry, if not meaningless.

[42]In the Notice of Proposed Rulemaking (FCC 1998a) leading to the Biennial Review

With their recent adjustments of the ISP rules, the FCC followed mainly three objectives. First, the FCC has eliminated the ISP rules where they have become insignificant due to the realities of a competitive telecom environment[43]. Second, the Commission has attempted to reduce the adverse effects on emerging competition and new entrants in selected markets, by permitting alternative settlement arrangements with non-dominant foreign carriers. Third, the FCC believes that the Biennial Review Order provides foreign carriers with a significant incentive to lower their settlement rates below benchmark level. "As competitive pressures develop in foreign markets, foreign carriers will have an incentive to lower their rates to take advantage of increased opportunities to enter into innovative arrangements as a result of lifting the ISP" (FCC 1999b).

Order, the FCC had originally proposed to waive the ISP (1) on routes between the US and WTO signatory countries where foreign carriers are authorized to provide ISR, or where the correspondent carriers lack market power. (2) for interconnection agreements between US carriers and carrier from WTO signatory countries, if these affect less than 25% of the traffic on the given route. The relaxation of the ISP made in the Biennial Review Order turned out to be much less far reaching than the relaxation originally proposed. The fact that the FCC largely maintained the ISP mainly goes back to the comments of the large facilities-based carriers AT&T and MCI WorldCom, which claimed that the proposed modifications would leave the US consumers with too little protection from foreign market power. (FCC 1999b).

[43]For example, international routes that qualified for a complete removal of the ISP as of May 1999 were the routes to Canada, the UK, Sweden, Germany, France, Hong Kong, the Netherlands, Denmark and Norway. (FCC 1999b at 55).

3.4.3 The Current and Future Regulatory Impact of the ISP

Despite this relaxation of regulatory oversight and despite the growing importance of alternative interconnection arrangements, the impact of Accounting Rate System, ISP and PRR remains significant. It is true that, as of May 1999, a total of 43 governments had formally committed to opening their markets to International Simple Resale (ISR)[44] by the year 2010, reducing the significance of traditional interconnection arrangements on routes to their respective countries. However, it is unclear whether these governments will meet their commitments in time.

The liberalization process in the WTO signatory countries has been slower than anticipated. As of April 1999, the FCC listed 22 countries as approved for ISR (FCC 1999a). 9 out of the 31 countries that committed to open their markets to ISR immediately failed to do so by FCC standards. Between July 1999 and May 2000, the FCC classified merely another 3 countries as ISR-approved, namely Singapore, the Netherlands Antilles, and Poland.

While settlement rates have already dropped significantly on most international routes, only few settlement rates have reduced to a level that is even close to the FCC's benchmarks. As of August 1999, the average settlement rate was 67 cents per minute on the 51 routes between the US and WTO signatory countries that are subject to the ISP. The FCC's benchmarks ranged

[44]These 43 Governments represent countries that account for 69% of the total US outbound traffic.

from 15 to 23 cents per minute, depending on the correspondent country's level of development On 42 of those 51 routes, the settlement rates exceed the benchmark rates by more than one hundred percent.

As of May 2000, the ISP restrictions have been completely removed on routes to only 11 countries (FCC 2000), up from 9 countries in 1999 (FCC 1999b at 55). The 1998 US outbound traffic volume on routes between the United States and these countries was 8,828 million minutes, or 36% of the total outbound (settled) traffic. On 25 routes, either ISP or ISR restrictions have been removed. 11,602 million outbound minutes, accounting for 47% of the total US outbound traffic, are transmitted on these routes. The US carriers' revenues from all routes with both ISP and ISR restrictions still in place amount to US$ 5.2 billion, or 55% of the total PSTN revenues earned by US carriers[45].

Despite all pro-competitive rhetoric, even the FCC's approach towards market liberalization can be described as cautious. The underlying premise of the ISP is clearly to allow for full competition and alternative interconnection arrangements only on routes to countries that have liberalized their market as well. On all other routes, the Commission has considered the potential harm of market power abuse by foreign carriers to be greater than the potential benefits of competition. Hence, the US regulatory approach has to a large extent not attacked, but conserved the structure of the Accounting Rate System including its anti-competitive effects.

[45]FCC (1998b).

3.5 The Economic Effect of Proportionate Return in Switched Service Markets

The recent modifications of the FCC's regulatory framework constitute a significant step toward removing unnecessary regulations and impediments to emerging competition created by the ISP. The Commission has however stopped short of identifying and eliminating all the economic distortions created by the PRR.

One immediate consequence of linking the inbound traffic allocation to outbound market shares is that facilities-based carriers take the profits associated with the inbound traffic in consideration for their output and price decisions on the outbound markets. In order to capture these profits, facilities-based carriers try to expand their outgoing minutes beyond the level they would choose without consideration of inbound calls in their output decision. This distortion aggravates the US traffic imbalance and affects both the wholesale and the end-user market. In the end-user market, the PRR creates a (downward) pressure on calling charges. In the wholesale market, it reduces the wholesale prices that facilities-based carriers charge to pure resellers[46] for the transmission of international traffic.

Galbi (1998) points out that the output distortion created by the PRR will act in the opposite direction of the output distortion from imperfect com-

[46]Pure ("Switchless") resellers do not own or lease facilities. Instead, they route traffic into the facilities-based carriers' network in exchange for an agreed-upon per minute transmission charge. Pure resellers neither directly pay settlements to foreign carriers, nor do they receive any return traffic.

petition. In imperfectly competitive markets, the PRR can therefore serve as a regulatory device to bring prices in line with marginal cost. In a near competitive market, on the other hand, the PRR may push wholesale prices and retail prices below marginal cost of outbound service. Facilities-based carriers then cross-substitute outbound service with profits from inbound service, thus forgoing profits from inbound service which they could have made without proportionate return traffic allocation[47]. Moreover, the PRR has a negative effect on the retail (end-user) market shares of facilities-based carriers. Market shares of facilities-based carriers will be lower and the market shares of the resale industry resale industry will be higher under the PRR, than without it. While consumers still profit from the PRR under this scenario, the overall welfare effect will be negative [48]. The economic evaluation of the PRR therefore largely depends on the degree of competitiveness in the international switched service market. The recent developments in the United States indicate that the telecommunications industry is rapidly moving towards a high degree of competition, particularly in the resale segment of the market. In 1996, the combined (retail) market share of all US pure resale carriers accounted for 37% of the total outbound call market, up from 6.3% in 1993 (FCC 1997b; Blake & Lande 1998).

[47] An alternative return traffic allocation scheme is, for example, a scheme under which each US carrier receives a fixed share of return traffic. Clearly, a US carrier that would be supplied with little return traffic or no return traffic at all under such a fixed allocation scheme would be worse off than under the PRR. Nevertheless, the facilities-based service industry as a whole is better off under a fixed allocation scheme.

[48] A detailed formal analysis of the economic effect of the PRR is provided in Chapter 4.

The number of resellers is large, and only few resellers have succeeded in obtaining a significant market size. In 1996, of the estimated 1000 or more pure resale carriers, the largest 2 served 12.3%, and 7.3% of the total pure resale market, respectively. Only 19 pure resellers had a market share of more than 1%; the typical market share of a pure resale carrier was below 0.01%. Wholesale competition between the three major facilities-based carriers serving these resale carriers is fierce, such that, in some instances, wholesale charges have been reported to be below the termination price at the corresponding destination (Galbi 1998). This price distortion can be directly attributed to the PRR and indicates that the PRR may already have adverse welfare effects, at least on some international routes[49].

The effect of the PRR on the correspondent foreign monopolist is less obvious. If the foreign monopolist's demand were independent of US wholesale rates and end-user charges, then the foreign monopolist would clearly benefit from the proportionate return allocation, since this rule would result in higher outbound traffic volumes and thus higher settlement revenues for the foreign monopolist. However, even with demand interdependencies, and particularly of callback services, there is some evidence that foreign monopolists may still profit from proportionate return traffic allocation.

[49]It is important to emphasizes that the effect of resale, particularly of pure resale on the market outcome under the PRR is an indirect. As resellers do not have direct interconnection agreements, they are not subject to the PRR. However, resellers compete with facilities-based carriers in end-user markets. The high degree of competition in these markets, resulting from the presence of resellers, then in turn aggravates the effect of the PRR.

Scanlan (1998) demonstrated that in the presence of the PRR, callback might in fact positively contribute to the profitability of monopoly operators in countries where a callback service is offered[50]. If this is the case, than the PRR effectively strengthens, rather than weakens, foreign monopolists' position vis-à-vis the US facilities-based carriers, and foreign operators may have an incentive to use proportionate return schemes even without an explicit requirement to do so. The appropriate regulatory reaction would be to prevent proportionate return allocation, rather than enforce it.

While more comprehensive research needs to be done in this field, it is reasonable to state that the PRR creates a number of economic distortions of outputs and prices, which are not taken into consideration in the relevant regulatory rulemaking (FCC 1999b), and which may counteract the very objectives of the ISP.

3.6 Summary and Conclusion

The Proportionate Return Requirement is a regulation that governs the allocation of US inbound telephone traffic in a significant, albeit decreasing portion of the US international PSTN market. It was implemented in order to prevent foreign monopolistic carriers from "whipsawing" competitive US carriers. Although the PRR has been removed on a number of routes, the

[50]Scanlan arrives at this result by employing a model of stylized accounts of international revenue streams, taking into consideration the various elasticities and feedback effects impacting international telephone demand.

FCC has made clear that it does not intend to remove the PRR on routes to non-liberalized countries unless settlement rates on those routes fall significantly below the FCC's benchmark rates.

The objective of this paper is to provide an analysis of the regulatory history of the PRR, its economic rationale and its effect on the US telephone industry. The main conclusion obtained from this analysis is that the actual economic effects of the PRR are not in line with its regulatory objectives. On one hand, the PRR is not needed to prevent "whipsawing" of US carriers by foreign monopolists. The FCC's justifications of the PRR are largely based on an erroneous interpretation and application of historic case law. On the other hand, the PRR creates excessive competition for incoming traffic. This competition aggravates the US traffic imbalance, distorts price and output decisions of facilities-based carriers and resellers, and may ultimately benefit the foreign monopolists.

As US markets for outbound international calls rapidly move towards more intensive competition, the PRR may have a negative effect on total US welfare in the near future. Large carriers, such as AT&T, MCI and Sprint have traditionally supported the FCC on their International Settlements Policy (including the implementation of the PRR), and even opted for an adaptation of similar rules in Canada, although, ironically, the PRR reduces the US facilities-based carriers' industry-wide profits and market shares.

There are four plausible reasons that could explain why the PRR has nevertheless been created and has existed for the past decade. One is that neither the FCC, nor the large facilities-based carriers has fully understood the implications of this regulation. In this view, the PRR is a temporary regulatory inconsistency that is caused by miscommunication and short "organizational memory" within the FCC and the large carriers, in conjunction with fast technological change and complexity of regulatory tasks. Second, the persistence of the PRR could indicate an agency problem within the facilities-based carriers' organizations. By tying together incoming and outgoing telephone markets, the PRR significantly reduces the number of managerial decision parameters to be considered relative to a situation where both markets would have to be managed separately. Furthermore, the PRR protects management from having to take responsibility for incoming market shares, which are largely due to the uncontrollable actions of foreign carriers. Hence, in view of the management of large carriers, abolishing the PRR may lead to an increase in managerial complexity and risk at little if any payoff for the managers. The managers may personally prefer an established regulatory system under which all or a part of the companies' potential windfall profits from incoming traffic are competed away. A third explanation, already noted and explained in section 3.4.2, is that established carriers may try to use the PRR as a means to prevent entry. Finally, the FCC could have established and maintained the PRR as a regulatory device to bring wholesale and retail prices of outbound calls in line with marginal cost. If this were the case, the FCC would have failed to publicly convey the true regulatory objectives of the PRR.

Chapter 4

The Economic Effect of the Proportionate Return Requirement

4.1 Introduction

Throughout the last decade, the Federal Communications Commission (FCC) has been paying considerable attention to the reduction of settlement rates in international telecommunications markets. Settlement rates[1] have traditionally been negotiated bilaterally between international telecommunications carriers. Where carriers from a country with a competitive telecommunications market interconnect with a telecommunications monopolist, the foreign monopolist has an incentive to play the competitive carriers against each other on the terms and rates of interconnection. The FCC has identified this asymmetry of market power in international telecommunications mar-

[1] A settlement rate is a per-minute charge, paid by an international carrier to a foreign carrier for terminating an international telephone call in its respective country.

kets as the leading cause of inflated settlement rates[2]. In conjunction with the prevailing traffic imbalances[3], high settlement rates have led to significant wealth transfers from US carriers and consumers to foreign monopoly carriers.

The FCC's regulatory responses to the market power asymmetry had two major thrusts. Starting in 1986, the FCC designed a set of restrictions on settlement rates that effectively formed a cartel between the competitive US carriers against the foreign monopolists. These restrictions, also called "Uniform Settlements Policy"[4], provided equal settlement rates among carriers ("uniform settlements rule"), same level of settlement rates for inbound and outbound traffic ("equal sharing rule"), and the sharing of incoming traffic among US carriers in proportion to their respective market share of outgoing traffic ("proportionate return requirement (PRR)") . By 1997 it became clear that in spite of the Uniform Settlement Policy, settlement rates were getting increasingly out of line with actual cost levels. As a result, the FCC further introduced "benchmarks" for international settlement rates[5]. These

[2]In their 1997 Benchmark Order (FCC 1997), the FCC stated: "U.S. consumers pay on average 88 cents per minute for international calls and they pay on average 13.5 cents per minute for domestic long distance calls. Yet, the difference in cost of the underlying facilities between the two services is minimal. Indeed, as we stated in the Notice, the costs of providing telephony have been decreasing and are becoming virtually distance insensitive due to recent technological advances."

[3]US outgoing traffic volumes are well above incoming traffic volumes on most international routes.

[4]The key FCC orders are FCC(1986) and FCC(1991). For more detailed information about all relevant FCC decisions with regard to the Uniform Settlements Policy, see Chapter 3.

[5]See FCC (1997).

benchmarks capped settlement rates to levels that the FCC perceived as reflecting foreign carriers' actual cost levels.

Ever since the implementation of international telecom regulations, economists have debated these measures and tried to assess whether they really help to achieve the intended regulatory objectives. O'Brian (1988) uses a Rubinstein-type bargaining model to analyze the effect of the Uniform Settlements Policy on the inter-carrier bargaining process. He finds that, contrary to common intuition, the Uniform Settlements Rule may in fact be the precise cause of the "whipsawing" problem, rather than its remedy. Hakim and Lu (1993) show that the equal sharing rule raises the collection charges when settlement rates are high. Cave and Donnelly (1996) argue that under the settlement rate system, rates often end up at the higher of the rates proposed by the two parties. Yun, Choi and Ahn (1996) develop a Cournot competition model to show how differences in demand, technology and market structure affect settlement rates as well as traffic and payment imbalances. They demonstrated that in some cases, high settlement rates might even have the role of reducing traffic imbalances.

Among the few studies that explicitly consider the PRR, Scanlan(1999) analyzes the incentives to provide callback services under the PRR, and Galbi (1998) discusses some welfare effects of proportionate traffic allocation. Finally, Chapter 3 of this thesis argues that the PRR is in fact not needed *over and above* the uniform settlement rate and the equal sharing rule as a competitive safeguard against foreign monopolists. If settlement rates are forced to be equal for all carriers *and* in both directions, there are no economic incentives left for the monopolist to prefer one carrier over the other, nor would a traffic diversion have any effect on the magnitude of settlement rates. Also, Chapter 3 argues that the regulatory process leading to the codification of the PRR exhibits a number of flaws and inconsistencies, such that there exist reasonable doubts about the proper justification of this regulatory rule. The questions arising are therefore: what impact does the PRR have on the different economic entities involved in the international telecommunications service markets[6], and to what extent may these entities have an interest in a continued PRR regulation.

The objective of this paper is to investigate these questions by supplementing the institutional analysis in Chapter 3 with a formal economic analysis of the PRR.

Extending international telecommunications competition models by Sharkey (1994) and Yun, Choi and Ahn (1996), it develops a two-stage model of international telecommunications markets. This model is used to simulate market outcomes with 1998 data of the US international telephone industry.

At the center of this analysis is not the interaction between the carriers of

[6]The economic entities affected by the PRR are the consumer, international telephone carriers owning transmission facilities (facilities-based carriers, *fb-carriers*), international switchless resale carriers (*resellers*), and the government. Fb-carriers assume a dual role in international telephone markets, as providers of end-user (retail) service, and wholesale service for resellers. Under the PRR, they receive the incoming traffic in proportion to the *total* volume of traffic they transmit to a foreign country, including the traffic originnating from resale carriers. Resellers generate a significant share of international outbound telephone traffic. Yet, they do not receive any share of incoming traffic.

two countries, as in the studies by Yun, Choi and Ahn. Rather, it focuses on the effect of proportionate return traffic allocation on the existence of equilibria and on their properties in the country where the PRR is implemented. In addition, this paper analyzes the discriminatory effect of the PRR on resellers, and the extent to which fb-carriers can use the advantage of receiving incoming traffic to increase their market share at the expense of resellers in the end-user market.

Section 4.2 presents the basic structure of the model. Section 4.3 provides a general analysis of international telecommunications markets under the PRR. It shows that the PRR may preclude the existence of equilibria, if fb-carriers and resellers incur different marginal costs of providing retail service. Welfare implications and some comparative statics results are discussed for the special case in which both types of carriers face the same marginal service cost.

Section 4.4 uses simulation techniques to illustrate equilibrium outcomes, and the effect of the PRR for the general case where fb-carriers and resellers incur different costs. It demonstrates that realistic parameter ranges exist where there is no equilibrium. If an equilibrium exists, then equilibrium prices and wholesale charges are lower under the PRR than they would be without it. Also, the resellers' market share is higher under the PRR, in spite the fact that they are apparently discriminated against regarding the allocation of incoming traffic. The simulation results also provide support for the claim that, although fb-carriers have continuously been in favor of the PRR, their profits may in fact be higher under a regulatory regime without proportionate return traffic allocation. Section 4.5 discusses policy implications, summarizes and concludes.

4.2 A Model of International Switched Service Competition under Proportionate Return

Consider a country pair market for international switched services between two countries, f (foreign) and h (home).

The market in f is served by a monopolistic telecommunications provider. The settlement rate is considered to be exogenous[7].

The telecommunications industry of h is competitive, but subject to competitive safeguards on the route to and from f. These safeguards are of the kind imposed by the FCC. In particular, they require settlement rates to be uniform among carriers in h, and equal for carriers in h and f. Furthermore, regulation requires return traffic to be allocated among the home country's carriers in proportion to their share of outgoing traffic (PRR). There is no International Simple Resale (ISR)[8].

[7]However, the carriers' incentive structure for setting settlement rates in the context of this model will be discussed below.

[8]International Simple Resale involves the use of private lines (with a connection to the public switched network at one or both ends) for the provision of commercial international telephone services. ISR interconnection agreements are neither subject to the FCC's uniform settlements policy, nor to the benchmark order. Note, however, that the FCC prohibits ISR on routes to countries with non-liberalized telecom markets. In particular,

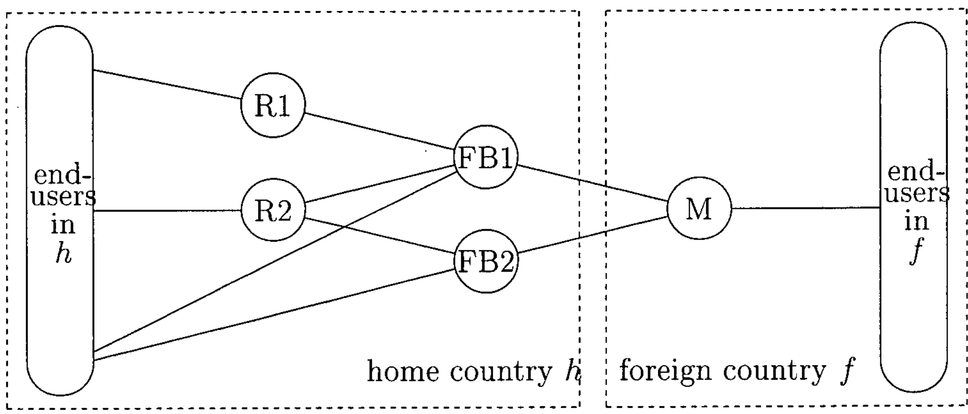


Figure 4.1. International telecommunications relation between a competitive market and a monopoly market

The end-user market in h is served by two types of carriers: resellers (denoted by superscript r), and fb-carriers (denoted by superscript fb). Resellers do not operate international transmission facilities. Instead, they exclusively offer end-user (retail) service, and route traffic into the fb-carriers' network in exchange for an agreed-upon per minute transmission charge. Fb-carriers, on the other hand, offer both end-user and wholesale service. They own or lease international transmission facilities and have direct interconnection agreements with foreign carriers.

Figure 4.2 depicts the market structure in the case of two fb-carriers (FB1, FB2), two resellers (R1, R2), and one monopoly carrier (M) in the foreign market. Fb-carriers derive profits from 3 distinct sources, domestic retail,

ISR is prohibited on most (but not all) of the routes that are subject to the PRR.

domestic wholesale, and from switching incoming traffic.

$$\Pi_i^{fb} = \Pi_{i,retail}^{fb} + \Pi_{i,wholesale}^{fb} + \Pi_{i,incoming}^{fb} \tag{4.1}$$

whereas resellers derive profits only from their retail operations

$$\Pi^r = \Pi_{retail}^r \tag{4.2}$$

Without the PRR, the profits from incoming traffic could be simply regarded as a windfall profit from regulation, a fixed amount of money that could be retained by the government[9], allocated to carriers according to some fixed sharing scheme, or the allocation scheme for the return traffic could be entirely left up to the foreign monopolist. No matter how it is distributed, the total surplus from incoming traffic is

$$\bar{\Pi}_{inc} = (s - c^t)Q^f \tag{4.3}$$

were s is the settlement rate, c^t is the transmission cost, and Q^f is the (fixed) total incoming traffic volume. $\bar{\Pi}_{inc}^{fb}$ would then enter the carriers' maximization problem as a constant and hence play no further role.

Under the PRR, the profits from incoming traffic are allocated among

[9]For example, the FCC could negotiate all settlement rates with foreign monopolists, and then auction the incoming traffic off to the fb-carriers that is willing to switch incoming traffic at the lowest per-minute charge.

fb-carriers according to their relative market shares:

$$\Pi^{fb}_{inc,i} = \frac{q_i^{fb} + \phi_i Q^r}{Q^h} \cdot (s - c^t) Q^f \tag{4.4}$$

where q_i^{fb} is fb-carrier i's output, Q^r is the total output of all resellers, ϕ_i is the fb-carrier i's market share of the resale market, and Q^h is the total home country output, i.e., the sum of all resellers' and fb-carriers' outputs.

To complete the model specification, the game theoretic framework used to model the interaction between the carriers in h is represented by the following two-stages.

In stage one, fb-carriers set the per-minute "wholesale" transmission charge for the telephone calls they transmit on behalf of their reseller clients, assuming Bertrand competition between the fb-carriers in the wholesale market.

In stage two, both fb-carriers and resellers compete in quantities on the retail (end-user) market[10].

[10]The assumption Cournot competition in stage two of the game allows for equilibria where the fb-carriers' and resellers' market shares differ, even when they charge the same collection charge. The solution to stage two profit maximization problem will however be algebraically complex. For instance, the first order condition to the profits from incoming traffic alone (equation 4.3) will be a polynomial of degree 3 in q_i^{fb}. The assumption of Bertrand competition in stage one of the game then has two merits. One is that it retains the tractability of the model. Under the Bertrand assumption, optimal wholesale charges of stage one can be computed without having to maximize a prohibitively complex profit function. Second, the assumption of Bertrand competition in the wholesale market reflects the realities of these markets reasonably well. In this wholesale market, a few fb-carriers with large excess capacity are offering wholesale service to a large number of resellers, and resellers can *instantaneously and costlessly* switch from one wholesale service provider to

The most general form of the fb-carriers and resellers' profit functions can then be written as

$$\pi_i^{fb} = \left(p^{fb}(Q^r, Q^{fb}) - c^{fb} - c^t - s\right) q_i^{fb}$$

$$+ \left(w_i - c^t - s\right) \phi_i Q^r + \left(\frac{q_i^{fb} + \phi_i Q^r}{Q^h}\right) \left(s - c^t\right) Q^f \tag{4.5}$$

$$\pi_j^r = \left(p^r(Q^r, Q^{fb}) - c^r - w\right) q_j^r \tag{4.6}$$

for fb-carriers $i = 1, \ldots, m$ and resellers $j = 1, \ldots, n$. Analogously to equation 4.1, the three terms of the fb-carriers' total profit function represent the profits from retail service, wholesale service, and incoming traffic. The fb-carriers' and resellers' calling charges are represented by p^{fb} and p^r, respectively.

Resellers face two types of cost, the retail service cost, and the wholesale transmission charge, levied by the fb-carriers. The *retail service cost*, c^r, is the long run marginal cost of operating the local switch to handle calls, and transmitting these calls to a fb-carrier. The *wholesale transmission charge*, w, is a per-minute price a reseller pays to fb-carriers for having its calls routed to the recipient in the call destination country. Under the assumption of Bertrand competition in the wholesale market, the resellers will route all their traffic via the cheapest available network connection, hence $w = \min_{\{i\}}\{w_i\}$, where w_i is the wholesale transmission charge levied by fb-carrier i.

another, if a better wholesale rate is offered.

Consequently, fb-carrier i's share of the wholesale market, ϕ_i, can only take the following discrete values:

$$\phi_i = \begin{cases} 1 & \text{if } w_i < w_k \quad \text{for all fb-carriers } k \neq i \\ \frac{1}{r} & \text{if } w_i = w \quad \begin{array}{l} \text{where } r \text{ is the number of facilities-} \\ \text{based carriers that charge } w \end{array} \\ 0 & \text{otherwise} \end{cases} \tag{4.7}$$

The basic structure of the model is similar to a model with an upstream (wholesale) and a downstream (retail) market, where the upstream firms also directly sell to the retail customers. The unusual feature of this setting is that the incoming call market is both price regulated and tied to the outgoing call market. By expanding service in the end-user market, fb-carriers can therefore not only increase their revenue from the end-users, but also their share of the incoming traffic. Alternatively, they can attract more traffic from resellers (i.e., more wholesale business) in order to increase their share of incoming traffic[11]. It is precisely this sharing rule, which confounds the analysis of international telephone markets, and leads to a number of surprising and counterintuitive market outcomes.

[11]It is important to note that revenues from switching incoming calls are exorbitantly high on routes to countries with non-liberalized markets, more so than switching outgoing calls. The "best-practice settlement rates", which can be assumed to reflect an upper bound to the true cost of switching inbound traffic, are currently at $0.10 per minute (FCC 1998), compared to a (worldwide, non-weighted) average settlement rate of $0.48 per minute received for switching incoming calls.

The following restrictions are necessary in order to make the model tractable:

(1) End-user telecommunications service is assumed to be a homogenous product - hence, resellers and facilities-based retail prices are identical, i.e. $p(Q^h) \equiv p^r(Q^r,Q^{fb}) = p^{fb}(Q^r,Q^{fb})$. The two types of carriers differ only with respect to their cost levels[12].

(2) The resellers marginal cost are at least as high as those of the fb-carriers, $c^r \geq c^{fb}$[13].

(3) The demand for telephone service is linear, i.e., $p = a - bQ^h$

(4) The number of fb-carriers serving a given inter-country route is typically small compared to the number of resellers[14]. This model will focus on the limiting case where the number of fb-carriers is finite and the number of resellers approaches infinity.

[12]In reality, resale service typically differs from fb-carriers' service in at least two aspects. One aspect is that the use of resale service imposes various "nuisance" cost on the end-user, such as dialing into the resellers switch, dialing pin-numbers, or buying pre-paid phonecards. In compensation, resellers levy lower per-minute calling charges then fb-carriers. This model collapses all of the above differences between fb-carriers and resellers into the differences between their the retail service cost, c^{fb} and c^r. One could hence interpret this setting as one where the price reflects both the end-user charge and the effort of using the service, and where the reseller grants the end-users a fixed per-minute rebate that exactly compensates for the nuisance of using the resale service. This rebate would then be reflected in the resellers' higher cost.

[13]Although this model does not incorporate fixed cost, it assumes that the resellers' long run marginal cost of servicing the end-user (i.e., the retail service cost) are higher than those of the fb-carriers, due to smaller-sized and less efficient technology.

[14]The largest three fb-carriers, AT&T, MCI Worldcom and Sprint together account for 95.6% of the 1998 international facilities-based service market (based on net revenues) (FCC 1999). On the other hand, the number of resellers reporting to the FCC in 1998 was 349. Most of these carriers have a market share of below 1% of the US resale market.

(5) The wholesale charges w_i are non-negative. If w were allowed to be negative, then resellers would be able to earn money by generating telephone calls.

Hence, the profit functions of equation 4.5 and 4.6 can be rewritten as

$$\begin{aligned}
\pi_i^{fb} &= \left(a - bQ^h - c^{fb} - c^t - s\right) q_i^{fb} \\
&\quad + \left(w_i - c^t - s\right) \phi_i Q^r + \left(\frac{q_i^{fb} + \phi_i Q^r}{Q^h}\right) \left(s - c^t\right) Q^f \qquad (4.8) \\
\pi_j^r &= \left(a - bQ^h - c^r - w\right) q_j^r \qquad (4.9)
\end{aligned}$$

It is obvious from the setup of this problem that corner solutions will play an important role when deriving the market equilibrium. This is due to two reasons

(1) The linear demand function may lead to negative prices when output is high

(2) Second and more importantly, the presence of incoming traffic may lead to situations in which the wholesale price or the carriers' output is driven to zero.

4.3 Home Market Equilibrium under Proportionate Return

4.3.1 An Equilibrium Characterization in the General Case

The home market carriers' two-stage optimization program is solved backwards, starting in the second stage, in which fb-carriers and the resellers simultaneously maximize their profit functions for any combination of wholesale prices with respect to the output quantities, given the other carriers' outputs. Formally, carrier i's and reseller j's stage two optimization problems can be written as

$$\begin{aligned} &\max_{\{q_i^{fb}\}} \quad \pi_i^{fb}(q_i^{fb} \mid \mathbf{w}, q_k^{fb*}, q_j^{r*}, k=1\ldots m, j=1\ldots n, k \neq i) \\ &\text{s.t.} \qquad q_i^{fb} \geq 0 \end{aligned} \tag{4.10}$$

and

$$\begin{aligned} &\max_{\{q_i^{fb}\}} \quad \pi_i^{r}(q_i^{r} \mid \mathbf{w}, q_k^{fb*}, q_j^{r*}, k=1\ldots m, j=1\ldots n, j \neq i) \\ &\text{s.t.} \qquad q_i^{fb} \geq 0 \end{aligned} \tag{4.11}$$

where $\mathbf{w} = (w_i, \ldots, w_m)$ is a vector of transmission charges. The first stage equilibrium, if it exists, can then be characterized by an optimal wholesale transmission charge, w_i^*, given the stage two solutions. In equilibrium,

$$\pi_i(w_i^*, \mathbf{w}_{\neq i}^*, q_i^{fb}(w_i^*, \mathbf{w}_{\neq i}^*), q_i^r(w_i^*, \mathbf{w}_{\neq i}^*)) \geq$$

$$\pi_i(w_i, \mathbf{w}^*_{\neq i}, q_i^{fb}(w_i, \mathbf{w}^*_{\neq i}), q_i^r(w_i, \mathbf{w}^*_{\neq i})) \tag{4.12}$$

for all and for all $i, j = 1, \ldots, m$ and for all w_i, where $\mathbf{w}^*_{\neq \mathbf{i}} = (w_1^*, \ldots, w_{i-1}^*, w_{i+1}^*, \ldots, w_m^*)$ for $i = 1 \ldots m$ and $w_i,\ w_i^* \geq 0$ for $i = 1, \ldots, m$.

4.3.2 Stage Two Equilibrium Output

From Equation 4.9, reseller k's stage two optimality condition is given by

$$\frac{\partial \pi_k^r}{\partial q_k^r} = a - c^t - w - b(\sum_{j=1}^{r} q_j^r + \sum_{i=1}^{m} q_i^{fb} + q_k^r) = 0 \tag{4.13}$$

The SOC $\frac{\partial^2 \pi_k^r}{\partial^2 q_k^r} = -2b < 0$ guarantees that the optimality condition characterizes a global maximum. Symmetry among the resellers implies that each reseller's optimal output can be written in its nonnegative range as,

$$q_j^{r*} = \frac{a - c^r - w - bQ^{fb}}{b(r+1)} \tag{4.14}$$

where $Q^{fb} = \sum_{i=1}^{m} q_j^{fb}$. Then, in the limiting case of the number of resellers approaching infinity

$$Q^{r*} \equiv \lim_{r \to \infty} r q_j^{r*} = \begin{cases} \frac{a-c^r-w}{b} - Q^{fb} & \text{if } Q^{fb} \leq \frac{a-c^r-w}{b} \\ 0 & \text{otherwise} \end{cases} \tag{4.15}$$

The expression $\frac{a-c^r-w}{b}$ represents the output of a competitive industry with the resellers' marginal cost. Equation 4.15 states that, as long as the fb-carriers produce less than that competitive resale output, the resale industry will provide - in the limit - the difference between the competitive resale output and the total combined output of all fb-carriers. It follows that

$$Q^{h*}(w) \equiv Q^{r*} + Q^{fb} = \frac{a - c^r - w}{b} \tag{4.16}$$

for all output combinations, and in particular for all stage two equilibria $(q_1^{r*}(\mathbf{w}), \ldots, q_r^{r*}(\mathbf{w}), q_1^{fb*}(\mathbf{w}), \ldots, q_m^{fb*}(\mathbf{w}))$, as long as $Q^{fb*} < \frac{a-c^r-w}{b}$.

Hence, as the number of resellers becomes infinitely large, the total industry output approaches the level of a competitive industry with the resellers' marginal cost. This marginal cost is the sum of the marginal cost of providing end-user service, and the per-minute wholesale charge.

Equivalently, the retail price of a call minute from h to f approaches the marginal cost of the resale industry:

$$p^*(w) = w + c^r \tag{4.17}$$

At $Q^{fb*} = \frac{a-c^r-w}{b}$, the fb-industry produces exactly the output of a competitive industry with the resellers' marginal cost. This situation occurs when the resellers' marginal cost, $w + c^r$ are high compared to the fb-carriers marginal retail service cost, c^{fb}, such that the resellers are driven out of the retail market. In general, there will always be a wholesale price beyond which the resellers are no more willing to provide retail services. Let $\hat{w}$ be this critical wholesale charge, i.e.,

$$Q^{fb*}(\hat{w}) \equiv \frac{a - c^r - \hat{w}}{b} \tag{4.18}$$

For $w \geq \hat{w}$, the resellers will offer no retail service, and there is hence no meaningful wholesale market. The two-stage game will then collapse into a one stage Cournot game between the fb-carriers. In order to exclude degenerate solutions, only solutions in the range $0 \leq w < \hat{w}$ will hereafter be considered[15].

The relatively simple form of the total output function in equation 4.16, Q^{h*}, makes it possible to derive the facilities based carrier i's stage two equilibrium outputs, contingent on the three relevant classes of stage one outcomes, namely $\phi_i = 0$, $\phi_i = \frac{1}{m}$, and $\phi_i = 1$. The case of $\phi_i = 0$ occurs if fb-carrier i offers wholesale service at a price above the minimum wholesale price in the market. In this case, no reseller will route traffic via carrier i's network, and i's wholesale market share is zero. If every carrier offers the same wholesale charge $w_i = w$ for $i = 1 \ldots m$, then each fb-carrier will have the same market share, and $\phi_i = \frac{1}{m}$. Finally, if carrier i undercuts all other carriers' wholesale prices, then it will obtain all resellers traffic and $\phi_i = 1$.

Depending on the fb-carriers stage one wholesale prices, $\mathbf{w}$, and carrier i's resulting wholesale market share, ϕ_i, the optimal fb-carriers' output schedules

[15]This restriction can be justified by noting that the FCC has explicitly required fb-carriers to offer wholesale service at reasonable wholesale charges, see, for example, (FCC 1988a at 22).

can be computed as[16]

$$q^{fb+}_{i,\phi_i=0}(w) = \frac{(Q^{h*})^2(w+\Delta c - s - c^t) + Q^{h*}Q^f(s-c^t)}{b(Q^{h*})^2 + Q^f(s-c^t)} \tag{4.19}$$

$$q^{fb+}_{i,\phi_i=\frac{1}{m}}(w) = \frac{w+\Delta c - s - c^t}{b} + \frac{m-1}{m}\frac{Q^f(s-c^t)}{bQ^{h*}} \tag{4.20}$$

$$q^{fb+}_{i,\phi_i=1}(w) = \frac{w+\Delta c - s - c^t}{b} + \frac{(m-1)Q^f(s-c^t)}{bQ^{h*}} q^{fb*}_{i,\phi_i=0} \tag{4.21}$$

where $\Delta c = c^r - c^{fb}$. Note, that the optimal quantities of equations 4.19, 4.20 and 4.21 do not necessarily satisfy the positive quantity constraint of the maximization problem 4.10. Hence, a complete specification of the solution to 4.10 for $w < \hat{w}$ is given by

$$q^{fb*}_{i,\phi_i=0}(w) \equiv \begin{cases} q^{fb+}_{i,\phi_i=0}(w) & \text{if } q^{fb+}_{i,\phi_i=0}(w) \geq 0 \\ 0 & \text{otherwise} \end{cases} \tag{4.22}$$

$$q^{fb*}_{i,\phi_i=\frac{1}{n}}(w) \equiv \begin{cases} q^{fb+}_{i\phi_i=\frac{1}{n}}(w) & \text{if } q^{fb+}_{i,\phi_i=0}(w) \geq 0 \\ 0 & \text{otherwise} \end{cases} \tag{4.23}$$

$$q^{fb*}_{i,\phi_i=1}(w) \equiv \begin{cases} q^{fb+}_{i,\phi_i=1}(w) & \text{if } q^{fb+}_{i\phi_i=0}(w) \geq 0 \\ 0 & \text{otherwise} \end{cases} \tag{4.24}$$

The corresponding optimal stage 2 profit schedules, contingent on the whole-

[16]The SOC for profit maximization are satisfied, since $\frac{\partial^2 \pi^{fb}_i}{\partial (q^{fb}_i)^2} = -2\left(b + Q^f(s-c^t)\frac{Q^{h*} - q^{fb}_i - \phi_i Q^{r*}}{(Q^{h*})^3}\right) < 0.$

sale rate, and for the domain of w for which $Q^{r*} > 0$ can be written as:

$$\pi^{fb*}_{i,\phi_i=0}(w) = \pi^{fb}_i(q^{fb*}_{i,\phi_i=0}(w), w) \quad (4.25)$$

$$\pi^{fb+}_{i,\phi_i=\frac{1}{m}}(w) = \pi^{fb}_i(q^{fb*}_{i,\phi_i=\frac{1}{m}}(w), w) \quad (4.26)$$

$$\pi^{fb*}_{i,\phi_i=0}(w) = \pi^{fb}_i(q^{fb*}_{i,\phi_i=0}(w), w) \quad (4.27)$$

4.3.3 Stage One equilibrium wholesale rates

The number and type of stage one equilibria in the wholesale market obviously depends on the shape and position of the profit schedules 4.25, 4.26 and 4.27 relative to each other. In general, the stage one equilibrium - if it exists - is characterized by a wholesale charge w^* with the following properties:

(1) $\pi^{fb*}_{i,\phi_i=\frac{1}{m}}(w^*) \geq \pi^{fb*}_{i,\phi_i=1}(w)$ for all $w \leq w^*$, $w^* > 0$

(2) $\pi^{fb*}_{i,\phi_i=\frac{1}{m}}(w^*) \geq \pi^{fb*}_{i,\phi_i=0}(w^*)$

The first condition postulates that no carrier can improve profits by undercutting w^*. The second condition guarantees that in equilibrium none of the carriers would be better off by charging a wholesale rate, which is higher than w^*.

While the exact shape and relative position of the profit schedules depend on the specific set of parameters, it can in general be shown that[17]

[17]The proof is by simply finding and evaluating the intersections between the profit schedules 4.19 to 4.21 and 4.22 to 4.24, respectively. While this exercise is purely alge-

(1) Each of the profit schedules intersects every other schedule at least one more time at a $w < \hat{w}$. However, these intersections may or may not fall on the same point, they may occur in the negative profit range, or in the negative part of the domain of w.

(2) If all three intersections fall into the positive profit range, *and* the output constraints are non-binding, then they will all intersect in the same point. In this case, the intersection of the three profit schedules constitutes a unique equilibrium in the wholesale market.

In order to illustrate this, the set of possible stage one equilibria can be classified into three stylized cases. Figures 4.2 to 4.4 depict these cases by schematically representing the (stage two) optimal profits as functions of the wholesale rate.

The thick lines represent a fb-carrier's profits for the case that all carriers choose the same wholesale rate. The solid thin lines represent the profits of a carrier that has undercut its competitors' wholesale charge, and therefore is the only provider of wholesale services. The dotted lines depict the profits of a carrier that charges a wholesale rate above the minimum rate in the market, and therefore has zero wholesale market share.

braic, it involves finding and comparing the solutions of polynomials of degree 5. The computations can be conveniently carried out using mathematical software such as Maple V or Mathematica. Due to the algebraic complexity, an presentation of the relevant expressions is omitted at this point.

Figure 4.2 illustrates the first of the stylized cases, *Case I*. Three zones can be identified in this figure. If the wholesale rate is high, i.e., for wholesale rates $w \geq \hat{w}$, the resellers total cost (relative to the fb-carriers' cost) are high to an extent that they would not provide any retail service. To exclude degenerate solutions, the feasible set of wholesale rates was previously limited to the range $0 \leq w < \hat{w}$. Hence, point **B** is not a feasible outcome by assumption.

At any point in the area between the points **A** and **B**, capturing the entire wholesale market will provide a carrier with benefits of supplying *all* resellers, and with associated benefits in the incoming traffic market. Note that a carrier will be willing to make losses in its direct dealing with resellers, if these losses are compensated or overcompensated by gains from incoming traffic, and from their own retail operations.

Point **A** is reached at the wholesale rate, at which undercutting the wholesale rate by an infinitesimal small amount would bring no further profits, as the additional gains in the incoming traffic and resale markets would be exactly compensated by additional losses in the wholesale operations. For $w < w^*$, a carrier would be better of by not offering wholesale service at all, than by offering it.

The only equilibrium point in this market is **A**, since at this point no carrier has an incentive to defect from the equilibrium. Undercutting the wholesale rate would result in lower profits and quitting the wholesale market altogether would not change the profits. In *Case II*, shown in Figure 4.3,

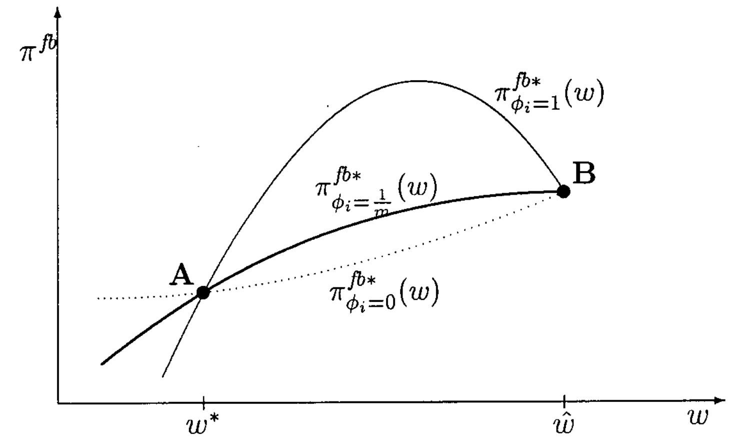


Figure 4.2. Stage two optimal profit schedules contingent of the stage one wholesale price. *Case I:* Unique equilibrium.

no stage one equilibrium (and therefore no stage two equilibrium) exists. None of the points on the $\phi_i = \frac{1}{m}$ profit schedule between **C** and **B** is an equilibrium, as at each of these points a carrier would have the incentive to undercut the wholesale price in order to receive a larger portion of the incoming traffic. However, **C** itself is not an equilibrium either, since for all $w < w^{\mathrm{E}}$ the carriers can make higher profits by only serving the end-users, than they could make by competing for wholesale business and for the associated gains from incoming traffic. There is no point, at which the two equilibrium conditions are met[18]. Finally, *Case III* (depicted in Figure 4.4) describes a situation where an infinite number of sage one and stage two equilibria exists. All points on the thick line between the **E** and **C** are

[18]Note that there is also no asymmetric equilibrium at **D**, since at any point between **D** and **E'**$=(w^{\mathrm{E}}, \pi^{fb*}_{\phi_i=1}(w^{\mathrm{E}}))$, a monopolist on the wholesale market would be better of by increasing the wholesale price w by in infinitesimal small amount.

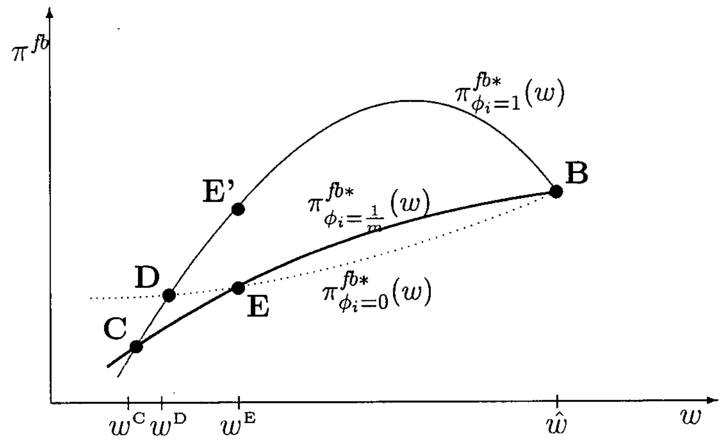


Figure 4.3. Stage two optimal profit schedules contingent of the stage one wholesale price. *Case II:* No equilibria.

equilibria, but there exists no equilibrium without resale. On the other hand, if $\pi^{fb*}_{i,\phi_i=1}(w)$ is non-decreasing left of point **B**, there will also be an equilibrium without resale. Situations like in Figure 4.3 and 4.4 can occur only if the output restriction[19] is binding at any of the points **C**, **D**, or **E**.

4.3.4 Market Equilibrium without PRR

Consider now a telecommunications market that operates under the same conditions as the market described in section 4.2, except that the government gets all the profits from incoming traffic[20]. Then the profit functions of fb-carrier i, reseller j and surplus from incoming traffic (which can either be

[19] I.e., the restriction that outputs be positive, see equations 4.22 to 4.24.

[20] The alternative of allocating an equal *fixed* share of incoming traffic to each fb-carrier would be equivalent in terms of equilibrium outcome and welfare implications. In the context of this model, both alternatives differ only with respect to *who* gets the fixed sum of profits from incoming traffic. In the following, either setting will be referred to as a market *without PRR.*

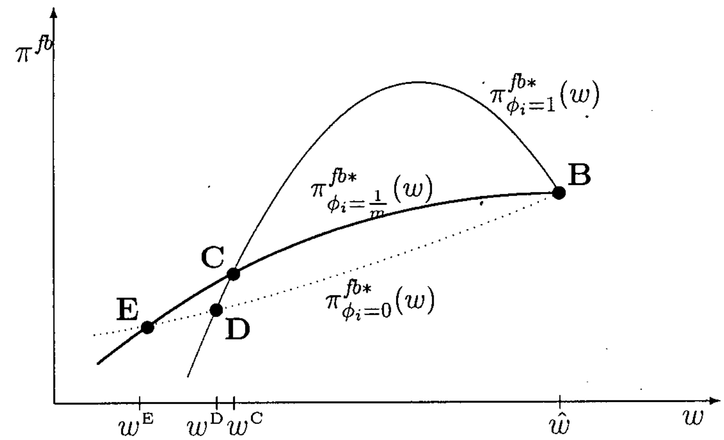


Figure 4.4. Stage two optimal profit schedules contingent of the stage one wholesale price. *Case III:* Multitple equilibria with resale.

allocated among the fb-carriers according to a fixed scheme, or retained by government) can be written as

$$\bar{\pi}_i^{fb} = (a - b\bar{Q} - c^{fb} - c^t - s)\bar{q}_i^{fb} + (\bar{w}_i - c^t - s)\phi_i \bar{Q}^r \tag{4.28}$$

$$\bar{\pi}_j^r = (a - b(\bar{Q} - c^r - \bar{w})\bar{q}_j^r \tag{4.29}$$

$$\bar{\pi}_{inc} = (s - c^t)Q^f \tag{4.30}$$

As in Equation 4.8, the first two terms of Equation 4.28 represents carrier i's profit in the home market, and its profit from transmitting resold traffic, respectively. It is easy to see that the equilibrium outcome of the two-stage game between fb-carriers and resellers (characterized by the equilibrium wholesale charge $\bar{w}^*$, and outputs $\bar{Q}^*$, $\bar{q}^{fb*}$) corresponds to the outcome of the game under proportionate return but without incoming traffic, i.e., $Q^f = 0$.

At $Q^f = 0$, the fb-carriers' optimal stage two output schedules contingent on the stage one outcome (equation 4.19 to 4.21) are always identical and the non-negativity constraint for the fb-carriers' output is never binding. Hence, there exists a unique equilibrium without proportionate return, and the equilibrium outcome simplifies to

$$\bar{\mathrm{w}}^* = c^t + s, \qquad \bar{\mathrm{Q}}^* = \frac{a - c^r - s - c^t}{b}, \quad \bar{\mathrm{q}}^{fb*} = \frac{\Delta c}{b} \tag{4.31}$$

Without the PRR, fb-carriers will set the wholesale charge to the marginal cost of transmitting outbound traffic. Due to their cost advantage over the resellers, fb-carriers will retain a profit from their retail service,

$$\bar{\pi}_i^{fb*} = \frac{(\Delta c)^2}{b} \tag{4.32}$$

4.3.5 An illustrative example: $\mathbf{c^{fb} = c^r}$

The market equilibrium, a number of comparative statics results, and the welfare implications of the PRR can be analytically illustrated for the special case that fb-carriers and resellers face the same retail service cost. In the case of $c \equiv c^{fb} = c^r$, the fb-carriers' stage one profit functions take the following simple form:

$$\pi_{i,\phi}^{fb} = \left(w - c^t - s + \zeta(w)(s - c^t)\right)(q_i, \phi^{fb}(\mathbf{w}) + \phi_i Q^r(\mathbf{w})) \tag{4.33}$$

where $\zeta(w) = \frac{Q^f}{Q^h(w)}$ is country h's traffic imbalance. If $\zeta(w^*) < \frac{s+c^t}{s-c^t}$, then there exists an equilibrium wholesale charge, w^*, at which the fb-carriers' equilibrium profits are zero, regardless of their wholesale market share, ϕ_i, and regardless of their second stage output decision.

$$w^* = s + c^t - \zeta(w^*)(s - c^t) \text{ if } \zeta(w^*) < \frac{s+c^t}{s-c^t} \tag{4.34}$$

$$\pi_i^{fb*} = 0 \text{ if } \zeta(w^*) < \frac{s+c^t}{s-c^t} \tag{4.35}$$

On the other hand, if $\zeta(w^*) \geq \frac{s+c^t}{s-c^t}$, then the non-negativity constraint of the wholesale charge is binding, and the fb-carriers equilibrium profits remain positive.

$$w^* = 0 \text{ if } \zeta(w^*) \geq \frac{s+c^t}{s-c^t} \tag{4.36}$$

$$\pi_i^{fb*} = \frac{1}{m}(Q^f(s - c^t) - Q^{h*}(s + c^t)) \text{ if } \zeta(w^*) > \frac{s+c^t}{s-c^t} \tag{4.37}$$

Carrier i's optimal second stage output can be computed as

$$q_{i,\phi=\frac{1}{m}}^{fb*} = \begin{cases} 0 & \text{if } \zeta^* \leq \frac{m}{m-1}\frac{s+c^t}{s-c^t} \\ \frac{w^*-c^t-s}{b} + \frac{m-1}{m}\frac{Q^f(s-c^t)}{bQ^{h*}} & \text{otherwise} \end{cases} \tag{4.38}$$

Hence, in the case of $c^{fb} = c^r$ there always exists unique equilibrium, characterized by the equilibrium wholesale charge, w^*. Figure 4.5 illustrates the stage two profit schedules. The relative positions of the profit schedules correspond to *Case I* of section 4.3.3. In this particular setting, however, the

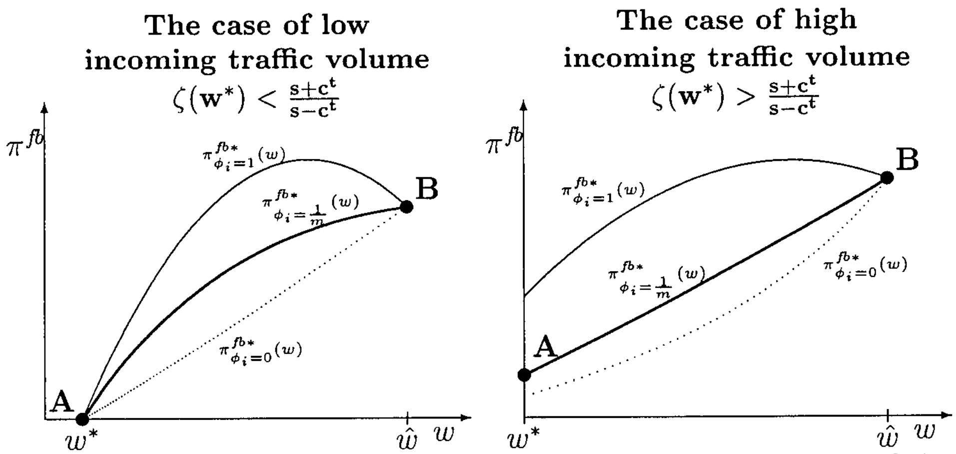


Figure 4.5. Stage two optimal profit schedules contingent of the stage one wholesale price. *Illustrative example of* $c^{fb} = c^r$

equilibrium is always a corner solution, either at the point at which the fb-carriers' profits are zero, or where the equilibrium wholesale charge is zero. Pont **A** in the left hand graph of figure 4.5 is obviously an equilibrium, as all three profit schedules intersect in **A**. In the right hand side graph, **A** is an equilibrium, because no carrier can undercut the wholesale charge of $w^* = 0$.

If the equilibrium traffic imbalance in is small (i.e., $\zeta(w^*) < \frac{s+c^t}{s-c^t}$[21]), then the wholesale charge takes on a positive value, but always remains below the marginal cost of transmitting outgoing calls, $s+c^t$. All profits from incoming

[21] In order to illustrate this boundary condition, assume that the settlement rate is at $0.20 and the transmission cost are at $0.02. Then the wholesale price will be zero if the incoming traffic volume exceeds the outgoing traffic volume by 22%.
On routes where the home country transmits more traffic to the foreign country than it receives in return, the traffic ratio will always be below the threshold, $\zeta(w^*) < \frac{s+c^t}{s-c^t}$. This is true for all but two international routes originating and terminating in the United States. One of these routes is the link between the US and Sweden, on which the ISP is waived. The other is link between the US and the French Overseas Departments, which carriers a relatively insignificant traffic volume.

traffic are passed on to the resellers and from the resellers to the end users. The fb-carriers, in spite of receiving all the lucrative incoming traffic, are not able to retain any profits. Furthermore, the fb-carriers offer no end-user (retail) service, but rather exclusively focus on the wholesale business.[22]

On the other hand, if the traffic imbalance is large (i.e., the ratio of incoming to outgoing traffic exceeds the threshold $\frac{s+c^t}{s-c^t}$), then the wholesale price is driven to zero. Only in this case are fb-carriers able to retain some profits. If the traffic imbalance exceeds the threshold of $\frac{m}{m-1}\frac{s+c^t}{s-c^t}$), the fb-carriers will also retain a positive retail market share.

An immediate consequence from equation 4.38 is that each fb-carrier's output increases with the number of fb-carriers in the market, $\frac{\partial q_i^{fb*}}{\partial m} > 0$, if $q_i^{fb*} > 0$. The intuition for this result is that an increase in the number of carriers has an effect in both the outbound call market as well as in the inbound call market. On the outbound market, more carriers compete to serve the end-users and resellers. The carriers' optimal reaction is to contract output. On the other hand, the revenues from incoming calls are split among more carriers, and the carriers will compensate lost revenues by expanding outbound output. The latter effect dominates the former one since the number of carriers splitting incoming traffic is smaller than the number of carriers

[22]It is intuitively clear that the fb-carriers will not offer retail services: In Cournot-type competition models, the equilibrium total industry output *increases* with the number of carriers in the market. Fb-carriers will therefore have an interest in using resellers to service the retail market - so as to outsource and "unmerge" their retail business in order to capture a larger market. Yet, they have to compete with other fb-carrier for the privilege to service customers through resellers. In the course of this competition, all potential gains are competed away.

competing on the outbound market.

Finally, the fb-carriers' equilibrium profits do not change with a marginal change of settlement rates as long as $\zeta(w^*) < \frac{s+c^t}{s-c^t}$. Otherwise, if the incoming traffic volume is large compared to the outgoing traffic, i.e., $\zeta(w^*) \geq \frac{s+c^t}{s-c^t}$, then the fb-carriers' profits will increase in the settlement rates. The effect of a change of settlement rates on the resellers' market share is ambiguous.

4.3.6 Discussion

The previous section highlighted some of the effects of the PRR on the equilibrium outcome for the simple case that both types of carriers face the same retail service cost. Linking incoming traffic to the carriers' outgoing traffic volume causes fb-carriers to set their wholesale charge below the marginal cost of transmitting outbound calls, which in turn will induce the competitive resellers to increase the retail output beyond the economically efficient levels, and set the retail price below the cost of producing the outbound service. Consumers benefit from the low retail price, but the fb-carriers compete away at least some of the potential gains from incoming traffic. On routes where incoming traffic volumes are lower than outgoing volumes, all gains will be competed away.

In a setting where the resale market is competitive, fb-carriers and resellers face the same cost, and incoming traffic volume is lower than outgoing traffic volume, fb-carriers may therefore have no advantage of receiving incoming traffic under the PRR, neither in terms of profits, nor in terms of retail market shares. It is easy to see that the PRR increases consumer surplus, but total welfare is higher under a regime where the profits from incoming traffic are retained by the government, or distributed among the carriers according to a fixed allocation scheme.

While the conclusions drawn from the case of $c^r = c^{fb}$ are intuitive, and they can help demonstrate some equilibrium properties under the PRR, the insights gained from this special case are somewhat limited. First, the assumption that both carriers face the same marginal retail service cost is unrealistic, given their differences in size, technology, experience, and image with consumers. Second, the market equilibrium under the assumption of $c^r = c^{fb}$ will be a corner solution, where the non-negativity restriction for outputs is binding, the non-negativity restriction for the wholesale price is binding, or the fb-carriers' equilibrium profits are zero[23].

For the general case where $c^r \neq c^{fb}$, section 4.3.3 demonstrated that the effect of the PRR may reach beyond *distorting* the outputs and calling charges in international telephone markets. Rather, the PRR can preclude the existence of equilibria in international telecom market. Under the PRR, there may exist a unique interior equilibrium[24], infinitely many equilibria, or no equilibria at all, depending on the specific set of cost and demand parameters.

The arithmetic complexity of the general model, however, makes it impos-

[23]Comparative statics exercises are mostly trivial in the case of corner solutions, since the relevant equilibrium outcomes do not change with a marginal change of model parameters.

[24]I.e., equilibria where fb-carriers' profits and outputs are strictly positive.

sible to derive a tractable closed form solution of the equilibrium outcome, or even to specify the range of parameters, for which one, several, or no equilibria exist[25]. The following section develops further perspective on the nature and comparative static properties of telecom market equilibria under proportionate return and *differential retail service cost*, by simulating equilibrium outcomes and their properties.

4.4 Simulating Equilibria under Differential Cost

4.4.1 Simulation inputs and assumptions

In order to make simulations useful and credible, it is important that inputs to the simulations be observable or estimable, and that the simulation results are consistent with the observable features of the market.

The exogenous parameters of the model characterized by equations 4.8 and 4.9 are the demand curve intercept and slope a and b, the marginal cost parameters c^r, c^{fb}, and c^t, the settlement rate s, incoming traffic volume Q^f, and the number of fb-carriers m. The endogenous model parameters are the outgoing traffic volume Q^{h*}, the wholesale charge w^*, the fb-carriers market share in the retail market Q^{fb}/Q^{h*}, and the elasticity of demand ϵ [26].

[25]Note that the arithmetic complexity is solely due to the proportionate return rule, equation 4.3, and not to the number of parameters in the model. In fact, assuming that any of cost parameters are zero will not significantly reduce complexity.

[26]The elasticity of demand in equilibrium can be directly inferred from the demand

Some, but not all of the model primitives are directly observable on a route-by-route basis. The observable data that will be used as simulation inputs are based on four exemplary routes between the United States and Chile, China, Laos, and the United Arab Emirates (UAE)[27].

Other exogenous model parameters are not directly observable, however, their value can be conjectured or inferred from observable information. The following values for non-route-specific parameters are assumed for *all* simulations:

(1) the number of facilities-based carriers is $m = 3$, reflecting the fact that the largest three facilities-based carriers in the 1998 US telecom market accounted more than 95% of the outgoing international facilities-based service.

(2) The transmission cost and the fb-carriers retail service cost are $c^t = 0.02\$$ and $c^{fb} = 0.08\$$, respectively[28].

(3) the price elasticity of demand is $\varepsilon = -0.6$ on all routes[29].

function parameters and the equilibrium output.

[27]The criteria for selecting the exemplary routes were that (1) all routes be subject the PRR; (2) bypassing the international settlement rate mechanisms be illegal on all routes, that is, *all* traffic between the United States and these countries is subject to the PRR; (3) the four country routes reflect a broad spectrum of routes in terms of applicable settlement rate, and traffic imbalance (that is, the route specific ratio of incoming over outgoing traffic).

[28]Where international telecom market are highly competitive on both sides of an inter-country relation, the settlement rate may be regarded as a proxy for the real cost of providing telephone service. In 2000, the lowest US settlement rate of 0.10$ applied on routes to and from Australia. It is therefore reasonable to assume that the facilities-based carriers' marginal cost components, c^t and c^{fb} add up to 0.10$.

[29]This value is in the range of elasticity estimates for US outbound telephone demand published in recent years (see Chapter 3) .

4.4.2 Simulated Equilibria

If the parameters of the demand function were directly observable, then the computations of model equilibria would be straightforward. This is however not the case. Rather, the underlying demand parameters can only be *inferred*, for example, from an observed output quantity and an estimated price elasticity. The output quantity itself is, on the other hand, *endogenous* to the model.

The approach taken in the context of these simulations is to *calibrate* the demand parameters a and b, such that the resulting simulated optimal total industry output coincides with the observed 1998 traffic volume on the respective route. For example, the top row of Table 4.1 shows the simulation results based on data from the US-Chile route. The first four columns contain the observable route-specific data, the settlement rate, and the total minutes of incoming traffic, the total minutes of outgoing traffic, and the

Table 4.1. Simulation results: Existence and characterization of equilibria in the case of four exemplary international routes, for $\Delta c =$ 0.12 US$

country	**observable route-specific data**				**simulation results**				
	s	Q^f	Q^h	ζ	a	b	w^*	$\frac{Q^{fb}}{Q^h}$	equilibrium
	US$	min $\star 10^3$	min $\star 10^3$			10^{-9}	US$		
Chile	0.38	81,068	128,217	0.63	1.11	5.429	0.212	0.36	unique
China	0.53	79,290	431,863	0.18	1.78	2.57	0.467	0.27	unique
Laos	0.67	9	1,536	0.01	2.37	963.5	0.687	0.24	unique
UAE	0.74	32,331	60,389	0.54	-	-	-	-	no equilibrium

traffic imbalance $\zeta = \frac{Q^f}{Q^h}$. The next two columns report the parameters of the underlying demand function, a and b. These parameters were calibrated such that Q^h, which is the endogenously determined stage two equilibrium outcome, coincides with the observed number of telephone minutes on the route from the United States to Chile, and such that the equilibrium price elasticity of demand equals -0.6. In the case of the US-Chile route, there exists a unique pair of demand parameters (a, b) that support an equilibrium at the observed quantity, and at the estimated elasticity.

The final three columns, labeled w^*, $\frac{Q^{fb}}{Q^h}$, and "equilibrium" show the key simulation results, that is, the characteristics of the simulated equilibrium. In the case of the US-Chile route, for example, the wholesale charge was simulated to be $w^* = 0.212$, and the fb-carriers market share in the retail market is at 36%.

Note that the equilibrium wholesale charge is at a level well below the settlement rate. On the routes US-China and US-Laos, the traffic ratio ζ is lower than on the US-Chile route. The distortion created by the proportionate allocation of incoming traffic is therefore less severe, and the equilibrium wholesale charge is closer to the marginal cost of transmitting outgoing calls. An extreme example is the route US-Laos, with only 9,000 minutes of incoming traffic from Laos. The simulated wholesale charge applicable outgoing traffic on this route is only little below the marginal transmission cost, $s + c^t$.

This simulated values of the market share, $\frac{Q^{fb}}{Q^h}$, provide some indication that the simulation results are approximately consistent with the observed market structure. The simulated values were 36% for the US-Chile route, 27% for the US-China route, and 24% for the US-Laos route. In comparison, the obvserved resale industry's average market share (averaged over all international routes) was 43% in 1998[30].

The first three rows of Table 4.1, based on data from routes to Chile, China and Laos correspond to *Case I* and figure 4.2 of section 4.3.3. For each of these routes, there exists a set of demand function parameters that supports a unique equilibrium. The example of the UAE, on the other hand, corresponds to *Case II* and figure 4.3 of section 4.3.3. There is no set of demand function parameters that supports an equilibrium with the observed traffic volumes, under the assumed values of the remaining model primitives.

One of the crucial parameters determining the existence of equilibria is Δc, the cost difference between fb-carriers and resellers. The results shown in Table 4.1 were based on the somewhat ad-hoc assumption that Δc=0.12\$. The following Table 4.2 exhibits different values of Δc for which equilibria exist on the same four exemplary routes. A black dot indicates a unique equilibrium at the given value of Δc. No black dot signifies that there is no equilibrium, at any given set of demand parameters. *Case III* of multiple equilibria did not occur in any of the simulations, although the possibility of its occurrence could analytically not be ruled out. At high values of Δc

[30]The FCC reports only the total market share of resale carriers for a given year. Market share data on a route-by-route basis are not available.

Table 4.2. Simulation results: Existence and type of equilibria for different values of Δc in the case of four exemplary international routes

Country	ζ^*	s	Δc																			
			.02	.07	.12	.17	.22	.27	.32	.37	.42	.47	.52	.57	.62	.67	.72	.77	.82	.87	.92	.97
Chile	0.63	0.38			•	•	•	•	•	•												
China	0.18	0.53		•	•	•	•	•	•	•	•	•	•	•	•	•						
Laos	0.01	0.67	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		
UAE	0.54	0.74					•	•	•	•	•	•	•	•	•	•	•					

• A unique equilibrium exists

the fb-carriers cost advantage is large, such that resellers are driven out of the market. There exists no feasible equilibrium[31]. The more interesting scenario occurs at low values of Δc, where the fb-carriers' market share in the retail market is low. The wholesale market, in conjunction with the associated incoming traffic, becomes so lucrative, that a fb-carriers would chose not to provide any retail output, if it were the exclusive wholesale provider[32]. Hence, the output constraint of equation 4.21 is binding, and there will be no equilibrium.

[31]That is, there exists no equilibrium in which resellers hold a positive market share, as required by assumption.

[32]That is, if it had undercut all competitors in the wholesale market and optimized the retail outputs according to the profit schedule $\pi^{fb*}_{i,\phi_i=0}(w)$ (equation 4.27).

4.4.3 Simulating the effect of the PRR on welfare and market structure

Using the demand parameters from table 4.1, it is easy to compute the equilibrium outcome of the model *without* the PRR (equations 4.28 to 4.30), and perform welfare comparisons between the two regimes[33]. The first four

Table 4.3. Simulation results: Characterization of equilibria without PRR for three exemplary international routes, for $\Delta c = 0.12$ US$

country	observable route-specific data		demand parameters (from Table 4.1)		simulation results without PRR		
	s	Q^f	a	b	$\bar{\zeta}$	$\bar{w}^*$	$\frac{Q^{fb}}{Q^h}$
	US$	min $*10^3$		10^{-9}		US$	
Chile	0.38	81,068	1.11	5.429	0.86	0.40	0.71
China	0.53	79,290	1.78	2.570	0.20	0.55	0.35
Laos	0.67	9	2.37	963.5	0.01	0.69	0.24

column of table 4.3 show the exogenous model parameters, as they appear in table 4.1. The equilibrium outcome without PRR is reported in the three right hand columns. Comparing the simulated values of $\bar{\zeta}$, $\bar{w}^*$, $\frac{Q^{fb}}{Q^h}$ with the respective figures in table 4.1, it is easy to see that the wholesale charge is higher under the regime without PRR. The traffic imbalance ratio is higher without the PRR, since the increased wholesale charge results in a smaller volume of outbound traffic, while the inbound traffic volume remains con-

[33]Obviously, welfare comparisons can only be performed for those routes where an equilibrium under PRR exists. The US-UAE route is hence not considered in the subsequent discussion.

stant.

A less intuitive simulation result is that the simulated fb-carriers' retail market share, $\frac{\bar{Q^{fb}}}{Q^h}$, is higher *without* the PRR on all three routes[34]. Contrary to intuition the PRR therefore does not necessarily help reinforcing the fb-carriers dominance over the resellers in the telephone retail market. Rather, it can provide the fb-carriers with an incentive to decrease their retail market share and place relatively more emphasis on the provision of wholesale service. The competition in the wholesale market under the PRR

Table 4.4. Simulation results: Welfare comparisons to equilibria under PRR in the case of four exemplary international routes, for $\Delta c = 0.12$ US$

country	**welfare analysis with PRR**			**welfare analysis without PRR**				
	PS	CS	W	$\bar{\pi}_{inc}$	$\bar{PS}$	$\bar{CS}$	$\bar{W}$	ΔW
	US$*10^6	US$*10^6	US$*10^6	US$*10^6	US$*10^6	US$ *10^6	US$*10^6	US$*10^6
Chile	10.54	44.63	55.17	29.18	7.96	23.93	61.07	-6.10
China	18.22	239.66	257.88	40.43	16.81	206.63	263.87	-6.01
Laos	0.05	1.14	1.19	0.06	0.05	1.13	1.24	-0.05

forces fb-carriers to pass a significant share of their windfall profits from incoming traffic on to the resellers, which in turn will pass it on to consumers. The figures shown in table 4.4 illustrate that the PRR results in a higher producer surplus and a higher consumer surplus than the alternative regime without PRR, assumed they receive no share of the profits from incoming

[34]The same results hold not only for the route and specific parameter values exhibited in table 4.1, but for all reasonable parameter combinations examined during the course of this research.

traffic under the alternative regime. However, the total welfare effect of the PRR, is negative. For example, for the three exemplary routes simulated for this study, the combined welfare loss from the PRR amounts to 12.16 million US$.

Note that in each of the exemplary cases, the consumers have the largest benefit from the PRR. A change from the PRR to a regime without the PRR would reduce the producer surplus by a relatively small amount, compared to the reduction of consumer surplus. Consider, for example, a situation where the FCC would exempt the US-Chile route from the PRR, and would leave the allocation of US-bound traffic to the discretion of the Chilean carrier. Then the fb-carrier industry, as a whole, would now have a Producer Surplus of 37.12 million US$, improved from 10.54 million US$ under the PRR.

Depending on the specific allocation of US bound traffic among the fb-carriers, each single one of the three fb-carriers, which had a third of the incoming traffic prior to the exemption, could face a loss of at most US$ 860,000. However, a carrier that receives only 2.9% or more of the US bound traffic after the exemption from the PRR would be better off relative to the situation before. If the incoming traffic were distributed *in equal parts* among the fb-carriers, each fb-carrier would always earn more profits without the PRR.

Hence, under the assumptions of this model and for realistic sets of parameter values, a fb-carrier benefits from the exemption of a route from the PRR, unless it is almost entirely excluded by the foreign carrier from receiving incoming traffic.

4.4.4 Simulated comparative statics

The final set of simulations illustrates the effect of increasing the number of fb-carriers in the market and of increasing the settlement rate on the equilibrium outcome. Section 4.3.5 showed analytically that, in the case of $c^{fb} = c^{r}$, the fb-carriers' output increases with their number in the market. The same result can be demonstrated in the general model with different marginal retail service cost. Figure 4.5 shows each carrier' profits, output, and market share in the case where 3, 4, and 5 fb-carriers serve the US-Chile route[35]. The

Table 4.5. Simulation results: Fb-carriers profits, outputs, and market share for varying numbers of fb-carriers in the market based on data from the US-Chile route

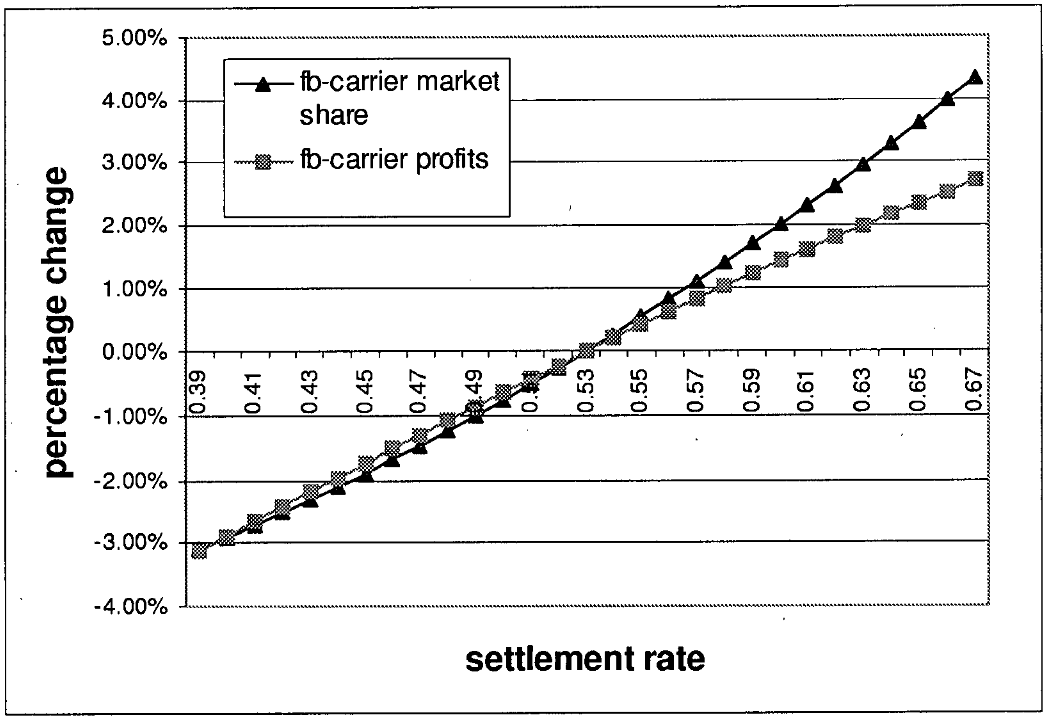
Number of fb-carriers	$\frac{q_i^{fb}}{Q^h}$	q_i^{fb} minutes	π_i^{fb} US$
m=3	0.12	15,354,580	3,515,071
m=4	0.15	18,839,000	3,515,071
m=5	0.16	20,929,650	3,515,071

simulation results indicate that for the given set of parameters, fb-carriers outputs and market shares increase with their number in the market, whereas each fb-carrier's profits were not affected by the number of competitors.

[35]The parameters used were the same as in table 4.1.

Finally, figure 4.6 demonstrates the percentage change of fb-carriers profits and market shares, based on data from the US-China route, if the settlement rate is changed from the base rate of 0.53 US$. Both profits and market shares increase with an increase of the settlement rate. Based on these results, fb-carriers can be expected to oppose a decrease of settlement rate, even in a setting with highly competitive wholesale and retail markets.

Figure 4.6. Simulation results: The effect of settlement rate changes on fb-carriers' profits and market shares, for $\Delta c = 0.12$ US$



4.4.5 Discussion

Simulations can be useful tools to gain insights into economic models that are algebraically too complex to solve. On the downside, there always remains some doubt about the general validity of results obtained under specific parameter assumptions. The approach presented in this section attempts take such concerns into account in two ways. First, the parameter values are chosen incorporating all available data and information on the international telecommunications market. Second, an array of different values were tested for those parameters, for which no obvious proxies were available.

The results reported in this paper represent only a snapshot the feasible set of parameter values. Yet, they can be considered a representative sample of results obtained from a reasonable range of parameters. The effects obtained from using alternative values may differ in magnitude, but qualitatively they remain the similar.

The simulations presented in this section served three objectives. First, it is *analytically* not possible to specify parameter ranges that support a unique equilibrium, multiple equilibria, or that do not support any equilibrium under the PRR. The simulation approach illustrated that, within reasonable parameter ranges, proportionate return traffic allocation may bring about situations in which no equilibrium exists.

Second, the simulations demonstrated the welfare implications of the proportionate return requirements. It provided some approximation of the relative magnitude of the impact of proportionate traffic allocation on fb-carriers' profits, consumer surplus, and total welfare.

Finally, it illustrated some counterintuitive effects of the PRR on the carriers' market shares, and some counterintuitive comparative statics properties of equilibria under the PRR.

4.5 Policy Implications, Summary and Conclusions

The Proportionate Return Requirement was implemented by the FCC as one of three measures to prevent US carriers from being whipsawed by foreign monopolists. Large carriers, such as AT&T and Sprint have supported this regulation, or even suggested to implement it in other countries, such as Canada (CRTC 1998). Yet, it is not clear why and how the PRR should prevent whipsawing in a setting where settlement rates are regulated to be uniform, and equal in both directions. Chapter 3 argues that the PRR does in deed not help to prevent whipsawing *over and above* the FCC's uniform settlement policy regulation, and that the PRR, as a codified regulation, is a product of a series of regulatory inconsistencies and misconceptions. The current paper supplements the institutional analysis of Chapter 3 by analyzing the economic effect of the PRR on the international telecommunications market in the country where it is implemented. This analysis is intended to clarify the impact of the PRR on international telecommunications markets, and on the different economic players involved.

The formal framework developed in this paper is a two-stage model with a wholesale and a retail market. In the wholesale market, fb-carriers compete to provide wholesale service to resale carriers. At the same time, fb-carriers compete with resellers in the end-user market. The PRR creates an incentive for fb-carriers to increase output beyond the economic efficient amount in order to secure a larger portion of the lucrative incoming traffic. The effect of this additional incentive on the equilibrium outcome may differ, depending on the specific model parameters.

For certain parameter ranges and under the assumptions of the model, the PRR may preclude the existence an equilibrium altogether. If an equilibrium exists, then the equilibrium wholesale price will be below the marginal cost of providing outbound service. Outbound traffic volume will be inflated beyond economic efficient levels, and prices pushed below efficient level. The consumers are the main beneficiaries of the PRR. Resellers earn no profits with our without the PRR under the assumptions of the model, however, they will obtain a higher market share under the PRR then under a regime where inbound traffic is not allocated among fb-carriers in proportion to their relative share of outbound traffic. Paradoxically, the PRR appears to work against the interests of its two main proponents: The fb-carriers earn lower profits and capture a lower market share under the PRR. The regulator would increase total welfare by eliminating the PRR.

The effect of the PRR on the foreign monopolist depends on the specific demand structure, and calling charges in the foreign country. However, from the view of the foreign monopolist, the proportionate allocation of its outbound traffic among the receiving carriers will result in higher volumes of return traffic, and with the higher levels of settlement payment transfers, paid in hard currency. The foreign monopolist may therefore have an interest in allocating traffic proportionally, even if it were not required to do so.

A regime without PRR can be implemented by the regulator in either of two ways. One way would be to have *the regulator* (rather than the carriers) negotiate settlement rates with foreign monopolists, and auction off the right to switch incoming traffic to the fb-carrier that is willing to do so at the lowest per-minute charge. The profits from incoming traffic would then be retained by the government. An administratively less burdensome approach is to simply eliminate the PRR on all routes, or even prohibit the use of proportionate return clauses in interconnection agreements. The regulator could then still continue to monitor the traffic allocation, and step in only in cases where traffic allocation is in a severe imbalance, without however affecting the carriers' output and pricing decisions on the margin. The profits from incoming traffic would then remain with the fb-carriers, but total welfare would be improved as compared to a regime with the PRR.

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Chapter 2

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Chapter 3

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Appendix A

Data Description for Chapter 2

This paper analyzes the annual telephone traffic between the United States and 43 countries over the period 1988 to 1995. Traffic data, that is, the total minutes of US outbound and inbound telephone calls, and the total number of outbound and inbound telephone calls, are obtained from the FCC's Statistics of Communications Common Carriers (FCC, 1989-1997). Data on AT&T's collection charges, including connection charges and marginal 'per minute' charges, are obtained form the SOCC. MCI's and Sprint's collection charges, as well as foreign carriers' collection charges for calls to the US, were provided by the telecommunications consulting group EURODATA.

There are several problems arising from the use of publicly collected and reported US pricing data. One is that reported collection charges are *list* prices, and do not reflect discounts. With increasing competition in international telephone markets throughout the 1990s, discounts have become an increasingly important and widely used pricing tool among US carriers. The dramatic reduction of collection charges in international telephony is in fact entirely reflected in discounts, while listed calling charges have been increasing. Discount schemes usually grant a percentage reduction on total charges for calls to one or several routes. The discounted routes may be determined by the caller, as part of an individual calling plan, or they may be determined by calling volume[1].

Second, US carriers commonly levy higher collection charges during peak hours than during off-peak hours. While the peak and off-peak rates as such are reported and readily available, carriers do not report what portion of traffic is transmitted during peak and off-peak periods. A third and similar problem exists with the carrier specific traffic data. Price data are available on a per carrier basis, whereas traffic data are not. Finally, a further complication is due to the recent emergence of resale carriers. Resale carriers are usually small enough such that they do not fall under the FCC's reporting requirements. It is well-known that their calling charges are significantly lower than those of the facilities-based carriers, however, there exists neither any publicly collected information on their calling charges, nor on their per-route traffic volumes.

Although prices may vary widely depending on call discount schedule, time of the day, or choice of carrier, the levels of the connection charges *relative* to the marginal charges do not necessarily vary. Let $\bar{p}_x$ be the listed connection charge and $\bar{p}_d$ the listed marginal charge per minute of call du-

[1]For example, the caller may get a certain discount on calls to the country she calls most often.

ration. Discount schedules, which give percentage discounts on the total monthly charges on a given route, equally affect both charges. They lower the *absolute* level of the charges, but do not alter the level of connection charges *relative* to marginal charges. Also, in the data sample used for this study, ratio of connection charges over marginal charges is typically similar for peak and off peak schedules. Price differences between reporting carriers, finally, are entirely reflected in their discount schemes. The reported collection charges of facilities-based carriers are virtually identical.

The gross (before discount) revenues can be computed from the carriers list prices and from the number of calls and average call durations reported in the SOCC, $\bar{R} = \bar{p}_x x + \bar{p}_d d$. The net (after discount) revenues, R, are directly reported in the SOCC. Hence, the average per route discount is $R/\bar{R}$, and the average discounted calling charges can be computed as $p_x = (R/\bar{R})\bar{p}_x$ and $p_d = (R/\bar{R})\bar{p}_d$.

p_x and p_d as computed above are used as price indices throughout the study. Collection charges of resale carriers are not considered in these price indices. Rather, they include the charges that facilities-based carriers obtain from resale carriers. For the purpose of the study, therefore, resellers are regarded as business customers without impact on telecommunications demand. This is equivalent to assuming that the resale market are perfectly competitive, and the cost of resellers are the same as the cost of facilities-based carriers[2].

[2]Moreover, the effect of the Proportionate Return Requirement is ignored.

Collection charges for telephone calls in the reverse direction, i.e., from various countries *to* the US, are not as readily available as US charges. The collected data set is balanced for only 23 out of 48 inter country routes[3].

The remainder of the Data is taken from a variety of sources. Data on total population, number of main lines, number of fax machines, GDP (as a proxy for income) and the Consumer Price Index are obtained from the ITU World Telecommunications Indicators Database (ITU 1997). Data on Tourism are provided by the World Tourism Organization (WTO 1999). The level of trade between the United States and the 43 countries is computed as the sum of imports and exports, reported by the OECD (OECD 1998, OECD 1993). Data on immigration into the US are obtained from the American Statistics Index (U.S. Immigration and Naturalization Service 1996). This study uses the 4-year stock of immigrants. For example, the 1988 figure for immigration from the UK is the total number of immigrants from the UK from 1985 to 1988. Immigration in the reverse direction, i.e., out of the United States, is assumed to be negligible. All financial data are deflated using the Consumer Price Index.

[3]That means, a complete set of pricing, output and explanatory data was available with regard to traffic in both directions on these routes. For the remaining 25 routes, collection charges applicable to US bound traffic were unavailable.

Appendix B

Glossary of Acronyms for Chapter 3 and Chapter 4

DBP	Deutsche Bundespost, former German monopolist of postal and telecommunications services
ECO	Effective Competitive Opportunities, Test developed at the US Federal Communications Commission to assess the degree of telecommunications market liberalization in foreign countries
FCC	Federal Communications Commission, US telecommunications regulator
FRG	Federal Republic of Germany
ISP	International Settlements Policy, a set of regulations developed by the FCC for the international telecommunications market
ISR	International Simple Resale, service concept that involves the use of a private line (with a connection to the public switched network at one or both ends) for the provision of commercial international telephone services
ITU	International Telecommunications Union, a civil international organization established to promote standardized telecommunications on a worldwide basis
OECD	Organization of Economic Co-operation and Development
PRR	Proportionate Return Requirement

PSTN	Public Switched Telephone Network, A telecommunications network publicly accessible by telephones, key telephone systems, private branch exchange trunks, and data arrangements
PTT	In countries having nationalized telephone and telegraph services, the organization, usually a governmental department, which acts as its nation's common carrier.
TLD	Telefonica Larga Distancia de Puerto Rico, Puerto Rican Telecommunications Carrier
USP	Uniform Settlements Policy, FCC Regulation for International Telecommunication Services, set out in FCC (1986), preceded the International Settlements Policy
WTO	World Trade Organization