Journal of Regulatory Economics; 15:xxx-xxx (1999)

International Telecommunications, Settlement Rates, and the FCC

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Abstract
This paper models settlement arrangements between international telecommunication carriers. The FCC in the United States claims these arrangements cost United States consumers billions of dollars annually, largely to subsidize foreign carriers in low-income countries. A model is given which makes sense of this claim, as well as the role of costs, competition, and income disparities in settlement rate determination. Findings are tested using data spanning 17 years and 167 countries. Some implications are drawn for the FCC's recently proposed settlement rate caps, as well as for proposals for multilateral solutions.

1. Introduction

The world market for international telecommunications is large and growing rapidly. In 1995, the world made more than 60 billion minutes of international phone calls. In 1996, the annual growth in the top five routes averaged over 15%. Despite this, and the important role telecommunication services play in communication and information related industries, there has been surprisingly little academic analysis of the arrangements which govern international telecommunications pricing.[2]

These arrangements can be traced back to 1865, when twenty European nations came together to form a Union, which is now known as the International Telecommunications Union (ITU). They conceptualized international telecommunications as a jointly provided service; an international phone call utilizes the services of a telephone company at each end.

1 I would like to thank Douglas Galbi, John Panzar, and an anonymous referee for useful comments and Richard Edlin and Sarah Russell for research assistance. I gatefully acknowledge the financial support of the Center for Research in Network Economics and Communications (CRNEC) at the University of Auckland. All errors are mine.

2 Carter and Wright (1991) discuss several alternative arrangements, Carter and Wright (1994) and Cave and Donnelly (1996) model existing arrangements, Ergas and Paterson (1991) and Scanlan (1996) discuss some problems inherent in existing arrangements, Manenti (1997) analyzes the impact of call-back, and De Fjaja and Valbonesi (1998) evaluate a proposal for settlement arrangements in which a uniform price (over all originating countries) is set for call termination in each destination country.

According to this view, the revenue should be shared between the two carriers providing the service. However, in practice, the revenue of a call is collected by the telephone company in the country where the call is originated, and this can differ across countries when demand levels differ. This suggests that carriers ought to have some way of compensating each other, in the case there is an imbalance of calls between them. The method of payment they chose was a negotiated fixed rate per minute, commonly referred to as the settlement rate, which applied to the imbalance of calls between the two carriers.[3]

This apparently innocuous arrangement, to share the revenue from international phone calls through settlement rates, has had far reaching implications for consumer welfare. In 1996, United States carriers paid out in the order of US $5.5 billion more in such settlements than they received. The Federal Communications Commission (FCC) estimates that two-thirds of this amount represents a subsidy from American consumers to foreign telephone companies. Moreover, they claim that artificially high settlement rates are preventing the price of international phone calls falling to competitive levels. From the start of 1999, the FCC plans to impose price caps on the rates United States carriers can pay for calls terminated overseas, a policy that has met stiff opposition from carriers in other countries (especially those in developing countries). In this paper, we try to understand what determines settlement rates, both theoretically and empirically. In doing so, we address the question: "Why do American consumers subsidize foreign telephone companies?" We also explore a variety of concerns regarding the FCC's proposed price caps.

We start by developing a simple model of international telecommunication pricing and settlement rates, under various assumptions about competition. Our model builds on the model introduced by Carter and Wright (1994). One of the key results of their paper is that retail prices increase with settlement rates. This arises because the settlement rate is a component of the marginal cost of the originating carrier providing its service. Thus, the settlement rate is not innocuous. [4] We obtain the same result, but explicitly explore its implications for the setting of settlement rates and retail prices when there is an asymmetry in demand between the countries.

Without competition in either country, the model predicts that settlement rates will be set above the marginal cost of incoming calls to the extent there are differences in costs and per-capita income between the two countries. To understand this later result, note that subscribers in a high-income country (United States) will tend to make more outgoing calls to a low-income country (China) than vice-versa. This generates an imbalance in calls between the two countries, so that the United States carrier wants a low (or negative) settlement rate and the Chinese carrier wants a high settlement rate. Starting from a point of cost-based settlement rates, the United States carrier earns greater profits (from the higher levels of demand), and thus stands to lose more if it does not reach an agreement with the Chinese carrier. For this reason, the outcome of bargaining is to share some of the United

3 They actually agreed on accounting rates, the settlement rate being defined as one-half the accounting rate.

4 Carter and Wright (1994) also provide a rationale for why when both carriers are monopoly providers, the carriers are allowed to collude over the settlement rate, rather than being forced to set settlement rates independently. Without collusion, each carrier would charge the other carrier the settlement rate that maximizes its own profit, given what the other carrier is charging it. Given these profit-maximizing settlement rates, and that the retail price is also set to maximize profits, double marginalization occurs. In this case, settlement rates are higher, retail prices are higher, and carrier profits are lower compared to under collusion.

States carriers profits with the Chinese carrier. This is achieved by agreeing on a settlement rate above the cost of carrying additional incoming calls. A high settlement rate raises the marginal cost of United States carriers providing outgoing calls, and hence leads to higher consumer prices. Essentially, United States consumers are subsidizing foreign telephone companies in low-income countries.

We explore through simulations how these results hold up when competition is introduced between the United States carriers and in the case where there is competition in both countries. Introducing competition to the United States has two main effects. Firstly, competition in the United States lowers United States prices which further accentuates the asymmetry in demand between the United States and low-income countries, increasing the settlement rate. Secondly, since the retail price in the United States is no longer the full monopoly mark-up, United States carriers (and the foreign carrier) benefit from a higher settlement rate, as this pushes prices back up to monopoly levels. Our simulation results suggest after the introduction of competition in the United States, the settlement rate and the foreign retail price increase while retail prices in the United States fall and the imbalance in settlement payments is worsened. However, introducing competition to the United States does not change our basic result, that settlement rates are increasing in income disparity, as well as in the costs of providing incoming calls.

In the case where competition is introduced in both countries, the asymmetry in demand is not different from the monopoly case, yet both countries prefer a higher common settlement rate to increase retail prices to monopoly levels. In this case, the settlement rate can be used as a legitimate instrument of collusion between carriers, since prices are increasing in the settlement rate. We argue this collusive outcome is only likely to be sustainable in the situation where rules, such as common settlement rate requirements and proportional return, are enforced, and where alternative forms of competition such as settlement rate bypass are prevented. Without these restrictions, competitive pressures are likely to drive down settlement rates towards the marginal cost of incoming calls. In this regard, we also discuss some other forms of competition which affect the level of settlement rates; namely settlement rate bypass, alternative routing, and call-back services.

Our model sheds light on the FCC's proposed rules. The FCC has detailed benchmarks which govern the maximal settlement rates that United States carriers may pay foreign carriers to terminate international traffic originating in the United States. The principle behind these rules is to force settlement rates, and therefore retail prices, into line with costs, thus reducing settlement imbalances between the United States and these countries, and increasing overall efficiency. This principle is consistent with the findings from our modeling. When settlement rates are set at the marginal cost of carrying incoming calls, rather than based on the carriers relative bargaining power, retail prices are lower, efficiency is increased, and the imbalance in settlement payments is reduced. We find the benefits of moving to cost based settlement rates are largest when there is competition in the United States, but no competition in the foreign country, and the greater the difference in income levels across the two countries. However, our model casts some doubt on the enforcability of these rules in practice.

Our model also has implications for a multilateral approach to settlement rate determination, as has been suggested by the World Trade Organization. We find that a carrier in a middle-income country may accept lower settlement rates with carriers in high-income countries, if this allows it to achieve lower settlement rates with carriers in high-income countries. This suggests most countries could be made better off if all settlement rates were

reduced simultaneously. We discuss the merits of a multilateral approach, as well as the role competition might play in any proposed solution.

Using data on settlement payments, call volumes, and prices, between the United States and other countries, from 1980-1996, we test some of the predictions of our model. We find support for the proposition that retail prices are increasing in the settlement rate; a $1 increase in the settlement rate increases the retail price by 51 cents. We also find support for the proposition that the settlement rate is increasing in the income disparity between the United States and the foreign country. Assuming no competition in the foreign country, an increase in income disparity of $1000 in 1985 increases the settlement rate by 5.6 cents. The positive relationship between income disparity and settlement rates is highly statistically significant across all years, although the magnitude of the relationship has weakened with the onset of domestic and foreign competition.

As well as income, proxies for the per-minute costs of providing submarine cables between countries (distance and population) and a proxy for the per-minute cost of the national link (area of the country) are important determinants of settlement rates, although their importance has diminished over time. Our estimates suggest that for every 1000 kilometers between the United States and the foreign country, the settlement rate increases by 19.3 cents in 1980, 5.1 cents in 1988, and 3.2 cents in 1996. If economies of scale are present, the per-minute cost of calls between the United States and a foreign country will also depend on the population of the foreign country. Our results suggest this is indeed the case. For every 1% increase in population, the settlement rate decreases by 27.4 cents in 1980, 5.2 cents in 1988, and 0.4 cents in 1996. Finally, a component of the per-minute cost of covering incoming calls is the cost of providing the national link (carrying the call within the country and delivering it to the customer). We use the area of a country as one measure of this cost, and find that for every 1% increase in area, the settlement rate increases by 10.7 cents in 1980, 3.4 cents in 1988, and 0.6 cents in 1996. These results are consistent with the idea that the distance related costs, as well as any fixed costs of providing international service, haven fallen dramatically over this period. They also reflect a fall in the per-minute costs resulting from these costs being shared over a growing number of calls. A third factor emphasized by our model, in addition to income and costs, is competition. Greater competition in the United States and foreign countries, generally decreases settlement rates, although the empirical results for foreign competition are somewhat mixed.

The paper is organized as follows. In section 2, we present a model of international telecommunications, considering the cases of no competition, competition only in the United States, and competition in both countries. In light of these results, we discuss the case for some of the proposed solutions to high settlement rates in section 3. Section 4 details out data set. Our estimation results are presented in section 5, while section 6 concludes with some further policy implications and future directions.

2. A Model of International Telecommunications

A critical assumption in modeling settlement rates and pricing for international phone calls is the degree of competition in the market for these services. The following sections make different assumptions about the degree of competition, as well as income disparity and costs, to determine their impact on settlement rates, retail prices, carrier profits, and settlement imbalances.

2.1. Model without Competition

Suppose there are n countries and each country is serviced by a single telecommunications company, referred to here as a carrier. Customers can call $n-1$ other countries. Suppose there are N_i customers in country i and define $N = \Sigma_{j=1}^{n} N_j$. Then the number of customers in countries i and j who connect with each other is assumed to be proportional to $N_i N_j / N$. Assume preferences of each of these $N_i N_j / N$ customers, in country i, can be represented by the following indirect utility function

$$v\left(p_{ij}, m_i, \theta_i\right) = \frac{a_{ij}(1 - b_{ij}p_{ij})^2}{2b_{ij}} + \ln m_i + \theta_i,$$

where p_{ij} represents the price charged per minute, m_i represents income, a_{ij} determines how much they want to call country j, b_{ij} determines the price elasticity of demand for calls from country i to j, and θ_i measures the other benefits customers receive from using the carrier in country i (this term will be used later to allow for competition between carriers). The particular functional form for the indirect utility function is chosen since it gives rise to the following simple linear demand function for minutes called between country i and j,

$$q_{ij}\left(p_{ij}\right) = a_{ij} m_i (1 - b_{ij} p_{ij}). \tag{1}$$

Profits of the i^{th} carrier can then be written as

$$\Pi_i = \sum_{\substack{j=1 \\ j \neq i}}^{n} \frac{N_i N_j}{N} \left[\left(p_{ij} - c_{ij}\right) q_{ij}\left(p_{ij}\right) - d_{ij} q_{ji}\left(p_{ji}\right) + r_j \left(q_{ji}\left(p_{ji}\right) - q_{ij}\left(p_{ij}\right) \right) \right] \tag{2}$$

or defining Π_{ij} as the profit to carrier i from calls between country i and j,

$$\Pi_i = \sum_{\substack{j=1 \\ j \neq i}}^{n} \pi_{ij},$$

where c_{ij} is the marginal cost of outgoing calls incurred by carrier i (for calls made between country i and j), and d_{ij} is the marginal cost of incoming calls incurred by carrier i (for calls made between country j and i). The agreed common settlement rate, denoted by r_j, is the price per minute that carrier i pays carrier j for any net imbalance of calls outgoing from country i (or vice-versa). We assume symmetry between any two countries, except in the level of income and in costs. Thus, we assume

$$a_{ji} = a_{ij}, \quad b_{ji} = b_{ij}.$$

As a first approximation, this assumption is reasonable. The *preference* for calls between any two countries is likely to be roughly symmetric, other things equal. On average, people who call each other to have a conversation are likely to get similar benefits from the phone call. Given the separable structure of the profit function above, we analyze the case between country i and j without reference to other countries (that is, we focus on π_{ij} hereafter).

Each firm i is assumed to choose its prices p_{ij} to maximize profits (which amounts to choosing p_{ij} to maximize π_{ij} for each country j). The resulting profit-maximizing price is

$$p_{ij}^{*} = \frac{1}{2b_{ij}} + \frac{c_{ij}}{2} + \frac{r_j}{2}. \tag{3}$$

The most important thing to note about this result is that prices are increasing in the settlement rate; carriers pass on one-half of any change in settlement rates to retail prices. Essentially, the settlement rate becomes part of the marginal cost of outgoing calls. Even if there is no net imbalance in calls, settlement rates still matter, since they alter the marginal incentive of carriers to change their retail price. By lowering its retail price, a carrier will start paying net settlement payments; the level of which depends on the level of the settlement rate. Thus, a high settlement rate reduces the incentive for a carrier to lower its retail price.

We now consider how these settlement rates are determined. Suppose carriers choose a common settlement rate r_j to maximize the joint profit between them. It can be shown this implies the settlement rate is set equal to the weighted average cost of incoming calls across the two countries $r_{j*} = \omega d_{ji} + (1 - \omega) d_{ij}$, where the weights are determined by the countries relative income levels $\omega = m_i/(m_i + m_j)$. When there is an income disparity between the countries, the settlement rate which arises from the bilateral bargaining process between the two carriers is likely to be higher than this. First, consider how each firm's profit depends on the choice of the common tariff. If all costs are identical then

$$\frac{d\pi_{ij}^{*}(r_j = r_j^{*})}{dr_j} = \frac{N_i N_j a_{ij}}{2N} (1 - b_{ij}(c_{ij} + d_{ij}))\,(m_j - m_i),$$

so starting from the point of the joint profit maximizing settlement rate the carrier in the low-income country will prefer to have a higher common settlement rate and the carrier in the high-income country will prefer to have a lower common settlement rate. A bargaining problem will also ensue when there are cost differences across countries, even if income levels are the same. In this case,

$$\frac{d\pi_{ij}^{*}(r_j = r_j^{*})}{dr_j} = \frac{N_i N_j a_{ij} b_{ij} m_i}{2N} (c_{ij} - c_{ji} + \frac{1}{2}(d_{ij} - d_{ji}))$$

and the carrier with higher costs will prefer higher settlement rates. This occurs not just from the direct affect of higher costs of carrying incoming calls, but also because when the costs of outgoing calls are higher, retail prices will be higher, causing an imbalance in calls.

While the results so far show there is conflict over the common settlement rate, and say something about the nature of this conflict, they do not imply the likely *outcome* of this conflict is affected by the income level and the costs of the countries. This is what we now show. To demonstrate this, we first have to specify how firms agree on a common settlement rate. We assume this bilateral bargaining process can be characterized by the Nash bargaining solution r_j^{NBS}, which is known to have reasonable properties. It is found as follows:

$$\max_{r_j} P\left(r_j\right) \text{ where } P\left(r_j\right) = \pi_{ij}^{*}\left(r_j\right)\pi_{ji}^{*}\left(r_j\right). \tag{4}$$

The disagreement point for this bargaining game is taken as the case no settlement agreement is reached between the two carriers (so they cannot provide international service between the two countries) and both their profits are zero. This is the ultimate threat both parties have. If the two carriers, through cooperation over a common settlement rate, can achieve jointly higher profits, they will do so, and the disagreement profit levels will influence how these higher profit levels are shared. Starting from a point of cost-based settlement rates, the firm that earns greater profits (from having higher levels of demand or lower costs), stands to lose more if it does not reach an agreement with the other firm. For this reason, the outcome of bargaining is for the carrier in the high-income (low-cost) country to share some of its profits with the carrier in the low-income country (high-cost country). This is achieved by agreeing on a settlement rate above the cost of carrying additional incoming calls, as we now show. To see this first note the solution to (4) is characterized by

$$\pi_{ij}^{*}\frac{d\pi_{ji}^{*}}{dr_j}+\pi_{ji}^{*}\frac{d\pi_{ij}^{*}}{dr_j}=0, \tag{5}$$

where using (3) we get that

$$\frac{d\pi_{ij}^{*}}{dr_{dj}}=-\left(q_{ij}-q_{ji}\right)-\frac{1}{2}\left(r_j-d_{ij}\right)\left|\frac{\partial q_{ji}}{\partial p_{ji}}\right| \tag{6}$$

and

$$\frac{d\pi_{ji}^{*}}{dr_j}=q_{ij}-q_{ji}-\frac{1}{2}\left(r_j-d_{ji}\right)\left|\frac{\partial q_{ij}}{\partial p_{ij}}\right| . \tag{7}$$

Using equations (5)-(7), and solving for r_j implies

$$r_j^{NBS}=\frac{d_{ij}\dfrac{\partial q_{ji}}{\partial pji}\pi_{ji_{*}}+d_{ji}\dfrac{\partial q_{ij}}{\partial p_{ij}}\pi_{ij}^{*}}{\dfrac{\partial q_{ji}}{\partial p_{ji}}\pi_{ji}^{*}+\dfrac{\partial q_{ij}}{\partial p_{ij}}\pi_{ij}^{*}}+\frac{2(q_{ij}-q_{ji})\,(pi_{ji}^{*}-\pi_{ij}^{*}ht)}{\dfrac{\partial q_{ji}}{\partial p_{ji}}\pi_{ji}^{*}+\dfrac{\partial q_{ij}}{\partial p_{ij}}\pi_{ij}^{*}} . \tag{8}$$

The first term in (8) is a weighted average of the marginal cost of incoming calls. If both countries have the same income and carriers have the same outgoing costs, then $q_{ij} = q_{ji}$ and $\pi_{ij}^{*} = \pi_{ji}^{*}$, so the second term in (8) will be zero, and the settlement rate is equal to a weighted average of the marginal costs of incoming calls. If income or outgoing costs differ across countries, then in general $q_{ij} \neq q_{ji}$ and $\pi_{ij}^{*} \neq \pi_{ji}^{*}$, so the second term in (8) will not be zero, and the settlement rate will diverge from the marginal cost of incoming calls. We want to show that this divergence is in the positive direction. Because both firms must earn positive profits, the second term will be positive provided $\pi_{ij}^{*} > \pi_{ji}^{*}$ whenever $q_{ij} > q_{ji}$ (and $\pi_{ij}^{*} < \pi_{ji}^{*}$ whenever $q_{ij} < q_{ji}$). We consider three cases.

Case 1: $d_{ij} > d_{ji}$ and $c_{ij} = c_{ji}$, $m_{ij} = m_{ji}$. Using equation (3), $p_{ij} = p_{ji}$, $q_{ij} = q_{ji}$, and the second term in (8) will be zero. This also implies $\partial q_{ji}/\partial p_{ji} = \partial q_{ij}/\partial p_{ij}$ and $\pi_{ij}^{*}<\pi_{ji}^{*}$. Thus in (8) greater weight is placed on d_{ij} compared to d_{ji}. This leads to the conclusion that:

"When the only difference between countries is a difference in the marginal cost of incoming calls, the settlement rate will be greater than the average marginal cost of incoming calls."

Case 2: $c_{ij} < c_{ji}$ and $d_{ij} = d_{ji}$, $m_{ij} = m_{ji}$. Using equation (3), $p_{ij} < p_{ji}$, which implies $q_{ij} > q_{ji}$. Suppose $\pi_{ij}^* < \pi_{ji}^*$. It is easy to show that this can only be true if $r_j > d_{ij}$. From (6), $d\pi_{ij}^*/dr_j < 0$, so for (5) to hold $d\pi_{ji}^*/dr_j > 0$. But then from (6) and (7),

$$0 < \frac{d\pi_{ji}^*}{dr_j} < \left| \frac{d\pi_{ij}^*}{dr_j} \right| .$$

The assumption that $\pi_{ij}^* < \pi_{ji}^*$ and the conclusion that $0 < d\pi_{ji}^*/dr_j < \mid d\pi_{ij}^*/dr_j \mid$ are inconsistent with (5). Thus it must be that $\pi_{ij}^* > \pi_{ji}^*$, which from (8) leads to the conclusion that: "*When the only difference between countries is a difference in the marginal cost of outgoing calls, the settlement rate is set above the marginal cost of incoming calls.*"

Case 3: $m_{ij} > m_{ji}$ and $d_{ij} = d_{ji}, c_{ij} = c_{ji}$. Equation (3) implies $p_{ij} = p_{ji}$, so $m_{ij} > m_{ji}$ implies $q_{ij} > q_{ji}$. The proof then follows exactly as in the proof of case (2), so that: " *When the only difference between the countries is a difference in incomes, the settlement rate is set above the marginal cost of incoming calls.*"[5]

A higher settlement rate leads to higher consumer prices from equation (3). In this case, imbalances in settlement payments will be linked with higher settlement rates and higher prices. Table 1 presents the results of simulations using four different levels of foreign income and three different levels of foreign costs. These simulations illustrate the theoretical findings above. As the disparity between the United States and the foreign country's income increases, so does the settlement rate, the retail prices, and the settlement imbalance.

A number of modifications to the model above can be considered.[6] The first modification is to allow a different disagreement point than zero profits. If negotiations break down we assume the two carriers unilaterally set a settlement rate to charge the other (the Nash equilibrium in settlement rates). In this case, the carrier in the low-income country has a better negotiating position, since if the two parties cannot reach an agreement it can still exploit the high level of incoming calls by charging a high settlement rate. Thus, we find that the results for this case are more pronounced than those in table 1.

Another modification to the benchmark case is to allow for reciprocal calling motives. In this case, the demand for calls will depend on the price of calls in both countries, as callers arrange between themselves to originate more calls from the low price country. Demand functions are adjusted to take this into account, so that the new demand function for calls is

5 Manenti (1997) derives similar results in the context of a constant elasticity demand function. In addition, he shows that when the demand elasticity is sufficiently low, then the settlement rate that results from the Nash bargaining solution increases with the degree of asymmetry in the demand size between the two countries.

6 For each of these modifications, we were able to replicate the qualitative features of table 1. For brevity, we only report overall conclusions here.

Table 1. No Competition Case

m_j	0.25	0.5	0.75	1	0.25	0.5	0.75	1	0.25	0.5	0.75	1
c_{ji}, d_{ji}	0.05	0.05	0.05	0.05	0.1	0.1	0.1	0.1	0.15	0.15	0.15	0.15
r_j^{NBS}	0.39	0.24	0.11	0.08	0.44	0.30	0.16	0.10	0.49	0.36	0.22	0.13
p_{ij}	1.25	1.17	1.10	1.09	1.27	1.20	1.13	1.10	1.29	1.23	1.16	1.11
p_{ji}	1.22	1.15	1.08	1.06	1.27	1.20	1.13	1.10	1.32	1.25	1.18	1.14
π_{ij}^*	0.31	0.37	0.40	0.40	0.30	0.36	0.40	0.41	0.28	0.35	0.39	0.40
π_{ji}^*	0.20	0.26	0.34	0.45	0.19	0.24	0.31	0.41	0.18	0.22	0.28	0.36
π_{ij}^{SD}	0.11	0.05	0.01	0.00	0.12	0.06	0.02	0.00	0.13	0.07	0.02	0.00

Note: Parameter values m_i=1, N_i=250, N_j=10, N = 2,500, c_{ij}=d_{ij}=0.1, a = 0.1, b = 0.5 are used throughout. To help interpret the results, think of i as being the United States, income (m_i, m_j) as measured in tens of thousands of United States dollars, customers (N_i, N_j, N) as measured in millions, and costs (c_{ij}, c_{ji}, d_{ij}, d_{ji}), the settlement rate (r_j^{NBS}), and prices (p_{ij}, p_{ji}) as measured in United States dollars. Then profits (π_i,π_j) and the settlement imbalance between the carrier in country i and the carrier in country j (π_{ij}^{SD},) are measured in billions of United States dollars. When π_{ij}^{SD} is a positive number, the carrier in country i (the United States) pays out more in settlements to the carrier in country j than vice-versa.

a decreasing function of the domestic price, but an increasing function of the foreign price. Reciprocal calling motives imply carriers will try to undercut each other in retail prices. To offset this behavior the carriers will agree to high settlement rates. For instance, even if both countries have the same income, settlement rates will be set above cost. The high settlement rates lead to high settlement imbalances, but the impact of income differences on settlement rates is somewhat reduced.

A third modification to the basic model is to allow governments, rather than carriers, to negotiate the settlement rate. If this is the case, then rather than trying to maximize profits, governments may want to maximize a weighted average of profits and consumer surplus. In general, this leads to lower levels of negotiated settlement rates, as the impact of high settlement rates on consumers is now taken into account. However, the basic findings of table 1 are not changed, with one exception. For some parameter values, high-income countries will agree on negative settlement rates and low-income countries will agree on positive settlement rates. Under this scenario, the relationship between income disparity and settlement imbalances can be non-monotonic. An extension of this case is to allow the weights on profits to increase (or the weights on consumer surplus to decrease) as the income level of the country decreases. It may be that governments in poorer countries are more concerned with maximizing profits as a source of government revenue rather than maximizing consumer surplus. This reflects the high cost of raising tax revenue in such countries and the view that international phone calls are a luxury for the rich only. For the range of different weights that we tried, introducing these effects only strengthened the relationship between income disparity and settlement rates found in table 1.

2.2. Competition in the United States

Perhaps the most important modification to our benchmark model is to allow for the introduction of competition. The United States was the first country to allow competition in its international telecommunications market. Despite MCI's entry in 1985 and the sub-

sequent undercutting of AT&T's price, it took until 1990 for MCI to achieve a 12.5% market share; AT&T's market share was still over 80%. That all consumers did not switch immediately to MCI, despite its slightly lower price, suggests the appropriate model of competition between carriers is one of product differentiation, rather than one of perfect competition. We use a Hotelling model of product differentiation.[7]

We assume the parameter θ_i in the consumers indirect utility function depends on the choice of carrier. Suppose there are two carriers in the United States, carriers *a* and *b*. Suppose $\theta_i^a = (1-x)/\alpha_i + \beta/\alpha_i$ and $\theta_i^b = x/\alpha_i$, where x measures a particular consumer's taste for each carrier, and x is distributed uniformly between 0 and 1. The parameter α_i measures the degree of product differentiation and so determines the degree of competition. If α_i is high, then consumers are not as concerned about the benefits of using a particular carrier as they are about the price differential between the two companies. The parameter β measures any brand loyalty towards carrier *a*. In the case $\beta = 0$, there is no brand loyalty, while if $\beta = 1$, then carrier *b* will only attract customers if it charges a lower price than carrier *a* (possibly because of switching costs). We denote the prices charged by carriers *a* and *b*, p_{ij}^a and p_{ij}^b for calls made between country *i* and *j*. We solve for the market share of carrier *a*, by finding the consumer which is just indifferent between the two carriers. The share of the N_iN_j/N customers that choose carrier *a* is then

$$s_{ij} = \frac{1}{2} + \frac{\beta}{2} + \alpha a_{ij} \frac{(1 - b_{ij}p_{ij}^a)^2 - (1 - b_{ij}p_{ij}^b)^2}{4b_{ij}},$$

while $1 - s_{ij}$ choose carrier *b*. The profit function of carrier *a* in country *i* (United States) from business with country *j* is

$$\pi_{ij}^a = \frac{N_iN_j}{N}\left[s_{ij}\left(p_{ij}^a - c_{ij} - r_j\right)q_{ij}\left(p_{ij}^a\right) + \frac{s_{ij}q_{ij}(p_{ij}^a)}{q_{ij}^m}\left(r_j - d_{ij}\right)q_{ji}\left(p_{ji}\right)\right]$$

and of carrier *b* is

$$\pi_{ij}^b = \frac{N_iN_j}{N}\left[(1 - s_{ij})\left(p_{ij}^b - c_{ij} - r_j\right)q_{ij}\left(p_{ij}^b\right) + \frac{(1 - s_{ij})\,q_{ij(}p_{ij}^b)}{q_{ij}^m}\left(r_j - d_{ij}\right)q_{ji}\left(p_{ji}\right)\right],$$

where the average demand for calls from country *i* to country *j* is defined as

$$q_{ij}^m = s_{ij}q_{ij}\left(p_{ij}^a\right) + (1 - s_{ij})\,q_{ij}\left(p_{ij}^b\right).$$

The profit of the carrier in country *j* with respect to business with the United States is then

$$\pi_{ji} = \frac{N_iN_j}{N}\left[\left(p_{ji} - c_{ji}\right)q_{ji}\left(p_{ji}\right) - d_{ji}q_{ij}^m + r_j\left(q_{ij}^m - q_{ji}\left(p_{ji}\right)\right)\right].$$

7 Similar models of competition can be found in Armstrong (1998), Carter and Wright (1999), and Laffont et al. (1998), who have used them to analyze competition in deregulated local telecommunication markets.

We have assumed a common settlement rate r_j for the two United States carriers. We have also assumed that the market for terminating foreign-billed international traffic is divided up in proportion to the United States carrier's own share of domestic-billed international traffic with the corresponding country. This follows the rules that the FCC has established.[8] Such rules are called proportional return rules, and international traffic that flows under such rules is known as settled traffic. These rules were introduced originally to prevent United States carriers competing against each other for call settlement, when dealing with a monopoly foreign carrier. Such competition could decrease the bargaining power of the United States carriers, shifting even greater levels of their revenue offshore. It could also lead the incumbent United States carrier to reach an exclusive deal with the foreign carrier, to prevent entry of other carriers into the United States market (*wipsawing*). We suppose that the two United States carriers act jointly in bargaining over the common settlement rate with the foreign country. In doing so, we assume they act as if they were a single carrier. The bargaining process is again assumed to be determined by the Nash Bargaining solution, with the disagreement point being zero profits. The Nash bargaining solution r_j^{NBS} is found as the solution to the following maximization problem:

$$\max_{r_j} P\left(r_j\right) \text{ where } P\left(r_j\right) = \pi_{ij}^*\left(r_j\right)\pi_{ji}^*\left(r_j\right) \text{ and } \pi_{ij} = \pi_{ij}^a + \pi_{ij}^b .$$

Table 2. Competition in the United States Only

m_j	0.5	1	0.5	1	0.5	1	0.5	1	0.5	1	0.5	1
c_{ji}, d_{ji}	0.05	0.05	0.1	0.1	0.15	0.15	0.05	0.05	0.1	0.1	0.15	0.15
α_i	1	1	1	1	1	1	2	2	2	2	2	2
r_j^{NBS}	0.36	0.25	0.41	0.29	0.46	0.33	0.45	0.44	0.49	0.47	0.53	0.50
p_{ij}^a	1.10	1.01	1.13	1.03	1.16	1.05	1.03	0.94	1.06	0.96	1.09	0.98
p_{ij}^b	0.92	0.81	0.95	0.82	0.98	0.84	0.84	0.74	0.88	0.77	0.91	0.79
p_{ji}	1.21	1.15	1.25	1.19	1.30	1.24	1.25	1.24	1.30	1.28	1.34	1.32
s_{ij}	0.70	0.69	0.71	0.69	0.71	0.70	0.65	0.64	0.66	0.64	0.66	0.64
π_{ia}^*	0.24	0.27	0.23	0.27	0.22	0.26	0.19	0.21	0.19	0.21	0.18	0.21
π_{ib}^*	0.09	0.11	0.09	0.10	0.08	0.10	0.08	0.10	0.08	0.10	0.08	0.10
π_j^*	0.31	0.47	0.28	0.42	0.26	0.38	0.35	0.51	0.32	0.46	0.29	0.42
π_{ij}^{SD}	0.10	0.03	0.11	0.03	0.12	0.04	0.15	0.08	0.16	0.09	0.17	0.10

Note: Parameter values and definitions are the same as intable 1. In addition, $\beta = 0.5$ and s_{ij} is the share of United States customers that use carrier *a* in the United States.

Introducing competition to the United States has two main effects. Firstly, competition in the United States lowers United States prices which further accentuates the asymmetry in

8 *Implementation and Scope of the International Settlements Policy for Parallel Routes*, CC Docket No. 85-204, 51 Fed. Reg. 4736 (Feb. 7, 1986), recon. 2 FCC 1118 (1987), further recon. 3 FCC Rcd 1614 (1988); *Regulation of International Accounting Rates*, 6 FCC Rcd 3552 (1991), recon. 7 FCC Rcd 8049, Fourth Report & Order, CC Docket No. 90-337, Phase II.

demand between the United States and poorer countries, causing the United States to want even lower settlement rates and poorer countries to want even higher settlement rates. Secondly, since the retail price in the United States is no longer the full monopoly mark-up, United States carriers (and the foreign carrier) benefit from a higher settlement rate, as this pushes prices back up to monopoly levels. Our simulation results suggest that after the introduction of competition in the United States, the settlement rate and the foreign retail price increase while retail prices in the United States fall, worsening the imbalance in settlement payments. One way to see this, is to note that settlement rates are well above costs, even when there is no income differential across countries. Table 2 presents the results of simulations using two different levels of foreign income, three different levels of foreign costs, and two different levels of United States competition. The simulations also confirm there is still a link between income disparity and settlement rates, and the relationship between settlement rates and retail prices remains much the same as before, as does the relationship between costs and settlement rates.

2.3. Competition in the United States and the Foreign Country

In this subsection, we consider what happens once competition is introduced to both the United States and the foreign country. Once competition exists in both countries, rules such as proportional return and a requirement of common settlement rates, may impede rather than enhance competition. In particular, these rules prevent carriers from undercutting each other in the rates they offer foreign carriers for call settlement, instead allowing them to collude over a common settlement rate. Such collusion can be used as a way to keep retail prices high, despite independent retail competition.[9] Because of this, when competition exists in the foreign country, as well as in the United States, the FCC has recently taken a different view on competition for call settlement.[10] Without the restrictions of proportional return and common settlement rates, domestic carriers can undercut each other by offering lower settlement rates so as to be chosen by foreign carriers to terminate their outgoing calls. Coalitions can form between domestic and foreign carriers to internalize any above-cost settlement rates, enabling such coalitions to lower retail prices and better compete against rival coalitions. In fact, with only two competing carriers in each of the two countries, there are 15 possible coalitions that can be formed.

In one extreme, all four carriers could form a coalition and negotiate settlement rates in a cooperative fashion. The idea would be to agree on high settlement rates, so as to keep retail prices high despite independent retail competition. However, such an agreement is necessarily fragile; two or three of the carriers could break away forming their own coalition and raising their own profit at the expense of the excluded carrier(s).[11] In the other extreme,

9 An earlier version of the paper (available at www.crnec.auckland.ac.nz), shows this is the case for the model of competition in section 2.2 extended to the case of competition in both countries, where proportional return and common settlement rates are required.

10 In *Regulation of International Accounting Rates*, CC Docket No. 90-337, Phase II, December 3, 1996, the FCC concludes that "United States carriers should be permitted to negotiate alternative settlement payment arrangements that deviate from the international standard practice with foreign correspondents in countries that satisfy the effective competition opportunities test..." This means that if there is effective competition in the foreign country, then a United States carrier and a foreign carrier will be able to reach alternative settlement arrangements.

11 The excluded carrier(s) will then have an incentive to entice a member of this coalition to break away, by

each carrier offers to settle calls at a rate it determines independently, and carriers choose to have their calls completed by the carrier offering the lowest such rate. The likely outcome in this case, is that settlement rates will be set at the marginal cost of carrying incoming calls. Retail prices will then be a mark-up on the cost of incoming and outgoing calls. As competition in the retail market approaches perfect competition (no product differentiation), retail prices will be competed down to the marginal cost of carrying calls.

If there are more than two carriers in each country, the number of potential coalitions which can be formed multiples very quickly; with three carriers in each country there are 63 possible coalitions; with four carriers in each country there are 255 possible coalitions. In this case, cooperative arrangements are less likely to be sustainable, and settlement rates will more likely be competed down to the marginal cost of incoming calls. Moreover, as more carriers emerge in each country, retail competition will intensify and retail price mark-ups will diminish.

The sustainability of cooperative arrangements which involve above-cost settlement rates is further weakened by new forms of competition which have received considerable attention in recent times; namely settlement rate bypass, refile, and call-back services. In the case of settlement rate bypass, the international settlement rate system is bypassed altogether by a private line, in which a carrier provides the entire international link between the two countries. This is particularly effective in putting downward pressure on settlement rates if the carrier can easily and cheaply obtain domestic call completion. This is likely to be the case for foreign carriers who want to provide a phone service to the United States. However, this is unlikely to be the case for United States carriers wanting to provide a service to a foreign country which has no competition. In this case, the foreign carrier may not provide access to its national lines, and so settlement rate bypass may actually accentuate the asymmetry between the United States and countries not subject to competition, thus raising negotiated settlement rates. In contrast, when domestic competition exists in the foreign country, a United States carrier should be able to reach an agreement with one of the carriers to bypass the settlement rate system, thus putting downward pressure on settlement rates and prices. This is another reason settlement rates and retail prices are likely to be lower in foreign countries with competition.

Two other forms of competition (refile and call-back services) arise from arbitrage opportunities caused by international call prices and settlement rates being set in non-competitive ways. According to Ergas (1998), “These pressures are, in particular, more effective in eliminating anomalies in the structure of rates than in forcing down the average level of those rates.” Refile, or alternative routing, is the re-routing of an international call through an intermediate country. This is done when the combined settlement cost of the two separate links is less than the direct link between the two countries. A more interesting form of arbitrage is call-back. Call-back firms exploit arbitrage opportunities between retail prices in the originating country and the wholesale price in the United States, re-routing calls that originate in a high-price country, vis the United States This involves the caller from the high-price country being called back from the United States and connected to the person they are calling, who is also called from the United States This increases the imbalance in calls between the two countries, and could actually lead to an increase in the settlement rate in the

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offering lower settlement rates.

high-price country; both Ergas (1998) and Manenti (1997) argue that this is the likely outcome. Offsetting this outcome is the possibility that both refile and call-back can be used to undermine or destabilize cooperative arrangements that attempt to maintain high settlement rates, thus putting further downward pressure on settlement rates when there is more than one carrier in each country.

In summary, competition can, in many cases, put strong pressure on settlement rates and prices to fall to cost based levels, but in some cases, particularly when proportional return and common settlement rate requirements remain in place, competition may not be as effective, as high settlement rates are used to offset the effects of this competition on retail prices. In section 4, we sort out the role competition plays in settlement rate determination, from an empirical perspective. We first analyze two policy suggestions in light of the above results.

3. The FCC Benchmarks and Multilateral Negotiated Solutions

The FCC has recently detailed benchmarks which govern the maximal settlement rates that United States carriers may pay foreign carriers to terminate international traffic originating in the United States.[12] The principle behind these rules is to bring settlement rates, and therefore retail prices, more closely in line with costs, thus reducing the settlement imbalances between the United States and these countries, hence increasing overall efficiency. Table 3 presents the percentage changes in prices, profits, the settlement imbalance, and overall efficiency, when settlement rates are changed from the Nash bargaining solution to the marginal costs of incoming calls ($d_{ij} = d_{ji} = 0.1$). This is done for four different levels of foreign income and with two different assumptions about competition. When settlement rates are set at the marginal cost of carrying incoming calls, rather than based on the carriers relative bargaining power, retail prices are lower, efficiency is increased, and the imbalance in settlement payments is reduced. We find that the benefits of moving to cost-based settlement rates are largest when there is competition in the United States but no competition in the foreign country, and the greater the difference in income levels across the two countries.[13]

These results provide a model-based justification for why the FCC would like to see settlement rates reduced to levels close to the costs of the services provided. A more challenging question is: "How can the FCC enforce its mandates and unilaterally reduce settlement rates in its favor?" One interpretation of the FCC mandate, in terms of our model, is that it changes the bargaining set that these carriers can legally agree on. Given that the United States carriers are only allowed to pay settlement rates that lie below the benchmarks

12 In United States dollars, these are \$0.15 for upper-income countries, \$0.19 for upper-middle income countries, \$0.19 for lower-middle income countries, and \$0.23 for lower-income countries. These are to be implemented by the start of 1999 for upper-income countries, 2000 for upper-middle income countries, 2001 for lower-middle income countries, 2002 for lower-income countries, and 2003 for countries with teledensity less than one. In 1997, the average settlement rate United States carriers paid their foreign correspondents (weighted by total minutes of outgoing calls) was roughly \$0.35, and the unweighted average was more than twice this.

13 In the case where competition exists in both countries and settlement rates are already cost based, the impact of the FCC mandates will be relatively small, if anything.

Table 3. Effects of Moving to Cost Based Settlement Rates

	No Competition				Competition in *i*			
m_j	0.25	0.5	0.75	1	0.25	0.5	0.75	1
p_{ij}^a	-13%	-8%	-3%	0%	-20%	-16%	-12%	-8%
p_{ij}^b					-28%	-21%	-14%	-9%
p_{ji}^a	-13%	-8%	-3%	0%	-14%	-12%	-10%	-8%
p_{ji}^b								
π_{ia}^*	36%	13%	2%	0%	35%	19%	9%	3%
π_{ib}^*					42%	21%	8%	1%
π_{ja}^*	-47%	-16%	-2%	0%	-54%	-28%	-12%	-4%
π_{jb}^*								
π_{ij}^{SD}	-72%	-63%	-36	0%	-72%	-71%	-68%	-68%
E_i	41%	17%	4%	0%	50%	30%	16%	8%
E_j	-6%	1%	1%	0%	-13%	-4%	2%	4%
E	21%	10%	3%	0%	23%	15%	9%	6%

Note: Parameter values and definitions are the same as in tables 1 and 2, where $\alpha_i = 1$, $\alpha_j = 0.5$, and $d_{ji} = c_{ji} = 0.1$. Results show the percentage change in prices, profits, the settlement imbalance, and efficiency (consumer surplus plus producer surplus) for each country and in total, resulting from changing the settlement rate from the Nash Bargaining Solution to the marginal cost of incoming calls.

mandated by the FCC, any agreed outcome will have to satisfy this property. Such a policy is likely to be successful, provided foreign governments do not react to it. However, rather than allowing their carrier(s) to agree to lower settlement rates, foreign governments may require them to re-route calls through third parties (involving higher costs), or to stop international service to the United States altogether. This suggests that the underlying bargaining problem is not necessarily changed by the FCC rules. Nevertheless, to the extent the rules gain international acceptance, they may put multilateral pressure on high settlement rate regimes, which could enhance the bargaining power of United States carriers.

To explore a multilateral approach to settlement rate determination further, note that a carrier in a middle-income country may accept lower settlement rates with carriers in high-income countries, if this allowed it to also achieve lower settlement rates with carriers in low-income countries. This suggests most countries could be better off if all settlement rates were reduced simultaneously. Bilateral negotiations between carriers create an inefficiency, whereby all countries are worse off, with the exception of the country with the lowest income. To illustrate this point, we consider the effects of moving to cost based settlement rates for a group of four countries with incomes *0.25*, *0.5*, *0.75*, and *1*, assuming no competition in each country, and the same parameter values as table 1. With four countries, there will be six bilateral settlement rates, and we consider the impact of forcing all six settlement rates to be based on the marginal cost of incoming calls.

From table 3, it can be seen that governments in middle-income countries (interpreted as $m_j = 0.5$ and $m_j = 0.75$) have little incentive to unilaterally require lower settlement rates with high-income countries, since there is almost no efficiency gain and the carriers profits are reduced substantially. If in middle-income countries carrier profits are valued more highly

by the government than consumer surplus, cost-based settlement rates may not be preferred. The government in the low-income country ($m_j = 0.25$) will certainly not force its carriers to unilaterally switch to cost-based settlement rates with the high-income country; doing so achieves lower overall efficiency, and in particular, dramatically lower carrier profits.

However, when all settlement rates are simultaneously reduced to cost, all four countries achieve efficiency gains, these being 18%, 12%, 7%, and 1%. Notice the efficiency gains for middle-income countries are now quite sizeable, and even the low-income country achieves a small efficiency gain. Moreover, now the upper-middle income country ($m_j = 0.75$) increases its carrier profits by 8% and the lower-middle income country ($m_j = 0.5$) lowers it carrier profits by only 4%. For such a proposal to be implementable, the lowest income country will probably still need to receive some compensation. Despite a small overall efficiency gain, the loss of carrier profits is likely to be valued more by the government than the gain in consumer surplus for such a country. Without some compensation it would not agree to these lower rates. No agreement means the benefits to the lower-middle income country will no longer be present and so the whole process of mutual benefits unravels.[14]

4. Data

To examine the determinants of settlement rates in practice, we obtained annual data on all available countries, for the period 1980-1996. This is an unbalanced sample of 2209 observations, with 167 countries having data on all variables for at least one year. It includes countries which existed earlier but not later in the sample (U.S.S.R.), and countries which existed later but not earlier in the sample (Kazakhstan). From the FCC, Statistics of Communications Common Carriers, we obtained data for the United States versus each other country j on minutes called (in each direction), denoted Q_{ij}, and settlement payments (in each direction), denoted S_{ij}. From the same source, we also obtained United States carrier revenue from country j, denoted REV_{ij}. Population for each country, POP_j, is taken from the March 1998 IMF's International Financial Statistics (IFS) database. We obtained real per-capita income, for each country j (denoted M_j), using the Summers and Heston Penn World Table, issue 5.6, which measures the gross domestic product per-capita in 1985 United States dollars converted at PPP exchange rates. This series ended in 1992; we updated it by splicing it to a 1985 constant price GDP from the IFS database, converted into United States dollars based on the market exchange rate in 1985, and divided by POP_j. We also obtained the 1985 GDP price deflator for the United States from IFS, denoted CPI_t. Data on distance was taken from the Web site (www.indo.com/distance), which calculates the air-distance between any two cities in the world. The distance between the United States and a country j is denoted $DIST_j$. The distance is the shortest distance between either New York city or Los Angeles, and the closest available city in the foreign country. When distance is unavailable for a particular country it is assumed to be equal to the distance to the closest neighboring country with available data. The area of each country, $AREA_j$, is taken from the 1994 Barro-Lee

14 The need for such compensating payments may explain why a multilateral approach has not been used to date, despite the inefficiencies created by bilateral bargaining.

growth data set, the 1995 World Bank Indicators, and the 1988 World Almanac. The variable *DC* measures the extent of domestic competition, as one minus AT&T's share of net revenue from international services in the United States, obtained from table 18 in Lande and Blake (1997). Finally, $COMP_j$, which measures the number of telecommunications firms offering international phone services operating in country *j*, was obtained from FCC accounting rate data, compiled from waivers filed with the FCC by United States international carriers. We used this to define the dummy variable for foreign competition; $FC_j = 0$ when $COMP_j = 1$ and $FC_j = 1$ when $COMP_j > 1$.

5. An Empirical Investigation of Settlement Rates

This section uses the data described above to investigate the determinants of settlement rates. We construct the average per-minute price of calls from the United States to country *j*, in constant 1985 dollars, $P_j = (REV_{ij}/Q_{ij})/CPI_i$ and the average per-minute settlement rate from the United States to carriers in country *j*, in constant 1985 dollars, $R_{ij} = (S_{ij}/Q_{ij})/CPI_i$. Then the average per-minute settlement rate which applies in both directions between the United States and country *j* is defined as, [15] $R_j = Q_{ij}R_{ij}/(Q_{ij} + Q_{ji}) + Q_{ji}R_{ji}/(Q_{ij} + Q_{ji})$. Table 4 gives some summary statistics on the variables used in the regressions below. The correlation coefficients suggest retail prices and settlement rates are highly correlated. Both these variables are positively correlated with distance and income disparity, and negatively correlated with domestic and foreign competition. However, these summary statistics mask interesting dynamic changes, such as the increase in domestic competition over the sample, the emergence of foreign competition from 1993 onwards, and the steady decrease in retail prices and settlement rates throughout the sample period (in 1985 United States dollars, the average retail price fell from $3.75 per-minute in 1980 to $0.70 in 1996, while the average settlement rate fell from $2.37 per-minute in 1980 to $0.46 in 1996). The dynamic aspects of the data are exploited below. The logarithmic transform is used for $POP_{j,t}$ and $AREA_j$, while $COMP_{j,t}$ is transformed into the dummy variable $FC_{j,t}$. Unscaled $POP_{j,t}$, $AREA_{j,t}$, and $COMP_{j,t}$ have very high levels of positive skewness and kurtosis, suggesting that without such scaling, results would be sensitive to the inclusion of outliers. With these scaled variables, all regressions below were checked for sensitivity to outliers. For each variable, we capped observations that were more than three standard deviations from their mean. This led to no qualitative change, and little quantitative change, in the results below.

One of the key relationships predicted by our model is the positive relationship between settlement rates and prices. Equation (3), which applies when there is no competition, implies $P_{j,t} = \alpha_{j,t} + 0.5R_{j,t}$, where $\alpha_{j,t} = 1/(2b_{j,t}) + 0.5c_{j,t}$. To estimate this relationship, we run the fixed effects regression $Pj,t = \alpha_i + \lambda_t + \beta R_{j,t} + \varepsilon_{j,t}$, which allows for different intercepts for each country and each year. The individual constants allow for the fact that the elasticity of

15 In practice, this will differ somewhat from the common settlement rate (which is one-half of the agreed accounting rate), since typically there is a peak period accounting rate and an off-peak period accounting rate, and the exact share of peak and off-peak calls in each country is likely to be different.

Table 4. Summary Statistics

x	Mean	Median	Std Dev	Min	Max	Corr(x,$P_{j,t}$)	Corr(x,$R_{j,t}$)
$P_{j,t}$	1.66	1.24	1.03	0.18	6.11	1	0.84
$R_{j,t}$	1.14	0.93	0.76	0.06	7.70	0.84	1
$M_{j,t} - M_{US,t}$	-12.27	-13.97	4.81	-18.36	18.65	-0.16	-0.15
$\lvert M_{j,t} - M_{US,t} \rvert$	12.36	13.98	4.56	0.02	18.65	0.20	0.19
$DIST_j$	8.18	8.24	3.50	0.54	14.12	0.35	0.32
ln $POP_{j,t}$	-0.52	-0.31	1.90	-5.52	4.81	-0.10	-0.06
ln $AREA_j$	4.85	5.27	2.41	-1.08	12.63	-0.01	0.04
DC_t	0.14	0.07	0.13	0.01	0.41	-0.49	-0.52
$COMP_{j,t}$	1.06	1	0.46	1	10	-0.11	-0.12
$FC_{j,t}$	0.03	0	0.16	0	1	-0.15	-0.17

Note: There are 2209 observations on each of the variables. $P_{j,t}$ is the average retail price per-minute for a call from the United States to country j (in year t), and measured in 1985 United States dollars. $R_{j,t}$ is the average per-minute settlement rate used between the United States and country j, again measured in 1985 United States dollars. $M_{j,t}$ measures per-capita income for country j, in thousands of 1985 United States dollars. $DIST_j$ is the distance between the United States and country j, measured in thousands of kilometres. ln $POP_{j,t}$ measures the natural logarithm of the population (meaured in tens of millions of people) in country j. ln $AREA_{j,t}$ measures the natural logarithm of the area (measured in thousands of square kilometres) in country j. DC_t is the share of United States net revenue from international calls that is not taken by AT&T. $COMP_{j,t}$ is the number of competing firms in country j, operating in the international market ($COMP_{j,t} = 1$ means there is a monopoly). $FC_{j,t}$ is 1 if there is foreign competition, and 0 otherwise.

demand b_{ij} may differ depending on the country called, and that the cost of calls c_{ij} will differ depending on the country called. The time-varying dummies allow for the fact, that over time, the cost of providing international calls has fallen, that competition in the United States has lowered prices, and that the elasticity of demand may have changed over time. Using our sample of *2209* observations, the estimated equation is $\hat{P}_{j,t} = \hat{\alpha}_i + \hat{\lambda}_t + \hat{\beta} R_{j,t}$, where $\hat{\beta} = 0.51$ with a (heteroskedastic-consistent) standard error of less than *0.05* (t-stat is *10.53*).[16] The results show there is a highly significant and positive relationship between settlement rates and retail prices, and this relationship is very close to that predicted from equation (3), despite the fact data from competitive regimes is also included. This suggests that United States carriers pass on roughly one-half of any change in settlement rates. If one accepts this link between settlement rates and retail prices, an important question becomes: "What determines settlement rates?"[17]

An important determinant of settlement rates, according to our theory of settlement rate determination, is income disparities. In particular, table 1 suggests that the greater the absolute difference between United States and foreign per-capita income $\lvert M_{j,t} - M_{US,t} \rvert$, the

16 Using all 2876 observations where both price and settlement rates data exists (but other variables are missing), β**HAT!!!!!** = 0.54, with a standard error of *0.04* (t-stat is *12.34*).

17 Even if one does not accept our theory of settlement rates and retail pricing, our empirical investigation of settlement rate determination provides the empirical regulatories which would have to be explained by alternative theories.

greater the settlement rate that will be agreed upon. We allow the strength of this relationship to differ depending on whether there is foreign competition or not. Our theory also suggests settlement rates should be increasing in the cost of carrying calls. We consider three different variables that proxy components of this cost. Firstly, the total cost of providing underwater cable is likely to be increasing in the distance of cable that has to be provided. Secondly, the greater is the population, the smaller is the per-minute cost of providing a given length of cable. Finally, for a given population, the greater the area of the country, the greater is the cost per-minute of delivering the call to (or taking the call from) local customers. It is cheaper to deliver calls to one million densely populated households than the same number dispersed over a large area.[18] To the extent the cost of cable has fallen (for a given volume of calls) and the economies of scale in laying cable has fallen (both underwater and across land), then distance, population, and area should all be decreasing in importance over time. Distance and area should also be decreasing in importance over time, as the volume of calls has increased over time, thus lowering the per-minute cost of covering additional distance or area. Finally, foreign competition could increase or decrease settlement rates, depending on whether carriers are restricted from reaching alternative settlement arrangements or not. We test these predictions by running a separate least squares regression for each year in the sample, as well as a regression on the means over the seventeen years of data.

The results from table 5 confirm one of the main predictions of our model, that settlement rates are increasing in the income disparity between countries. The coefficient on income disparity is statistically significant (at the 1% level) in every year. The results suggest that an increase in income disparity of $1000 in 1985 increases the settlement rate by 5.6 cents; in 1996, the same increase leads to a 2.7 cent increase in the settlement rate when there is no competition in the foreign country, and a 0.9 cent increase in the settlement rate when there is competition in the foreign country. Interestingly the reduction in the importance of income disparities for settlement rates in the mid to late 1980s appears to coincide with the emergence of competition in the United States market. We find further support for this proposition from time series regressions below. Table 5 suggests distance, population, and area are important determinants of settlement rates, although their importance diminishes over the sample, most likely because the costs that these variables proxy were falling over the sample period (at least when measured on a per-minute basis). Of the three variables, distance appears to be the most important; it is statistically significant (at the 1% level) in every year, and a standard deviation shock to distance has a bigger impact on settlement rates than a standard deviation shock to either population or area.

The decline in the costs over the sample period, suggested by these results, is quite dramatic. In 1980, an extra 1000 kilometers in distance, increases the settlement rate by 19.3 cents, but by 1996, an extra 1000 kilometers in distance, increases settlement rates by only 3.2 cents. Similarly, in 1980 an extra one percent in area (population), increases (reduces) the settlement rate by 10.7 cents (27.4 cents), but by 1996 the same increase, increases

18 Of course the national lines and local networks have to exist regardless of international calls. Nevertheless, international carriers will typically have to pay an access fee to the national carrier which will often be determined by the price of national calls (if not directly on the cost of running the national and local network). Where the international and domestic operators are one and the same, presumably a portion of the incremental cost of running the national and local network is implicitly factored into the cost of offering international phone calls.

Table 5. Settlement Rate Regressions from 1980 to 1996%

	1980	1981	1982	1983	1984	1985
No. of Obs.	131	138	139	140	142	144
R^2	0.44	0.26	0.39	0.43	0.48	0.22
Constant	-0.733	-0.233	0.291	0.233	-0.114	-0.332
	(0.375)	(0.361)	(0.172)	(0.152)	(0.136)	(0.207)
$\lvert M_{j,t} - M_{i,t} \rvert$	0.077	0.061	0.050	0.045	0.056	0.056
	(0.018)	(0.015)	(0.009)	{(0.007)	(0.007)	(0.009)
$DIST_j$	0.193	0.099	0.080	0.072	0.070	0.071
	(0.028)	(0.016)	(0.012)	(0.009)	{(0.009)	(0.011)
ln $POP_{j,t}$	-0.274	-0.110	-0.029	-0.048	-0.072	-0.109
	(0.069)	(0.060)	(0.031)	(0.028)	{(0.024)	(0.033)
ln $AREA_j$	0.107	0.089	0.012	0.022	0.041	0.063
	(0.048)	(0.053)	(0.024)	(0.020)	{(0.019)	(0.028)
	1986	1987	1988	1989	1990	1991
No. of Obs.	140	140	143	140	139	135
R^2	0.32	0.31	0.30	0.33	0.20	0.23
Constant	-0.080	0.112	0.025	-0.008	0.133	0.239
	(0.265)	(0.161)	(0.158)	(0.142)	{(0.130)	(0.106)
$\lvert M_{j,t} - M_{i,t} \rvert$	0.038	0.030	0.029	0.026	0.025	0.021
	(0.007)	(0.006)	(0.005)	{(0.005)	(0.006)	(0.005)
$DIST_j$	0.070	0.055	0.051	0.054	0.050	0.032
	(0.014)	(0.010)	(0.009)	(0.009)	{(0.015)	(0.008)
ln $POP_{j,t}$	-0.088	-0.058	-0.052	-0.041	-0.017	-0.004
	(0.044)	(0.029)	(0.028)	(0.025)	{(0.022)	(0.019)
ln $AREA_j$	0.040	0.025	0.034	0.028	-0.007	0.001
	(0.033)	(0.022)	(0.022)	(0.020)	(0.025)	(0.016)
	1992	1993	1994	1995	1996	Between
No. of Obs.	133	129	117	87	72	147
R^2	0.24	0.32	0.35	0.38	0.45	0.46
Constant	0.117	0.071	-0.043	0.056	-0.140	-0.071
	(0.112)	(0.106)	(0.114)	(0.100)	{(0.129)	(0.137)
$\lvert M_{j,t} - M_{i,t} \rvert$	0.021	0.023	0.025	0.019	0.027	0.040
	(0.004)	(0.004)	(0.004)	{(0.004)	(0.004)	(0.007)%
$\lvert M_{j,t} - M_{i,t} \rvert * FC_{j,t}$		{-0.001	-0.006	-0.006	-0.018	
		(0.009)	(0.009)	(0.007)	(0.009)$	
$DIST_j$	0.031	0.031	0.033	0.024	0.032	0.066
	(0.008)	(0.007)	(0.008)	(0.007)	{(0.009)	(0.009)
ln $POP_{j,t}$	-0.020	-0.015	-0.026	0.002	-0.004	-0.071
	(0.021)	(0.018)	(0.020)	(0.016)	{(0.020)	(0.024)
ln $AREA_j$	0.013	0.008	0.015	0.006	0.005	0.035
	(0.016)	(0.016)	(0.016)	(0.010)	{(0.014)	(0.019)
$FC_{j,t}$		-0.134	-0.092	-0.105	0.027	
		(0.092)	(0.091)	(0.073)	(0.081)$	

Note: All variables are defined in table 4. “Between” is a means-on-means regression. Heteroskedastic-consistent standard errors are shown in parenthesis.

Table 6. Settlement Rate Regressions over Time

	Pooled	Fixed Effects	Random Effects
No. of Obs.	2209	2209	2209
R^2	0.59	0.74	0.71
$\lvert M_{j,t} - M_{US,t} \rvert$	0.049 (0.003)	0.050 (0.025)	0.069 (0.007)
$\lvert M_{j,t} - M_{US,t} \rvert * DC_t$,	-0.083 (0.013)	-0.069 (0.016)	-0.106 (0.016)
$\lvert M_{j,t} - M_{US,t} \rvert * FC_{j,t}$	-0.006 (0.004)	0.016 (0.005)	0.016 (0.012)
$DIST_j$	0.116 (0.008)		
$DIST_j * YEARS_t$	-0.007 (0.001)	-0.006 {(0.001)	-0.004 (0.001)
ln $POP_{j,t}$	-0.134 (0.022)	-0.395 (0.238)	-0.029 (0.017)
ln $POP_{j,t} * YEARS_t$	0.010 (0.002)	0.008 {(0.002)	0.006 (0.001)
ln $AREA_j$	0.068 (0.018)		
ln $AREA_j * YEARS_t$	-0.005 (0.002)	-0.004 {(0.002)	-0.003 (0.001)
FC_t	-0.082 (0.049)	-0.184 (0.064)	-0.192 (0.131)

Note: "Pooled" is a standard OLS regression using all available date, and allowing for time dummies; "Fixed Effects" is a standard panel regression, allowing for individual and time dummies; "Random Effects" assumes the country intercepts are drawn from a common distribution, but still allows for time dummies. All variables are defined in table 4, except $YEARS_t$ which takes on the value 0 in 1980, 1 in 1981, ... 16 in 1996. Heteroskedastic-consistent standard errors are shown in parenthesis.

(reduces) the settlement rate by only 0.5 cents (0.4 cents). Surprisingly, foreign competition is not a significant determinant of settlement rates in these regressions.[19] These results suggest that reductions in costs could be a more important reason for the reduction in settlement rates over the period 1980-1996, than increases in competition. Developments such as settlement rate bypass and competition for call completion are relatively new phenomena, so most of their impact is most likely felt after the end of our sample.

Table 6 pools the data across years to extract additional information from the time variation in the data. Based on the results of table 5, we allow the coefficient on income disparity to depend on the degree of domestic and foreign competition. We also allow the cost of calls to fall over time, by interacting distance, population, and area with time. Three

19 Using $COMP_{j,t}$ instead of $FC_{j,t}$ lead to less significant results. For 1993-1996, the t-stats using $COMP_{j,t}$ are -1.18, -0.82, 0.17, and 0.21, while using $FC_{j,t}$ they are -1.46, -1.01, -1.44, and 0.33.

regression models are considered: a pooled regression, a fixed effects regression, and a random effects regression.

The results from exploiting the time series nature of the data mostly confirm those obtained from the separate single-year regressions above, but some differences emerge. In all three regressions, settlement rates are increasing in income disparity, although the rate of increase, decreases with the extent of domestic competition. The signs on coefficients for distance, population, and area are the same as those found in table 5, although the magnitude of the coefficients falls.[20] Foreign competition emerges as a more important factor in lowering settlement rates, compared to the results from the cross-sectional regressions. According to the pooled regression, the move to multiple carriers in the foreign country reduces settlement rates by 8.2 cents, while with the fixed and random effects models, the fall in settlement rates is more than 18 cents. Thus, in contrast to table 5, these results suggest that the emergence of competition was an important factor behind the reduction of settlement rates in the 1990s.

One of the less obvious implications of our bilateral bargaining theory of why income disparity matters for settlement rates, is that the absolute value of the difference between two countries incomes matters, rather than just the difference in incomes. This implies, other things equal, settlement rates will be higher between a carrier in a middle-income country and a carrier in a high-income country, than between carriers which are both in middle-income countries. While the United States had the highest per-capita income in some of the later years in our sample, there were countries with higher per-capita incomes in earlier years. Using the pooled regression model, the additional variables $(M_{j,t} - M_{US,t})$, $(M_{j,t} - M_{US,t}) * DC_t$, and $(M_{j,t} - M_{US,t}) * FC_{j,t}$ are added to the model, and an F-test is conducted to test whether these three variables are jointly significant. Even at the 10% significance level, these variables cannot be rejected as insignificant (p-value is 0.71). In contrast, using the same unrestricted model, an F-test on the three variables $|M_{j,t} - M_{US,t}|$, $|M_{j,t} - M_{US,t}| * DC_t$, and $|M_{j,t} - M_{US,t}| * FC_{j,t}$ yields an F-stat of 14.57 (p-value is 0.00), thus supporting this implication of the theory. A more powerful test of this implication could be achieved using settlement rate data from a middle-income country. In this case, results based on just the level of foreign income, as opposed to the absolute value of the deviation, should yield starkly different conclusions.

As well as the variables directly implied by our theory of settlement rate determination, we also considered three other less obvious variables. Per-capita gross domestic product is unlikely to be a perfect measure of households ability to spend on international phone calls. A better measure, especially for countries with a lot of income inequality, maybe the median household income. Unfortunately, this is not available. Instead, we consider two variables that may be correlated with income inequality. $POLRIGHT6_j$ is an index of political rights (from 1 to 7; 1=most freedom), taken from the Barro-Lee 1994 data set and based on the average over 1985-89. $PINSTAB5_j$ is a measure of political instability (the average of the number of assassinations per million per year and the number of revolutions per year), taken from the Barro-Lee 1994 data set and based on the average over 1980-84. Appending these

20 There were only two cases where these coefficients were not significant at the 5% level; the coefficients on population in the fixed and random effects regressions.

two variables to the pooled model above, the estimates on the other variables remain largely unchanged, while the coefficient on $POLRIGHT6_j$ is significant.[21] The results suggest countries where there are few political rights, have higher settlement rates. To the extent income is less equal in countries with repressive political regimes, this supports the argument that income inequality also matters. A one-standard deviation increase in political repressiveness raises the settlement rate by nearly 13 cents. Settlement rates could also be higher with repressive governments if such countries have greater bargaining power in settlement rate negotiations. This assumes, as is likely the case, these are low-income countries which, therefore, want high settlement rates.[22] Another variable that was found to be significant when appended to our pooled model, is the standard measure of teledensity $LINES_{j,t}$; the number of main lines per 100 inhabitants of country j. This is taken from the 1995 World Database published by the International Telecommunications Union. There are 36 observations where $LINES_{j,t}$ is not available for our sample set. An increase in teledensity increases the settlement rate, which is consistent with the view teledensity is another component of the cost of providing the national link; the more lines that are provided per-person, the more costly is the national link per-call. A one standard deviation in teledensity raises the settlement rate by 12 cents; the coefficient is 0.004 with a standard error of 0.001. As with the political variables, adding $LINES_{j,t}$ does not materially alter the other estimated coefficients, or their significance.[23]

6. Further Policy Implications and Future Directions

An alternative policy direction to the multilateral cooperative approach and the FCC's mandates, examined in this paper, is the abandonment of government regulations on international carriers and the opening up of markets to competition. Once retail competition is achieved, government rules such as proportional return rules and common settlement rates, may serve to only increase settlement rates and hinder competition. To achieve truly cost based retail prices, carriers should be allowed to compete with each other for call settlement. Existing international carriers have the most to lose from such competition and may well argue for multilateral agreements and rules which effectively stifle competition for call settlement.[24] This suggests a two-tiered approach may be optimal: encourage competition

21 We lose 264 observations when adding these two variables. The coefficient on *POLRIGHT6* is 0.056 with a standard error of 0.008. The coefficient on *PINSTAB5* is -0.037 with a standard error of 0.065.

22 Ergas (1998) points out these countries typically have governments that are more concerned with raising revenue than consumer welfare. This is consistent with the findings of the benchmark model in section 2.1, modified to take this fact into account.

23 Using an F-test on the pooled model with the reduced sample size, we cannot reject that the coefficients on the remaining variables, other than a constant term, are unchanged after the introduction of $POLRIGHT6_j$, $PINSTAB5_j$, and $LINES_{j,t}$; the p-value from this test is 0.966. The introduction of these three variables leads to a slight increase in the importance of income and foreign competition, and a slight decrease in the importance of the three cost measures. We also included these variables in our other regressions and reached similar conclusions. These variables are not considered as part of our benchmark model as data is not available for all observations, the political variables are not directly suggested by our model, and the variable $LINES_{j,t}$ is likely to be endogenous.

24 An alternative proposal, which has been put forward by the International Telecommunications Union, is to require a uniform price (over all originating countries) for call termination in each destination country. This price is called the international terminating traffic fee. Such a proposal, to the extent it prevents

over call completion by permitting alternative settlement arrangements to develop between countries which have more than one carrier offering international telephone services, and where competition does not develop, promote multilateral rather than bilateral negotiations which allow all countries to lower settlement rates and improve welfare, with only the carriers in the lowest-income countries needing compensation for losses.

Our empirical results give one justification for the FCC's approach of having higher benchmark rates for carriers in low-income countries. The justification is that the adjustment to the FCC benchmark rates will be greater for low-income countries since they start from higher levels of settlement rates. A more appropriate approach, to the extent costs are the same across countries, is to impose a common benchmark rate for all countries, but with different glide paths to this common rate. Carriers in low-income countries would be allowed more time to adjust, given their different starting points. This is a feature of the FCC mandates; carriers in low-income countries are allowed three extra years to adjust to their prescribed benchmark rates compared to carriers in high-income countries.

If distance captures a component of the cost of providing international telecommunication services between countries, then this suggests that distance should also be reflected in the FCC benchmark rates. In fact, this has been suggested by the United States carrier Sprint. According to the *International Settlement Rates Report and Order*, IB Docket No. 96-261, released on August 18, 1997 (p.47), "Sprint urges the Commission to adopt country-specific benchmarks on the grounds that the Tariffed Components Prices reflect cost differences among countries. Sprint states that a country's geography or distance from the United States, for example, would, all other things being equal, appear to be highly relevant to its Tariffed Components Prices." Our results provide mixed support for one aspect of Sprint's claim, and do not support the other. The cross-section regression results suggest that in 1996 distance still measured an important component of costs, but geography, in so much as this can be proxied by area, was no longer a significant component of costs. The panel data regressions suggest neither variable is important by 1996. A one-standard deviation increase in distance increases settlement rates by between 1.4 and 11.2 cents in 1996, depending on which of the two types of regressions are used.

Given the phenomenal changes occurring in the telecommunications market, further work to evaluate different policy approaches and to examine the implications of different types of competition is urgently needed. Explicit models of competition for call completion, settlement rate bypass, refile and call-back services are in short supply. Further modeling of multilateral versus bilateral bargaining seems warranted, given our illustration that multilateral bargaining could, to a large extent, overcome the biases towards high settlement rates introduced by bilateral bargaining. Similarly, further modeling of the implications of relaxing proportional return rules and common settlement rate restrictions, would seem to be fruitful. Future empirical work will be able to address some of these issues, as new data becomes available. Future empirical work should also test our bargaining theory of settlement rate determination using data from a middle-income country, thus providing a more powerful test of its predictions. In this case, results based on just the level of foreign income, as opposed to the absolute value of the deviation, should yield starkly different conclusions. Finally, our

domestic carriers from reaching separate settlement rate agreements with different foreign carriers, may also restrict competition. De Fjaja and Valbonesi (1998) analyze this proposal in a model without competition and show, even in this case, it leads to higher prices.

estimation results could be used to discriminate between alternative theories of settlement rate determination.

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