Telephone Demand Over the Atlantic

Evidence from Country-Pair Data

Jan Paul Acton, Ingo Vogelsang

RAND

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PREFACE

This report examines the determinants of international calling, both theoretically and empirically. It centers particularly on the role of prices to and from the United States and explains the volume of calling across the North Atlantic market. This market is important for economic and policy reasons, since the governments play a role in setting prices and terms of access; the net impact of calling affects the balance of payments between country pairs. The study is based on recent data on call use, along with detailed information about pricing structures. The period of analysis was one of rapid expansion in calling, important price changes, and deregulation of services in some countries. Consequently, these recent price estimates may be particularly relevant for contemporary policy deliberations.

The report should be of interest to domestic and foreign telecommunications carriers, and to regulatory and legislative bodies in the academic research community.

This work is funded under grants from the National Science Foundation (Dr. Laurence C. Rosenberg, Project Monitor) and The Markle Foundation. A related study, *Competition, Pricing, and Regulatory Policy in the International Telephone Industry*, R-3790-NSF/MF, by Leland L. Johnson, July 1989, was also prepared under the same grants.

SUMMARY

International telephone calls are important as an economic good, and they play a significant role in balance of payment. In recent years, U.S. carriers received over $3 billion in revenues for their overseas calls. Because international calling requires payments to the country where the call terminates, transfer payments from U.S. carriers must also be made (and reciprocal payments for calls terminating in the United States). In recent years, the net payment by U.S. carriers to foreign telephone systems was in excess of $1.2 billion.

The demand for telephone calls is similar in many ways to the demand for other goods and services, but some added considerations are important. Since calls involve two parties, calling can generate externalities (positive or negative). That is, both parties can benefit or lose from a call, even though only one party pays for it. Furthermore, the price for initiating a call generally differs from country to country, so the opportunity exists to lower the cost if the two parties agree to initiate their call from the lower priced country. We designate these two features as "call externalities" and "arbitrage," respectively. The practical significance is that one or both of these features may be present in international calling, and they may affect the normal working of price changes on the quantity of calls originating in the United States and in other countries. A change in the price of outbound calls in one country can affect the volume of both outbound and inbound calls.

The empirical analysis is based on annual data for minutes of calling between the United States and 18 West European countries from 1979 to 1986. We examined the volume of calls both originating and terminating in the United States as a function of the price in the country of origin (the "own-price" effect) and the price in the country where the call terminated (the "cross-price" effect). In addition, we allowed for economic and conditioning variables such as the volume of trade between the countries, the percentage of employment in major sectors of the economy, the number of telephones, and the price of telex services (a potential alternative form of communication).

In 1979–1986, the price for calling to and from the United States fell in nominal terms for most countries and it fell in real (adjusted for inflation) terms for all countries. In general, it was less expensive to initiate a call in the United States throughout this period than to terminate one, although the differences have shrunk, especially since 1982.

We concentrated specifically on the role of price and tested the effects of several alternative specifications of price in the demand equations. Following economic theory, we selected marginal price as influencing the quantity of calling—rather than the inframarginal charge (say, the higher price for the first minute of calling) or the average price. Empirically, in this sample, marginal price and average price have fairly similar effects on the demand for calls. We also examined the effects of expressing prices in the currency of the country of origin or in U.S. dollar equivalents. The latter would be especially appropriate if arbitrage were a significant consideration. Expressing prices in each country's units strengthened the effects of European prices on calls terminating in the United States and diminished slightly the effect of U.S. prices on those calls. It also weakened the effect of other countries' prices on calls originating in the United States.

Overall, the price for calling from the United States produced negative, but statistically insignificant, coefficients on the minutes of calling from the United States in 1979–1982, and negative, significant coefficients equal to approximately –1.0 in 1983–1986. The price for calling to the United States likewise produced a negative coefficient on minutes of calling to the United States. The coefficient generally has values between –0.3 and –0.5 and is statistically significant in both 1979–1982 and 1983–1986. Cross-price effects—the effect of U.S.-origination prices on the volume of calls to the United States (and vice versa)—are always negative when they are statistically significant. This implies that the inbound and outbound calls are economic complements. The pattern is consistent with our call-externality theory developed in Sec. III.

Most other explanatory variables yield expected coefficients on the volume of calls and the country of origin. The interesting—possibly unexpected—finding of a negative effect of telex prices on the number of calls is consistent with a business practice of requiring a telex confirmation for certain commercial transactions or communications; calls and telex services are economic complements. Thus, a rise in telex prices acts in the same manner as a rise in telephone prices. We also found a strongly positive coefficient on the number of telephones in each country. This structural variable obviously facilitates calling and seems to be acting as a proxy for income—which we omitted from our specification because of multicollinearity.

Empirical results such as the ones we present can be useful in many possible policy applications. Perhaps most important, they can help regulators and suppliers of telephone services to anticipate the effects of price changes on call volume. The estimates also provide a possible explanation for some of the puzzling pricing practices we observe in

U.S. international telephone carriers. For example, some off-peak rates for calls originating in the United States are below the accounting rates that U.S. carriers are required to pay their foreign counterparts for those calls. This would suggest, on the face of it, that such rates are set below marginal cost. However, if the cross-price effects are strong enough to stimulate a sufficient volume of return calls from outside the United States, for some values of prices and price elasticities the practice becomes rational because of the effect on total revenue.

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I. PURPOSE AND MOTIVATION OF THE REPORT

We chose to study international telecommunications demand as an economic good and because of the policy issues surrounding it. In aggregate, international telephone-service demand is a $3 billion market for U.S. carriers alone and probably exceeds $2 billion for foreign countries as well.[1] International telecommunications resulted in a net payment of $1.2 billion in 1986 by U.S. carriers to foreigners, which—considered in isolation—contributes to the U.S. balance-of-trade deficit.[2]

Telecommunications demand is applicable to policy analysis because the prices charged are subject to review or regulation in all countries, and in other instances, the government—through post, telegraph, and telephone services (PTTs)—supplies the services itself. Thus, the government is involved in reviewing capacity and pricing decisions for international telecommunications supply. Furthermore, in some instances, governments consciously use excess revenues from international telephone calls to subsidize other telecommunications services or to contribute to general revenues.[3] The result is that pricing and demand are subjects for explicit policy analysis in the United States and abroad.

The telecommunications market has changed substantially in recent years. Technology has permitted significant increases in capacity and quality of service while permitting lower costs per call. The volume of voice traffic in particular has grown substantially, and aggregate capacity for handling international calls has grown even more dramatically. In recent years, competitive suppliers have entered the market, and customers on some routes have a choice. Partial deregulation in the United States has led to this increased competition and to a richer variety of pricing schedules in some international markets as well.

Despite the policy significance of the market and these recent substantial changes, relatively few public studies have been made of the demand for international telephone calls. Most such studies include

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[1]Federal Communications Commission (1987c), Table 1.

[2]Federal Communications Commission (1987c). Trade in other goods and services may be associated with international telecommunications as well, so the net effect on balance of payments is not easily determined.

[3]See Johnson (1987) or Bruce, Currand, and Director (1986) for discussions of some aspects of governmental involvement in this arena.

data through only the late 1970s, before the most recent increases in supply, the fall in prices for many services, and the deregulation of long distance service in the United States.[4] Telecommunications policy analysis would benefit from better understanding of demand in order to: project future levels and usage patterns, estimate likely deficits or surpluses, examine the effects of alternative pricing policies on use and capacity and on economic welfare, and so forth. The purpose of the present report is to contribute in a preliminary way to such understanding, using recent data across the heavily used North Atlantic market.

OVERVIEW OF THE REPORT

In Sec. II, we briefly summarize broad trends in the industry in recent years. Next, we discuss the nature of international telecommunications demand as an economic good, emphasizing the features that make such calls somewhat different from conventional goods. In Sec. IV we discuss our modeling and estimation approach and describe the data available for our analysis. In Sec. V we present the empirical results and in Sec. VI our conclusions.

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[4]Previous international studies include Lago (1970), Yatrakis (1972), Craver (1976), Rea and Lage (1978), Appelbe, Larson, and Lehman (forthcoming), and Appelbe et al. (forthcoming).

II. BROAD TRENDS IN INTERNATIONAL TELECOMMUNICATIONS SUPPLY AND PRICING

Telecommunications include voice, data, telex, and telegraph services. We concentrate on voice communications using public, measured services, which are the largest component in dollar terms. We allow for telex services as a potential substitute or complement, but do not examine other services in this report.

The price of international calling has fallen substantially in nominal and real terms over the last decade. Figure 1 gives an abbreviated summary of the trends in prices for selected West European countries. Prices are for one minute of direct international calling to the United States, converted to U.S. dollars.[1] These prices fell by roughly 50

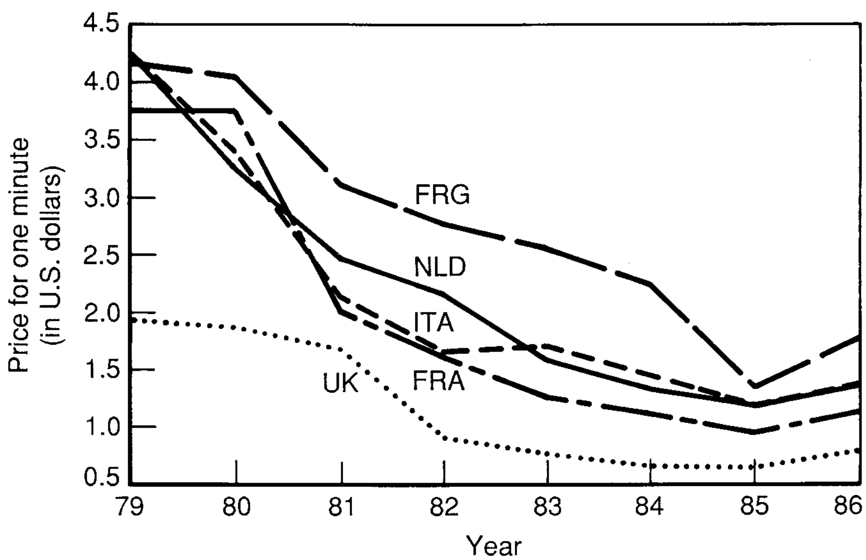

Fig. 1—Trends in prices of direct calls to the United States

[1]All price variables are constructed to reflect the average price paid over a calendar year. If a rate changes during the year, a weighted average of prices is taken, where weights are number of months.

percent for each country from 1979–1986. Rates from most countries began the period at about $4.00 per minute (after the initial one- or three-minute period) and fell to less than $2.00 per minute by the mid-1980s. The price for calling from the United Kingdom was substantially lower throughout this period, but it too fell by over 50 percent.

The cost of a comparable call from the United States to these countries started much lower than the European rates, but the difference has narrowed. Figures 2 through 4 illustrate the trend for three countries. France, like many other countries, started the period at about twice the U.S. price level, but ended it about the same when stated in U.S. dollars. The Federal Republic of Germany has always had higher rates, although the difference has narrowed substantially. Rates between the United States and the United Kingdom have been very close throughout the period.

At the same time, the volume of international calls has increased substantially—aided no doubt by the expansion of capacity and the widespread introduction of direct international dialing. Figure 5 presents highlights of these trends for selected countries.

Table 1 gives prices for a marginal minute of an international call in both local and U.S. currency, and for calls originating in both the United States and the European countries. As prevously noted,

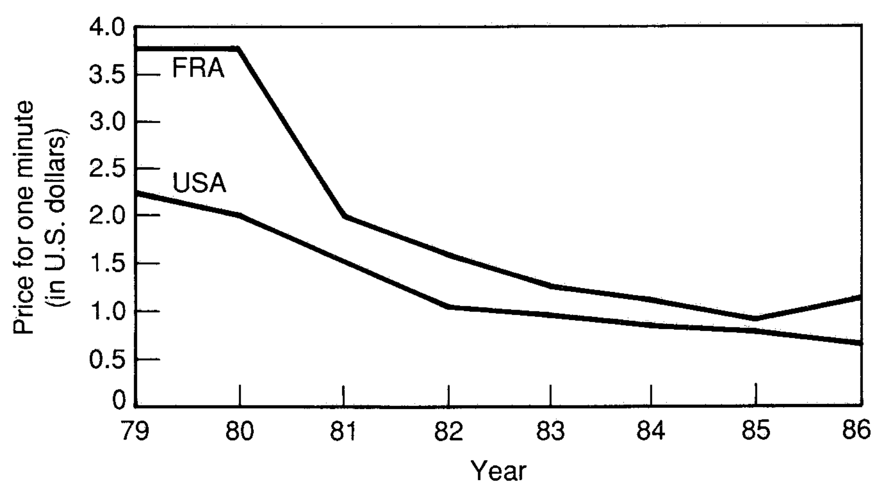

Fig. 2—Trends in relative prices of direct calls from the United States and from France

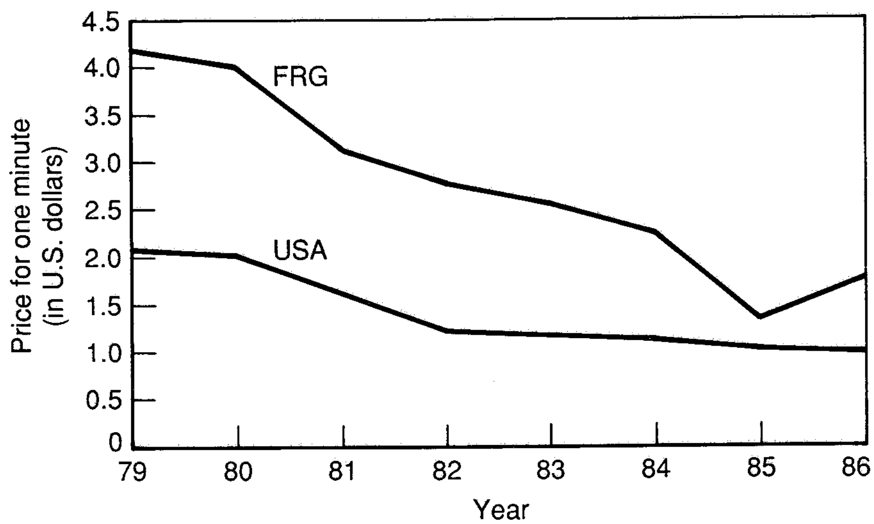

Fig. 3—Trends in relative prices of direct calls from the United States and from West Germany

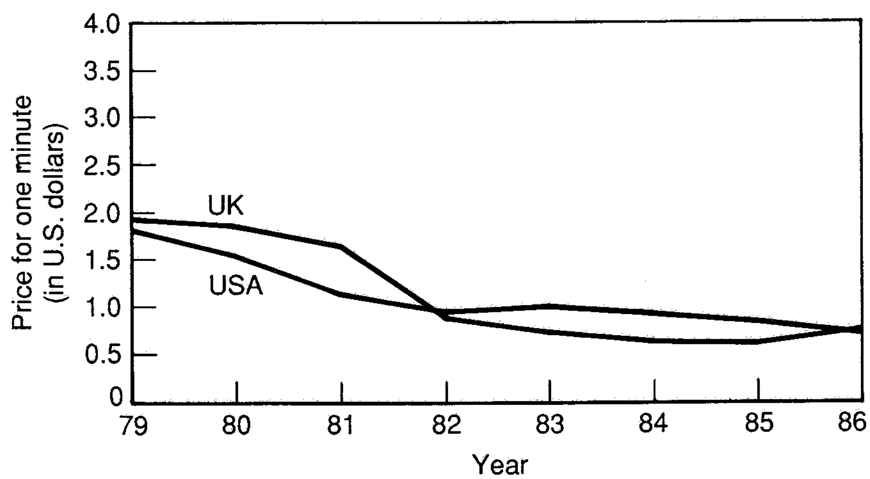

Fig. 4—Trends in relative prices of direct calls from the United States and from the United Kingdom

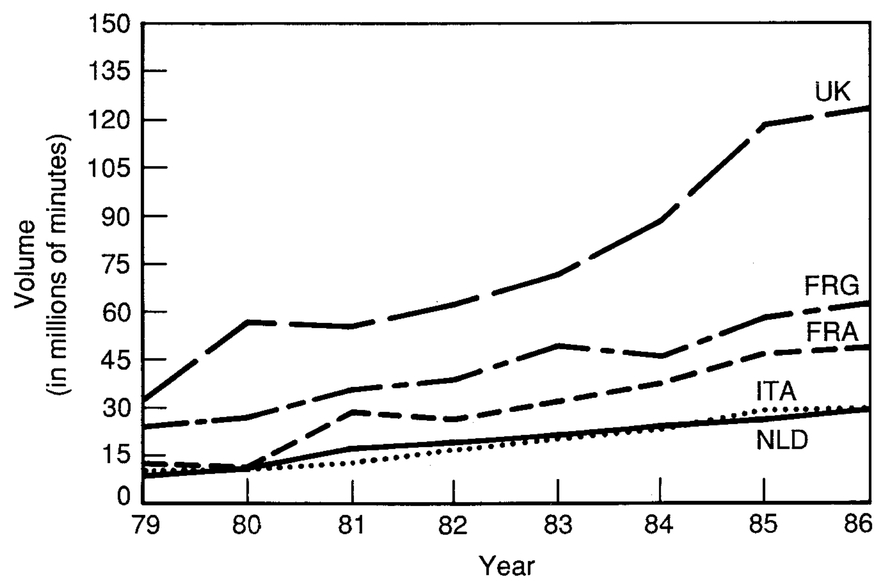

Fig. 5—Trends of international calls to the United States

marginal-minute prices are generally lower for calls originating in the United States.

NATURE OF PRICING FOR INTERNATIONAL TELEPHONE CALLS

Broadly speaking then, it is less expensive to call from the United States to European countries than vice versa, but this masks some important distinctions. As suggested in Table 2, European rate structures generally make very short calls less expensive than the same length call placed in America; but for longer calls, the total cost of the call becomes lower for calls originating in the United States.[2]

This is due to several features of the rate structures. Rates in the United States are higher for the first block of time (three minutes in the earlier period, now one minute) and lower per minute for additional minutes. Furthermore, the United States charges for each fraction of a minute at the whole-minute rate. European rates generally do not

[2]See Federal Communications Commission (1987c) for a recent review of the relative costs of calls of different lengths in 1986.

Table 1

PRICES OF MARGINAL MINUTE OF INTERNATIONAL CALLS BETWEEN THE UNITED STATES AND SELECTED COUNTRIES

	1979			1986		
	Local Currency		Real U.S.	Local Currency		Real U.S.
Country	Nominal	Real	Dollars	Nominal	Real	Dollars
To the United States from:						
France	14.07	15.788	3.715	12.833	7.903	1.141
Germany	7.333	7.685	4.193	4.656	3.866	1.781
Italy	2905.86	3505.88	4.219	4214.56	2048.38	1.374
Netherlands	8.00	8.44	4.209	3.96	3.35	1.368
United Kingdom	0.750	0.898	1.906	0.742	0.517	0.759
From the United States to:						
France	2.00	—	2.182	1.09	—	0.819
Germany	2.00	—	2.182	1.22	—	0.920
Italy	2.00	—	2.182	1.09	—	0.819
Netherlands	2.00	—	2.182	1.09	—	0.819
United Kingdom	1.50	—	1.636	1.05	—	0.791

SOURCES: Eurodata *Voice Book*, various years; and ATT rate schedules, various years, private communication.

NOTE: Real values are calculated so that real equals nominal in 1980.

have a declining price per minute; instead the same per-minute price applies to short and long calls. Moreover, European countries generally charge only for the fraction of a minute that is used, which further reduces the price of shorter calls relative to calls originating in the United States. This policy of charging for only a fraction of a minute—combined with lower first-minute rates—encourages brief "call me back" calls from Europeans to Americans (see Sec. III for a discussion of gift and arbitrage motivations for calling).

Other distinctions between U.S. and European international rates may affect bills as well. In the United States, customers pay different prices during peak, shoulder, or off-peak periods, while European customers generally face only peak or off-peak prices. In some instances (notably West Germany), customers pay the same price for international calls at all hours. Unfortunately, the data available for our estimation do not distinguish calls by the time at which they were placed.

Table 2

ILLUSTRATION OF INTERNATIONAL TELEPHONE RATES IN 1986

Country	Prices in U.S. and Country-of-Origin Currencies
	To the United States from:
France	Price:[a] 10.04 fr/min Period: 4.6 sec Equivalent U.S. price: $1.45/min
Germany	Price: 0.23 DM/2.964 sec Equivalent U.S. Price: $2.14/min
United Kingdom (Brit Tele)	Peak:[b] 65 p/min Standard: 59 p/min Cheap: 51 p/min Equivalent U.S. Price: $0.96/min for peak

Country	Call Type[c]	Price of Initial Minute (In U.S. dollars)	Price of Additional Minutes (In U.S. dollars)
	From the United States to:		
France	Standard	1.94	1.09
	Discount	1.46	0.82
	Economy	1.16	0.65
Germany	Standard	2.17	1.22
	Discount	1.63	0.93
	Economy	1.30	0.73
United Kingdom	Standard	1.65	0.99
	Discount	1.23	0.75
	Economy	0.99	0.60

SOURCE: Eurodata Foundation, 1986.

[a]Reduced by 7/30ths from 8 pm to 2 am; reduced by 39.5 percent from 2 am to 10 am.

[b]Peak = 3 pm to 5 pm, Monday through Friday; standard = 8 am to 8 pm, excluding peak hours, Monday through Friday; cheap = all other hours.

[c]Standard = 7 am to 1 pm, discount = 1 pm to 6 pm, economy = 6 pm to 7 am.

PAYMENTS BETWEEN TELEPHONE CARRIERS

The mechanism by which telephone companies earn money from international calls is complex. It involves both collections from customers placing the calls and settlements among international carriers—called accounting rates. If traffic in and out of two complementary countries is balanced, these charges cancel one another; otherwise, the country initiating the most calls pays.[3] With few exceptions, U.S. carriers make net payments to other international telephone carriers. Because inbound traffic earns foreign countries hard currency, they have an incentive to cause traffic to be inbound. In recent years, payments by U.S. telephone carriers to foreign telephone carriers have exceeded $2.3 billion per year; receipts from foreign carriers have exceeded only $1.1 billion for a net payout of over $1 billion.

Although these international settlements are important to the telephone carriers—and they affect the balance of payments between the United States and its trading partners—they have little direct significance for our demand estimation. The customer faces a posted price and is unconcerned with the manner in which revenues are divided between the U.S. carrier and the international telephone carrier. Indirectly, however, international settlements and telephone tariffs are and should be interdependent.

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[3]See Dansby and Luciano (1987) for a description of this settlement process.

III. INTERNATIONAL TELECOMMUNICATIONS SERVICES AS AN ECONOMIC GOOD

International telecommunications are a rapidly growing service industry providing for increasing international trade in goods and other services. This in itself may not justify the study of international telecommunications demand. In addition, some methodological and empirical peculiarities challenge research efforts.

Telecommunications—and telephone calls in particular—are different from many economic goods. A call requires two (or more) parties for the good to be "consumed." Thus, economists for a long time noticed the presence of two types of externalities in telecommunications demand. Until very recently only one of these has been the subject of empirical work: the network or access externality created by adding a further subscriber to the telecommunications network. Such a new subscriber increases the value of the network to others because she can now also call or be called. The second type of externality is created by calling a party that does not have to pay for being called.

This call externality has been neglected in the literature for three reasons.[1] First, the value of being called is hard to determine empirically. Second, as Littlechild (1975) has argued, parties regularly calling each other are likely to establish a quid-pro-quo or gift relationship, thus internalizing the call externality. At the same time Littlechild suggests that the number of irregular calls is closely related to the size of the network, so that the call externality can be captured simultaneously with the network externality. Third, much of the analysis has considered local calling, where—at least in the United States—the marginal price of calling is often zero. This is not true of long distance or international calling.

In contrast, in international telecommunications the call externality is worth special attention. It is likely to be substantially more important here than domestically because the fairly high tariffs reduce nuisance calls and increase incentives for free riding by those who want to be called rather than initiate the call. Also, as illustrated by Table 1, the difference in point-to-point tariffs between both directions can be quite substantial. Thus, call externalities are more likely to prevail internationally because internalization is more difficult than domesti-

[1]Larson, Lehman, and Weisman (forthcoming) have included call externality in their model but without naming it as such.

cally. If this is so, welfare effects from these externalities gain in importance because asymmetric benefits may accrue to foreign and domestic callers. For example, if in domestic calls the call externality is internalized by party D's paying for party F's benefit, then domestic social surplus is unequivocally increased.[2] If, however, D is the domestic caller and F the foreign receiver, this may well reduce domestic welfare (although it will improve world welfare).

Thus, we are interested in answering the following questions:

1. What is the nature of the call externality; in particular, how can we derive proxies or boundaries for its size with the tools of consumer-demand theory?
2. Under what conditions are consumers likely to internalize the externality, and what are the equilibrium outcomes short of internalization?
3. How can we empirically determine the existence and measure the size of this externality?
4. How does the presence of a call externality affect welfare considerations, in particular, for optimal pricing?

THE LIKELY SIZE OF THE CALL EXTERNALITY[3]

A telephone call can have different characteristics in different situations. Larson, Lehman, and Weisman (forthcoming) capture these characteristics in final consumption-good "information" that is produced in a household production function with outgoing and incoming telephone calls as inputs. This is a roundabout approach that may pay off once we have some idea of the nature of this production function. With as little as we know about it we might as well restrict ourselves to a single black box that is the utility function.[4] Physically, telephone calls are always an exchange of information. In a broad economic sense, however, they can have characteristics of direct consumption pleasure, information, or action. Are there major differences among these cases with respect to the call externality?

Hearing the voice of someone you love clearly provides *direct consumption pleasure*. This is likely to be reciprocal and to be accompa-

[2]To the extent that the richer person acts as the altruist, there is even going to be a distributional gain in addition to the surplus gain.

[3]In the following, we totally ignore access externalities. These may play some role, for example, if less-developed countries are involved. However, even there, access to the network is rarely directly affected by international tariffs.

[4]This does not mean that the production function approach would not be fruitful, for example, for firms as parties to telephone calls.

nied by altruistic behavior. Thus, as demonstrated below, chances are good that under the pleasure characteristic, call externalities may be internalized. On the other hand, the party being called may (altruistically) reduce the duration of the call in order to save the caller money. If both had the possibility to share the cost of the call in proportion to their utility gain, they might talk longer and call more often. Expressed in willingness to pay, the values of calling and being called may be quite different under the pleasure characteristic. This kind of problem and possible solutions are clearly accessible to economic experimentation.

Calling an airline for fares and flight schedules or calling a doctor for the results of a test are clearly *informational* calls. The value to both sides here may be quite asymmetric. That is why the airline will have an 800 number and the doctor may have an unlisted home number. Still, informational exchange is likely to benefit both parties. The person receiving the information will benefit from it while the other side will receive some exchange value in terms of a fee, business, or future information. Informational exchange is likely to have equal expected value for both sides in integrated multinational companies.

Buying a flight ticket or remotely switching on the heating in a weekend home are *actions* that can be effected by means of the telephone. The mutual benefit of an action usually goes further than that of pure informational exchange. The airline sells a ticket rather than providing only flight information. Again, action-related calling in integrated multinational companies should have an equal expected value for both sides.

To sum, the call externality (and its potential internalization) has some importance for all three types of calls. With the exceptions of multinational companies and families, willingness to pay for calling and for being called is rarely going to be equal. In fact, if "free-rider" considerations are absent and point-to-point tariffs are symmetric, callers will self-select to be those with the higher willingness to pay.

This gives us a convenient upper bound for the *marginal* social willingness to pay for calls. By revealed preference, an upper bound would be the sum of the tariff rates of the calling and the receiving parties. On the other hand, a lower bound of the marginal social willingness to pay for a call would be the tariff rate of the caller.

Both of these boundaries hold in an expected value sense. Calls, especially information-related calls, may be worth much more to the person being called than the tariff rate indicates but often this is known only after the call. Of course, one may receive a nuisance call with negative value, but when picking up the telephone the expected value is still positive.

EQUILIBRIA WITH CALL EXTERNALITIES

Internalizing externalities usually requires some prior communication and agreement. Since call externalities occur in situations of small numbers of participants (bilateral monopoly), internalization or bargaining about the externality is not unlikely. Before characterizing these possibilities, let us follow Larson, Lehman, and Weisman (forthcoming) in deriving demand functions for outgoing calls for D (the domestic consumer) and F (the foreign consumer) from solving for the Nash equilibrium in quantities. We currently restrict ourselves to the individual level. The quantity of telephone calls originating domestically is denoted Q_D, and the quantity originating in the foreign country is Q_F. In this section a change in Q shall mean a change in the volume of calls (an increase in the number, an increase in the length, or both).

The domestic consumer maximizes $U_D = U_D(X_D, Q_D, Q_F)$ subject to $Y_D \geq X_D + P_DQ_D$ and $Q_F \leq Q^*_F$. Here Y_D is income and X_D is other expenditure by the domestic consumer. The volume of incoming calls Q^*_F is taken as given for the moment. Thus the consumer maximizes the Lagrangian function:

$$L_D = U_D(X_D, Q_D, Q_F) + \mu_D(Y_D - X_D - P_DQ_D) + \gamma_D(Q^*_F - Q_F) \quad (1)$$

where μ_D and γ_D are Lagrange multipliers. First-order conditions are:

$$\frac{\partial L_D}{\partial X_D} = \frac{\partial U_D}{\partial X_D} - \mu_D = 0 \quad (2)$$

$$\frac{\partial L_D}{\partial Q_D} = \frac{\partial U_D}{\partial Q_D} - \mu_D P_D = 0 \quad (3)$$

$$\frac{\partial L_D}{\partial Q_F} = \frac{\partial U_D}{\partial Q_F} - \gamma_D Q_F = 0 \, , \; \frac{\partial U_D}{\partial Q_F} \geq 0 \quad (4)$$

$$\frac{\partial L_D}{\partial \mu_D} = Y_D - X_D - P_DQ_D = 0 \, . \quad (5)$$

Condition (4) says that the domestic consumer will only accept calls from which he expects to gain positive marginal utility (free disposal of incoming calls). All other conditions are the same as in usual demand analysis for other goods.

Consumer F in the foreign country faces a problem similar to D's. Thus, we only have to replace subscript D by subscript F in Eqs. (1) through (5) to state F's problem and first-order conditions. This gives us a way to characterize Q^*_F. Simultaneous solution to D's and F's maximization problem gives a Nash equilibrium Q^*_D, Q^*_F :

$$Q^*_D = f(Y_D, P_D, Q^*_F) \text{ and } Q^*_F = g(Y_F, P_F, Q^*_D) .$$

Such an equilibrium will generally exist only if both consumers, D and F, are not saturated with respect to incoming calls. Otherwise, at least one consumer would be able to control the variable set by the other. We believe, however, that it is unlikely that incoming calls are rejected. We are interested in the comparative statics properties of this equilibrium, in particular dQ^*_D/dQ^*_F and the cross elasticities ϵ_{DF} and ϵ_{FD}.

Larson, Lehman, and Weisman (forthcoming) characterize $dQ^*_D/dQ^*_F < 0$ as the case of "information content" while they name $dQ^*_D/dQ^*_F > 0$ as the case of "reciprocity." "Information content" shall mean that what matters is the amount of information exchanged, and that is independent of who calls. "Reciprocity" shall mean that calls have value only if the other side has called back. Without this informational background let us ask how the sign of dQ^*_D/dQ^*_F is related to conventional economic notions of substitutability and complementarity. From the Larson, Lehman, and Weisman characterization it may appear that "information content" means substitutability while "reciprocity" means complementarity. This may be empirically correct, although it is not necessarily so in theory.

Consider perfect substitutes: From D's point of view outgoing and incoming calls would be perfect substitutes in the utility function if they could simply be exchanged without affecting utility. In other words, at all levels $\partial U_D/\partial Q_D = \partial U_D/\partial Q_F$.[5] Now, what happens to D's maximization problem if we increase Q_F by a small amount, dQ_F? First, D's total utility goes up by approximately $P_D dQ_F$ units because P_D is what D was willing to pay for the last unit of Q_D. Second, there is a substitution effect in favor of Q_F and against Q_D and X_D. The substitution effect is $dQ_D = -dQ_F$. Third, there is an income effect because the real income of the consumer has increased by $P_D dQ_F$ units. This income effect could be positive and theoretically may more than compensate for the negative substitution effect.

On the other hand, if outgoing and incoming calls are strict complements, we have $U_D(X_D, Q_D, Q_F) = U_D(X_D, \min\{Q_D, Q_F\})$. This introduces a nonconvexity in the indifference curve between Q_D and X_D. Now, assuming nonsaturation in telephone calls, an increase in Q_F will always lead to an increase in Q_D. The question is whether this holds for any degree of complementarity. The problem is that complemen-

[5]This characterization implies that they are also perfect substitutes in the sense of infinite cross elasticities. However, in our case incoming calls have a price of zero and are constrained in supply.

tarity is only easy to define with respect to cross elasticities but not with respect to utility functions. A hypothetical experiment would have to be run in which D would determine the quantity of incoming as well as outgoing calls and pay for both. Complementarity would, in this case, be defined by a negative cross elasticity ϵ_{DF}. In reality, however, D is only paying for her outgoing calls. An increase in P_F would via ϵ_{FF} lead to a decrease in Q_F. This would increase the shadow price of incoming calls for D, but probably by a lesser amount than the change in P_F that caused it. This change in shadow price will have a substitution effect and an income effect.

The substitution effect is the same per unit of price change as in our hypothetical experiment. However, the observed income effect is going to be much larger than the hypothetical one. Thus, negative cross elasticities in the hypothetical experiment easily translate into negative observed cross elasticities, while positive cross elasticities do not. Assuming that telephone calls are a normal good, negative observed cross-price elasticities are quite likely. Thus, $dQ^*_D/dQ^*_F < 0$ implies substitutes while $dQ^*_D/dQ^*_F > 0$ is compatible with complements as well as substitutes.[6]

Now, own-price elasticities are as follows: An increase in P_F will decrease Q_F. If $1 \geq dQ_D/dQ_F > 0$ and $1 \geq dQ_F/dQ_D > 0$, then the demand function $Q_D(P_D, Q_F)$ with adjustment of Q_F is going to be more elastic in P_D than the demand function $Q_D(p_D, Q^\circ_F)$ with fixed Q°_F. Also, outgoing and incoming calls will look like complements: $\epsilon_{DF} < 0$ and $\epsilon_{FD} < 0$. Similarly, if Q_D and Q_F are perfect substitutes in D's and F's utility functions, demand with adjustment of the other's quantity will be flatter than without such an adjustment. Furthermore, $dQ_F/dQ_D \geq 0$, $dQ_F/dQ_D \leq 0$, $dQ_D/dQ_F \geq 0$, and $dQ_D/dQ_F \leq 0$ are possible in this case; that is, cross elasticities may have either sign. Note that observed nonzero cross elasticities here come about without either of the consumers having the choice of initiating incoming calls.

We can confirm these relationships more easily for specific functional forms. In particular, let us assume log linear demand equations of the form:

$$\log Q_D = a_D + b_D \log P_D + c_D \log Q_F + d_D \log Y_D \qquad (6)$$

[6]This characterization also means that in theory "information content" as a label for $dQ^*_D/dQ^*_F < 0$ and "reciprocity" for $dQ^*_D/dQ^*_F > 0$ are misnomers. The statement that only information content matters is compatible with $dQ^*_D/dQ^*_F > 0$. Empirically, however, one may expect income effects to be small since international telephone costs make up a small fraction of people's budgets.

$$\log Q_F = a_F + b_F \log P_F + c_F \log Q_D + d_F \log Y_F \ . \qquad (7)$$

Eliminating the endogenous variables Q_F and Q_D on the right-hand side of these equations, we get the following elasticities:

$$\epsilon_{DD} = \frac{b_D}{1 - c_D c_F} \text{ and } \epsilon_{FF} = \frac{b_F}{1 - c_F c_D}$$

$$\epsilon_{DF} = \frac{c_D b_F}{1 - c_D c_F} \text{ and } \epsilon_{FD} = \frac{c_F b_D}{1 - c_F c_D} \ .$$

We can safely assume that c_D and c_F have the same sign and an absolute value smaller than one. Therefore, the own-price elasticities with call externalities tend to be larger than without such externalities. This is an application of the Le Châtelier principle, which accounts for the price elasticity of the demand for one good rising as more complements and substitutes are available. Cross-price elasticities will tend to be smaller in absolute value than the corresponding own-price elasticities; that is:

$$| \epsilon_{FF} | > | \epsilon_{DF} | \text{ and } | \epsilon_{DD} | > | \epsilon_{FD} | \ .$$

The problem described so far is very similar to a duopoly problem. As there, the Nash equilibrium in quantities is only one of the possible outcomes. D and/or F might also act as Stackelberg leaders or they could hold some (consistent) conjectural variations about each other's behavior. In this case $Q_F = Q_F(Q_D)$ would become part of D's optimization problem in Eq. (1).

ARBITRAGE WITHOUT INTERDEPENDENT UTILITY

In the approaches presented so far, nonzero cross elasticities between incoming and outgoing telephone demand could only occur with at least one nonvanishing cross term, $\partial U_D/\partial Q_F$ or $\partial U_F/\partial Q_D$, in the utility functions. However, in reality, cross elasticities could also become substantial if differences in international telephone rates invite arbitrage.

With perfect arbitrage and no interdependence between D's and F's utility, any such price difference would shift all calls to the country with the lower telephone tariffs. Under this scenario, cross elasticities ϵ_{DF} and ϵ_{FD} would have three distinct ranges:

Cross Elasticity	For: $P_F > P_D$	$P_F = P_D$	$P_F < P_D$
ϵ_{DF}	0	∞	ϵ_{DD}
ϵ_{FD}	ϵ_{FF}	$-\infty$	0

Here ϵ_{DD} and ϵ_{FF} are the hypothetical own-price elasticities of demand if arbitrage were impossible.

Perfect arbitrage is highly unlikely for international telephone calls. At least some transaction costs will have to be incurred in order to assure that the party with the lower tariff will initiate a call. Also, the party paying for the call will have to bill the other party. While determining bills and payments leads to fixed transaction costs, the costs of coordination are variable. And they usually involve telephone call time. The party that wants to be called, say F, has to make this wish known to the other side, D. The wish can, for instance, be communicated through a short "call me" call (Method I), or it can be stated at the end of the last call (Method II). In the following we assume that all rents from arbitrage are captured by F.[7]

Under Method I, transaction costs per call would be

$$T^I = Q_F^{min} E_F P_F + \underline{c}$$

where Q_F^{min} = time required to initiate a call from D,

$\underline{c}$ = fixed transaction cost per arbitraged call, and

E_F = exchange rate.

Introduction of the exchange rate is important here because the arbitrage gain is a financial one (not a utility gain). Thus, a change in the exchange rate has an effect on arbitrage opportunities. The telephone tariff P_F is assumed to be linear in time, and $P_F > P_D$. Now there is a critical length of call for F at which point she would transfer all longer calls to D and make all shorter calls herself. This length is

$$\hat{Q}_F = (Q_F^{min} E_F P_F + c)/(E_F P_F - P_D) \quad . \qquad (8)$$

[7]If rents are split on a 50/50 basis, the results would change little.

First derivatives of this critical value with respect to E_FP_F and P_D are

$$\partial\hat{Q}_F/\partial(E_FP_F) = (Q_F^{min} - \hat{Q}_F)/(E_FP_F - P_D) < 0 \tag{9}$$

and

$$\partial\hat{Q}_F/dP_D = \hat{Q}_F/(E_FP_F - P_D) > 0. \tag{10}$$

Method I then implies the following own-price and cross-price effects of price changes. Because of the arbitrage opportunity, a change in P_F will have smaller substitution and income effects than otherwise. Thus, except for the initiatory calls necessary to effect the arbitrage, F's total telephone activity (including transfers to D) will be hardly influenced by a change in P_F. As a consequence, the number of calls originating from F would hardly respond at all to a change in P_F or P_D as long as $E_FP_F > P_D$. F would continue to make shorter calls herself and transfer long calls to D. Each long call would be preceded by a very short call from F to D. Thus, the average duration of calls from F to D would be a declining function of P_F and an increasing function of P_D. At the same time D would pay for more calls as P_F increases and as P_D declines. The average duration of calls transferred to D decreases in P_F and increases in P_D.

The effect on the duration of all calls made by D is somewhat ambiguous. The reason is that this mixes in with the length distribution of calls originating from D. The most likely overall effect is that an increase in P_F will first increase the average length of call paid for by D. This is because the marginal call transferred from F is longer than the average call made by D. After some critical value of P_F, further increases of P_F will decrease the average length of call paid for by D because the marginal call transferred by F becomes shorter. An increase in P_D is likely to decrease the average length of call originating from D. This mixes in with an increase in the average length of call transferred from F. At values of P_D very close to E_FP_F and very far from E_FP_F, the first effect is certainly going to dominate, while at values of P_D closer to the middle of that range the second effect may be stronger. In this case, as P_D increases, the average length of call first decreases, then increases, and then decreases again.

Under Method II the transaction cost per call would be

$$T^{II} = Q^{min}P_D + \underline{c}$$

Here Q^{min} is the extension of call time necessary to set a date for the next call. If $Q^{min} = Q_F^{min}$, this method would be cheaper than Method I. Again there is a critical length of call for F at which point she would transfer all longer calls to D. This length is

$$\hat{Q}_F = (Q^{min}P_D + \underline{c})/(E_F P_F - P_D) \quad . \qquad (11)$$

The two relevant first derivatives are

$$\partial\hat{Q}_F/\partial P_F = -\hat{Q}_F/(E_F P_F - P_D) < 0 \qquad (12)$$

and

$$\partial\hat{Q}_F/dP_D = (\hat{Q}_F - Q^{min})/(E_F P_F - P_D) > 0 \quad . \qquad (13)$$

Under Method II, F would make substantially fewer calls to D. F would continue to make the short calls for which the cost of arbitrage exceeds the cost difference between F and D. Thus, both number and duration of calls paid by F would decrease in P_F and increase in P_D. The change in average length of call from F to D would be smaller than under Method I. The implications for D are quite similar to those in Method I with respect to number and average duration of calls, although Q^{min} is now added to the length of all calls transferred to D from F.

Figures 1 through 4 show that rate differences between calls originating and calls terminating in the United States for each of the specified countries except the United Kingdom have decreased considerably from 1979 to 1986. Hence incentives for arbitrage should have gone down. However, the available data show that our prediction for the average length of calls holds only for West Germany and France but not for Italy and the Netherlands.

For $P_D > E_F P_F$ all conclusions drawn for Methods I and II would stay the same with the roles of D and F exchanged. At $P_D = E_F P_F$ there would not necessarily be a discontinuity since the probability of very long calls is going to be very small.

There is a third method of arbitrage, and that is through implicit contract, in particular between business partners. Assume that $P_D < P_F$ and that D wants to sell and F wants to buy widgets that are traded over the telephone. D can initiate all or most of the calls provided F pays a higher price for the widgets. F, who is reselling the widgets, would still be better off than a competitor who makes his own purchasing calls. The effect of this kind of arbitrage on number and average duration of calls is going to be similar to that with Method II: It will reduce the number and truncate the length of calls from F to D.

JOINT UTILITY MAXIMIZATION

We have so far assumed that the two consumers maximize utility independently. In doing so they usually fare worse in the presence of the call externality (and arbitrage opportunities) than they could have. Now assume that they successfully try to maximize their joint utility (aggregate consumer surplus) subject to the joint budget constraint:

$$\max L_{D+F} = U_D(X_D, Q_D, Q_F) + U_F(X_F, Q_F, Q_D) \tag{14}$$

$$+ \mu_{D+F}[Y_D - X_D - P_DQ_D + E_F(Y_F - X_F - P_FQ_F)] \ .$$

First-order conditions are:

$$\frac{\partial L_{D+F}}{\partial Q_D} = \frac{\partial U_D}{\partial Q_D} + \frac{\partial U_F}{\partial Q_D} - \mu_{D+F}P_D \leq 0 \tag{15}$$

$$\frac{\partial L_{D+F}}{\partial Q_F} = \frac{\partial U_D}{\partial Q_F} + \frac{\partial U_F}{\partial Q_F} - \mu_{D+F}P_F \leq 0 \tag{16}$$

$$\frac{\partial L_{D+F}}{\partial \mu_{D+F}} = Y_D - X_D - P_DQ_D + E_D(Y_F - X_F - P_FQ_F) \leq 0 \ . \tag{17}$$

The optimum described by Eqs. (15) through (17) will usually differ from the result under independent maximization. In particular, conditions (15) and (16) clearly demonstrate the public-goods character of incoming calls. The question therefore arises of how the joint maximum can be reached.

Assuming that $P_D = E_FP_F$ and that D and F know each other's utility function, the two consumers could agree on a cost-sharing rule for outgoing calls made by either of them. The rule would share the price of each call in proportion to the marginal utility derived by each participant. D would maximize

$$L_D = U_D(X_D, Q_D, Q_F) + \mu_D[Y_D - X_D - \alpha P_DQ_D \tag{18}$$

$$- (1 - \beta) E_FP_FQ_F] + \gamma_D(Q^*_F - Q_F) \quad .$$

Here α and β are the sharing factors with $\alpha/(1 - \alpha) = (\partial U_D/\partial Q_D)/\partial U_F/\partial Q_D)$ and $\beta/(1 - \beta) = (\partial U_F/\partial Q_F)/(\partial U_D/\partial Q_F)$. Assume that these ratios are constant. Then the first-order condition to Eq. (18) with respect to Q_D yields Eq. (15). F would maximize in a similar way, yielding first-order condition (17). Clearly, the assumptions needed for this simple sharing rule to lead to an optimum are quite stringent.

However, setting $\alpha = \beta = 1/2$ may approximate the optimum fairly well. There is still the problem that one party may have to make net payments to the other, for example, because of differences between P_D and $E_F P_F$. Such net payments are unlikely to be made without some formal agreement on cost sharing. The transaction costs per pair of consumers could then be fairly high compared with the gain.

An alternative is related to the Larson, Lehman, and Weisman notion of reciprocity and best described by an example in a multiperiod framework. Assume that the willingness to pay for telephone calls between D and F, who are in regular contact, rises with the time since the last (incoming or outgoing) call. Then we can use the following self-policing device: In period one, D makes a call to F with the understanding that F will call D once the sum of D's and F's marginal utility from the call exceeds its price (rather than wait until F's marginal utility alone exceeds the price of the call), and vice versa for the following call. If F does not call at the agreed-upon time, then D will forever go back to independent calling at time intervals when D's own marginal utility from calling F exceeds the price. This can be seen as a supergame. Each player will play the repeated "cooperative" strategy as long as the discounted payoff exceeds the one-time gain from "cheating" plus the discounted payoff from independent maximization (single-period Nash) ever after.

Consider a numerical example for this phenomenon: Assume that in each period the individual willingness to pay is \$1.90 if the last telephone conversation was made during the last period and \$2.10 otherwise. The telephone tariff is \$2.00 in both directions. The payoff matrix for period one is:

	F call	No call
D call	.9/.9	−.1/1.9
No call	1.9/−.1	0/0

The top-left cell contains an expected payoff: If both want to call in the same period, there is a 50 percent chance that the other party will get through first.

In the second period we get the same payoff matrix for all period one outcomes in which a call was made. However, for the no-call situation in period one, we get the following payoff matrix for period two:

	F call	No call
D call	1.1/1.1	.1/2.1
No call	2.1/.1	0/0

Other payoff matrices are irrelevant for our example. Now assume that the two players play Nash every period. Then in the first period they will not call, in the second period they will both try to call, in the third period they will not call, in the fourth period they will both try to call, and so on. Assuming an infinite time horizon, we get a discounted stream of $V_D = V_F = 1.1(1 + r)/(2r + r^2)$, where r is the interest rate. Now if they "cooperate," they will each have a discounted surplus stream of $V_D = V_F = .9/r$. Collusion pays better than playing Nash all the time if r is less than 350 percent. Now assume that under collusion, D calls in period one but F cheats and does not call back in period two. Then by assumption both will play Nash from period three to infinity. The discounted payoff for D will then be $V_D = 1.1/(1 + r)(2r + r^2) - .1/(1 + r)$, which is smaller than playing Nash from the start. The payoff for the "cheater" F is $V_F = 1.1/(1 + r)(2r + r^2) + 1.9/(1 + r)$. It turns out that cheating only pays for F if the interest rate is above 72 percent.

Now, what is the likely effect of joint maximization on elasticities? Let us again use log linear demand equations of the form (6) and (7) and assume that joint maximization is achieved by independently calling and sharing the other's costs as done in Eq. (18). Then Eqs. (6) and (7) become:

$$\log Q_D = a_D + b_D(\log \alpha + \log P_D) + c_D \log Q_F \qquad (19)$$

$$+ d_D(\log (1 - \beta) P_F Q_F + \log Y_D)$$

$$\log Q_F = a_F + b_F(\log \beta + \log P_F) + c_F \log Q_D \qquad (20)$$

$$+ d_F(\log (1 - \alpha) P_D Q_D + \log Y_F) \quad .$$

It is clear that at zero-income elasticities ($d_D = d_F = 0$), joint maximization would have no effect on own- and cross-price elasticities of demand. Only the *level* of demand would be affected by joint maximization. However, with nonzero-income elasticities we get the following price elasticities:

$$\epsilon_{DD} = \frac{b_D + (c_D + d_D)\, d_F}{1 - (c_F + d_F)(c_D + d_D)} \;, \quad \epsilon_{FF} = \frac{b_F + (c_F + d_F)\, d_D}{1 - (c_F + d_F)(c_D + d_D)} \;,$$

$$\epsilon_{DF} = \frac{d_D + (c_D + d_D)\, b_F}{1 - (c_F + d_F)(c_D + d_D)} \;, \quad \epsilon_{FD} = \frac{d_F + (c_F + d_F)\, b_D}{1 - (c_F + d_F)(c_D + d_D)} \;.$$

We cannot restrict the size and sign of the income-related terms d_D and d_F. Therefore, these elasticities can differ almost arbitrarily from those under independent maximization in both sign and magnitude.

Certainly, if P_D is unequal to $E_F P_F$, then arbitrage also becomes important for joint maximization. This arbitrage may involve transaction costs similar to those incurred commercially and described by Methods I and II above. However, the fixed cost *c* may be smaller or missing. The basic conclusions therefore should carry over. One of these conclusions is that the cross elasticities under arbitrage are sensitive to the exchange rate, while the cross elasticities under independent maximization without arbitrage are sensitive to the domestic purchasing power of each currency.

INTERACTION OF EXTERNALITY AND ARBITRAGE

International telephone-demand elasticities are likely to be simultaneously influenced by call externalities and opportunities for arbitrage. The externality (or reciprocal calling) effect will depend on the quantity of calling by the other party, while the arbitrage effect will depend on the price difference between the two countries. Larson and Lehman (1986) describe the arbitrage effect with transaction costs in a much simpler way than do the stylized Methods I and II described above. Larson and Lehman do not differentiate by call length. Then $| P_D - P_F | > T$ implies that arbitrage is possible. Larson and Lehman assume that the fraction of arbitraged calls is a logistic function of $(P_D - P_F)$.

While the logistic function certainly has merits in this case, we believe that it can be linearized for most of its range. For practical reasons we also prefer to use the price ratio rather than the price difference to describe the arbitrage effect. In particular, in log linear demand equations, the price ratio can be expressed as the logarithmic difference between the two prices. Thus, we do not have to add an extra variable. Equations (6) and (7) now become:

$$\log Q_D = a_D + b_D \log P_D + c_D \log Q_F + d_D \log Y_D \quad (21)$$

$$+ e_D(\log P_D - \log P_F)$$

$$\log Q_F = a_F + b_F \log P_F + c_D \log Q_D + d_F \log Y_F \quad (22)$$

$$+ e_F(\log P_F - \log P_D) \quad .$$

Solving for the elasticities we get:

$$\epsilon_{DD} = \frac{b_D + e_D - c_D e_F}{1 - c_D c_F} \quad , \quad \epsilon_{FF} = \frac{b_F + e_F - c_F e_D}{1 - c_D c_F} \quad ,$$

$$\epsilon_{DF} = \frac{(b_F + e_F)c_D - e_D}{1 - c_D c_F} \quad , \quad \epsilon_{FD} = \frac{(b_D + e_D)c_F - e_F}{1 - c_D c_F} \quad .$$

Assuming that $|c_D| < 1, |c_F| < 1$, and that arbitrage effects are symmetric and negative ($e_D \simeq e_F < 0$), we find that arbitrage will make own-price elasticity of demand more elastic. At the same time arbitrage will make otherwise negative cross elasticities less elastic or even positive and make positive cross elasticities more elastic.

We now want to include the possible effects of inflation and exchange rates. Equations (21) and (22) will have to include exchange rates E_F to account for the fact that arbitrage opportunities depend on financial gains. They will have to include the foreign price at purchasing-power parity P_P to express real prices in the country's currency. And they will have to include GDP (gross domestic product) deflators D_D and D_F to account for inflation. Then Eqs. (21) and (22) become:

$$\log Q_D = a_D + b_D \log P_D D_D + c_D \log Q_F + d_D \log Y_D D_D \quad (23)$$

$$+ e_D(\log P_D D_D - \log E_F P_F)$$

$$\log Q_F = a_F + b_F \log P_F P_P D_F + c_F \log Q_D + d_F \log Y_F D_F \quad (24)$$

$$+ e_F(\log E_F P_F D_F - \log P_D) \quad .$$

It is clear now that we could use D_D, D_F, E_D, E_F, and P_P as separate variables along with nominal prices. For example, Eq. (23) would then become:

$$\log Q_D = \frac{1}{1 - c_D c_F} [a_D + c_D a_F + (b_D + e_D - c_D e_F) \log P_D \quad (25)$$

$$+ (b_D + d_D + e_D) \log D_D + (c_D b_F + c_D e_F - e_D) \log P_F$$

$$+ (e_D e_F - e_D) \log E_F + (c_D(b_F + d_F + e_F)) \log D_F$$

$$+ c_D b_F \log P_P + d_D \log Y_D + c_D d_F \log Y_F] \quad .$$

This equation indicates some clear restrictions on the relative size of coefficients for deflators, exchange rates, and the purchasing-power parity that could be used for empirical testing.

To sum, in terms of own-price elasticities we expect that arbitrage alone should result in positive cross elasticities. Combining arbitrage and interdependent utility may give us positive cross elasticities due to both positive arbitrage effects and positive interdependence effects or due to stronger positive arbitrage effects than negative interdependence effects. Negative cross elasticities could occur only as the result of strong negative interdependence effects that outweigh the positive arbitrage effects.

POLICY CONSEQUENCES

In this section we have characterized different configurations for international telephone demand, each for a pair of telephone consumers. We consider all of these configurations to be realistic and to occur side by side. For policy considerations and empirical estimation it therefore matters how the different effects sum up in the aggregate. We expect arbitrage to play a major role in determining the length of calls. Since arbitrage opportunities depend on financial gains, their effects could be tested by looking at cross elasticities with prices converted at current exchange rates. Interdependence effects of call externalities depend on the quantity of incoming calls; this quantity in turn depends on the real price in the country of the caller. These interdependence effects could therefore best be measured by looking at cross elasticities with prices expressed in local deflated currencies.

OTHER SERVICES

Other telecommunications services such as telex and telegraph may be either substitutes or complements to voice calls. In some circumstances they may represent an obvious substitute: Consider, for example, placing a hotel reservation abroad, especially if the time difference is substantial or if the other party may not speak the caller's language. In other circumstances, the telex may represent a complementary good: For example, a common business practice is to request that an order for manufactured goods be confirmed by telex after an agreement is reached by telephone.

IV. MODELING, ESTIMATION, AND DATA CONSIDERATIONS

MODELING

We are estimating demand for telephone calls across the North Atlantic market. It is reasonable to ask if supply is exogenously determined, or if our estimates reflect a simultaneous determination of supply and demand.[1] In the present case, we believe that supply can legitimately be considered exogenously determined. Prices for international calls are set in advance of the call being placed, and they remain in effect for a period of time—typically a year or longer. During that period, supply is rarely constrained; for practical purposes, the consumer faces an infinite supply of international calling capacity at the posted price. (It is possible in principle that local access to international capacity will be congested and that international calls will not be completed; with the exception of major holidays, we suspect that this is relatively uncommon for the bulk of traffic across the North Atlantic, although it may be more significant for calls placed to and from less-developed countries.) Earlier studies of demand may include data from the early 1970s when some capacity constraints existed in international supply. By the late 1970s, aggregate capacity of cable and satellite exceeded the annual maximum traffic demand by a substantial factor, and it now exceeds demand by a factor of two (see Johnson, 1986).

The other possible source of simultaneity between demand and supply is introduced by the declining block pricing structure faced by U.S. customers and those in some other countries. Under those structures, some of the observed variation in quantity will be correlated negatively with price.[2] We feel that this problem is not significant in our case for two reasons. First, for our analysis we use the marginal price faced by customers who consume in the tail block of the rate structure. This means that there is no artificial negative correlation between quantity and the average price (which necessarily falls as quantity increases under a declining block structure). Second, empirically, the average length of calls is over eight minutes, which is substantially beyond the

[1]Working (1927) introduced the concern that simultaneous movements of supply and demand curves may present the empiricist with price-quantity combinations that do not uniquely reflect either supply or demand.

[2]See Acton, Mitchell, and Sohlberg (1980) or Halvorsen (1978) for discussions of demand modeling in the face of declining block pricing structures for electricity.

one- or three-minute period for inframarginal blocks of the rate structure. Consequently, the marginal price faced in the "average" call is that of the tail block.

When a declining block pricing structure applies (including two-part rates broken into an "entry" charge and a single marginal price per unit consumed), the extra costs associated with the inframarginal block of the rate structure should act as an income effect to the customer.[3] That is, if MP1 represents the marginal price in the first block and MP2 represents the marginal price in the second block, then consumers whose consumption takes them to the second block pay an "entry" charge equal to MP1 minus MP2 times the number of minutes to which the first block applies.

CHOOSING SHARE OR QUANTITY AS THE DEPENDENT VARIABLE

Above, we developed predictions for the share of outbound calls as well as predictions for the quantity of calls inbound and outbound. There is no theoretical reason to prefer one dependent variable over the other; the choice probably depends on (1) the policy questions one considers most important and on (2) one's view of the world.

Policy Considerations

If the analyst is most concerned with the distribution of effects between inbound calls and outbound calls and the manner in which pricing policies may affect that balance, then share equations are satisfactory. If, on the other hand, the analyst is primarily interested in the magnitude of the effects, and not just their distribution, then quantity is the preferred dependent variable. Quantity equations permit direct predictions of such effects as those on welfare and on balance of payments, which are important for the evaluation of many policy alternatives. In areas of policy, we prefer quantity as the dependent variable.

Views of the World

The alternative views of the world that may influence one's choice of dependent variable can be summarized as follows. (a) Volume of calls is determined by factors other than price; relative prices between inbound and outbound calls only influence the balance between inbound and outbound traffic. This view favors share equations. (b)

[3]See Taylor (1975), Halvorsen (1978), or Acton, Mitchell, and Sohlberg (1980).

Prices have an effect on (i) the quantity of calls, (ii) the choice of calls versus other forms of communication, and (iii) the direction of calling (inbound or outbound). This view favors equations with quantity as the dependent variable.

We favor a specification with quantity as the dependent variable both for policy reasons and because we think it captures more realistically the dimensions of calling; consequently, most of our discussion focuses on quantity regressions. However, we summarize the effects of share equations as well in the discussion below.

THE DATA

We examine telephone traffic between the United States and 17 West European countries over the period 1979–1986. Our consumption data are taken from the annual reports of international telecommunications use of the Federal Communications Commission (FCC). This information presents total number of calls and minutes for traffic between the United States and foreign countries.[4] We use minutes of calling as the dependent variable. The data are available in greater aggregation than we would prefer: They are annual, they include all customer groups, and they are not distinguished by the rating period during which the call was placed. In future work it would be desirable to disaggregate along each of these dimensions.

The price variable used in our analysis is the marginal price faced by customers in the tail block of the standard daytime rate schedule; this marginal price applies to the majority of calls that take place. It is deflated by the GDP deflator for each country and then converted to U.S. dollars using the exchange rate.[5]

Other explanatory variables try to capture the major factors that may determine volume of calling between countries or the balance of inbound and outbound traffic. Given the relatively limited number of observations, we have selected a small set of variables. The volume of trade between the United States and each of the 17 countries is entered as an explanatory variable.[6] This is deflated by the U.S. GDP deflator. To account for possible differences among countries in the composition of trade-related communication with the United States, we enter a second explanatory variable that indicates the share of employment in

[4]See Federal Communications Commission, various years. It also reports telegraph and telex use, but we confine our attention to international measured voice traffic.

[5]International Monetary Fund, *International Financial Statistics.*

[6]International Monetary Fund, *Direction of Trade Statistics, Yearbook 1987.*

each country in five major economic activities.[7] We expect, for example, that countries with a higher fraction of their labor force in manufacturing may be more likely to have trade-related communications with the United States than do countries with a higher fraction of their employment in, say, transportation.

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[7]The activities are (1) agriculture, (2) restaurants and hotels, (3) transportation, (4) banking and financial, and (5) manufacturing.

V. EMPIRICAL RESULTS

We estimate the demand for international telephone calls using pooled time-series cross-sectional data. Given the aggregated nature of the annual data, the limited number of observations, and the general—rather than specific—guidance provided by economic theory in this case, we approach the estimation in the spirit of exploratory data analysis rather than in the spirit of rigorous testing of a theoretically derived set of hypotheses. We focus our attention on the effects of call prices, telex prices, and some economic and demographic information. The primary emphasis is on quantity of minutes as the dependent variable, although we also provide a comparison with share of calls originating in the United States as the dependent variable.

There are a number of considerations in this exploratory analysis, including whether to weight the observations, whether to correct for autocorrelation in the data, whether to separate price effects by time, and whether to include country-specific dummy variables. The results are based on regression where the variables are weighted by the share of U.S. telephone traffic going to the country involved. This may help deal with heteroscedasticity in the data, and it means that the coefficients should be interpreted as the effects (caused by changing a variable applied to all countries) on total minutes called.[1] We could not reject the hypothesis of no autocorrelation in the error term, and therefore made a first-order autocorrelation correction in the data.[2] Finally, we included country-specific dummy variables because an examination of the residuals indicated that when those variables are omitted the mean residual by country is not zero.

PRINCIPAL EFFECTS IN THE QUANTITY REGRESSIONS

The general form of the equations is as follows:

[1]In our preliminary analysis, we also estimated each specification using unweighted regressions. In fact, once outliers were excluded, most coefficients were little changed between weighted and nonweighted regressions in the core specifications, and the level of statistical significance sometimes improved with weighting.

[2]The price estimates did not actually appear to be very sensitive to these corrections, but econometric theory leads us to prefer models with correction for autocorrelation because otherwise the estimates of statistical significance will be biased.

$$\ln Q = a + \Sigma\, b_j \ln P_j + c \ln \text{Trade} + d \ln \text{Num Telephones} \qquad (26)$$

$$+ \Sigma\, e_i\, \text{Sector}_i + \Sigma\, f_i\, \text{Country}_i$$

where Q indicates minutes of calls from (to) the United States to (from) each of the 17 West European countries, P_j indicates the price of four telecommunications services (for the marginal price of telephone calls originating and terminating in the United States and the average price of a telex minute originating and terminating in the United States), *Trade* is the sum of exports and imports between the United States and each country (in real terms, converted to U.S. dollars), *Num Telephones* is the number of telephones in the European country, *$Sector_i$* indicates the fraction of the labor force employed in each of five major economic sectors in the European country, and *$Country_i$* is a dummy variable for each of the 17 countries (the omitted country variable is the United Kingdom).

Price Effects

Prices are all stated in real terms, using the country's GDP deflator. However, we still have a choice between converting prices to U.S. dollars or leaving them in the country's currency. We base our principal discussion on prices expressed in U.S. dollars. However, we also report the effect of leaving prices in the country's currency. Likewise, our initial focus is on a single marginal price for the marginal minute of calling. Later we report the effect of including the inframarginal charges in a specification using average price instead.

Table 3 reports the estimated price coefficients for outbound and inbound telephone traffic between the United States and the 17 countries. The first four sets of coefficients report the effect of marginal price. We saw some evidence of differences between price response in our exploratory analysis of earlier and later years and between report coefficients for two subperiods.[3] Since they were estimated in a double-logarithmic specification, these coefficients are the price elasticities of demand in this specification. The own-price elasticity gives the percentage change in minutes of calling *from* the United States as a function of the percentage change in price of calls *originating* in the United States (and works similarly for calls *terminating* in the United States and price of calls *to* the United States). The cross-price elasticity gives the percentage change in minutes of calling for calls *from* the United States as a function of the percentage change in price of calls *to*

[3]After empirically discovering this apparent shift in demand, we also learned that international direct distance dialing was generally made available in the early 1980s—providing a possible explanation for the shift.

Table 3

ESTIMATED COEFFICIENTS WHEN MARGINAL PRICE IS USED AS AN EXPLANATORY VARIABLE

Category	Originating in the U.S.	Terminating in the U.S.
Marginal price effects (ln)		
Telephone price from U.S.		
1979–1982	−0.14	0.41
	(−1.00)	(1.33)
1983–1986	−0.98	−0.62
	(−8.75)	(−2.54)
Telephone price to U.S.		
1979–1982	−0.10	−0.51
	(−2.28)	(−5.19)
1983–1986	−0.07	−0.31
	(−1.78)	(−3.82)
Telex price from U.S.	−0.82	−0.51
	(−6.06)	(−1.60)
Telex price to U.S.	0.43	−0.25
	(4.06)	(−1.02)
Other variable effects		
ln International trade volume	−0.16	0.26
	(−1.74)	(1.39)
ln Number of European telephones	1.76	0.77
	(14.37)	(2.78)
Size of economic sector		
Agriculture	1.04	0.85
	(4.51)	(1.86)
Restaurants and hotels	1.56	3.37
	(3.20)	(3.32)
Transportation	−0.74	0.75
	(−2.33)	(1.10)
Banking and financial	0.35	1.01
	(1.90)	(2.34)
Manufacturing	0.37	2.90
	(0.95)	(3.29)
Intercept	0.11	−0.15
	(1.68)	(−1.03)
R^2	0.999	0.999

NOTES: Values of country-specific dummy variables and autocorrelation correction are reported in the appendix. T ratio is in parentheses.

the United States (and works similarly for calls *terminating* in the United States and price of calls *from* the United States).

Generally, own-price coefficients are statistically different from zero, while cross-price coefficients are negative and not all statistically different from zero. When significantly different from zero, demand is generally more price elastic for calls originating in the United States, and it is inelastic for calls terminating in the United States. As we discussed in Sec. III, a statistically significant, negative cross-price elasticity is consistent with the "externalities" interpretation of complementarity in calling. It is not consistent with an arbitrage motivation as the dominant effect. Coefficients that are not statistically different from zero could be consistent with either motivation. On balance, the cross-price effects seem most consistent with the externalities interpretation.

The own-price elasticity for calls originating in the United States is statistically insignificant in the earlier period (1979 to 1982) and highly significant in the second period at approximately −1.0. The value −1.0 is large for most economic goods, but it lies within the range of values reported by some earlier reseachers.[4] The statistically insignificant result in the earlier period may reflect the relatively greater importance of the block pricing structure before 1982—where the initial rating period was longer and notably greater than the second block. The results discussed in the next subsection explore a richer price specification. The insignificance may also reflect data aggregation across rating periods; further disaggregation into periods and into classes of customers would help determine more precisely the effects of the prices.

The effect of U.S. telex charges is negative and significant for telephone minutes from the United States. The effect of foreign telex charges is statistically insignificant for inbound telephone traffic. The complementary nature of telex to telephone calls for calls originating in the United States is consistent with the business practice of requesting a confirmation or elaboration of telephone conversations.[5]

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[4]Taylor (1980), p. 149, reports a price elasticity of −0.38 for minutes from the United States to the United Kingdom, and a short-run elasticity of messages with respect to price ranging between −0.23 and −0.89. He reports long-run elasticities of messages between −0.52 and −3.65. Tests of statistical significance are not reported. Many such studies are based on Canadian data. However, Rea and Lage (1978) report own-price elasticities of −1.78 using data from 1969 to 1973, and Lago (1970) reports elasticities ranging from −1.249 to −1.689 using data from 1962 to 1963.

[5]Two earlier studies include telex prices in an international telephone demand equation; one, Rea and Lage (1978), reports a positive effect of 0.78; the other, Yatrakis (1972), reports negative values between −0.42 and −0.49.

Other Variables

Table 3 also shows the effects of the other economic and demographic variables entered into the principal specification. Volume of international trade with the United States has a statistically insignificant effect on telephone calls. The number of telephones is statistically very significant and provides a more than proportional increase in volume. International calling is increased with increases in the economic sectors of agriculture, restaurants and hotels, banking and financial, and manufacturing. It is decreased by a greater fraction of the employment involved in transportation for calls originating in the United States.

In earlier analysis, we examined the effect of the level of economic activity (GDP) and population size in a specification that did not include the number of telephones. Both variables had positive, generally significant effects on minutes of calling. However, when the number of telephones was included as an explanatory variable, the coefficients on GDP and population became erratic and almost always statistically insignificant. We selected the specifications reported here because of the stability in the coefficients, and we offer the interpretation that income is acting through the number of telephones to influence the level of calling.

We do not report the values of the country-specific dummy variables in this table, but the results are available in the appendix. Recall that the omitted country variable is for the United Kingdom. Relative to that value, 11 of the 16 variables are different at a statistically significant level—with eight of these values being positive.[6]

EFFECTS OF THE INFRAMARGINAL CHARGE

Under a declining block pricing structure, the added payment above the tail-block marginal price—multiplied by the number of minutes in the block—acts as an entry charge for consumption in the tail block. This entry charge should have an effect on consumption similar to the income effect—although opposite in sign. Given the relatively small share that telecommunications constitutes in most budgets, this effect should be small for consumers who regularly make international telephone calls, although it may be more important for those considering whether to call at all.

[6]Belgium, Greece, Ireland, Luxembourg, the Netherlands, Norway, Portugal, and Switzerland have statistically significant positive coefficients in this specification. France, Italy, and Spain have statistically significant negative coefficients.

Table 4 shows the effect of a quantity specification in which both the marginal price and the inframarginal charge in the U.S. rates are entered as explanatory variables.[7] This specification sheds some light on the own-price coefficient reported in Table 3. In the first time period (1979 to 1982), the step between the first and second blocks of the rate structure is larger than in later years, and it applies to three minutes rather than one minute. In Table 4, the coefficient of the marginal price for calls originating in the United States is statistically insignificant, but the inframarginal price coefficient is statistically significant and negative. This is consistent with the interpretation that the overall price of the call affects demand and that the inframarginal charge is an important component.

In the second period of time, both the inframarginal and marginal price components are statistically significant, with the inframarginal component having the wrong (positive) sign. However, elasticity with respect to the marginal component is larger in magnitude and very similar to the value reported in Table 3 for the marginal-price-only specification. The remaining coefficients in this equation are very similar to those in Table 3, with the exception of the telex price to the United States and the trade variable—both of which become statistically insignificant.[8] These findings are still consistent with an externalities interpretation of the price effects of telephone rates, as well as the complementary relationship between telephone and telex usage for calls originating in the United States. Introducing these two components of the U.S. telephone tariff has little effect on the coefficients in the equations describing calls terminating in the United States.

EFFECTS OF USING AVERAGE PRICE

It is theoretically correct to use elements of the rate schedule—the marginal price, inframarginal charges, and so forth—when estimating demand by individuals or groups of individuals facing identical pricing schedules. In the present circumstances, however, the annual data include business and residential users facing peak, shoulder, and off-peak rates when calling from the United States, and foreign callers sometimes facing multiple schedules. As a result, some of the calls are billed at lower rates than the marginal price of peak-period calls used

[7]We do not enter such variables for calls terminating in the United States because most European schedules charge identical amounts per period of time without a declining price feature.

[8]The coefficients on the country-specific dummy variables are virtually identical, although West Germany becomes negative and significant and the Netherlands becomes statistically insignificantly different from zero.

Table 4

ESTIMATED COEFFICIENTS WHEN INFRAMARGINAL PRICE IS USED AS AN EXPLANATORY VARIABLE

Category	Originating in the U.S.	Terminating in the U.S.
Marginal and inframarginal price effects		
Marginal telephone price from U.S.		
1979–1982	0.02	0.47
	(0.12)	(1.03)
1983–1986	−0.91	−0.65
	(−7.97)	(−2.37)
Inframarginal telephone price from U.S.		
1979–1982	−0.09	−0.01
	(−2.41)	(−0.11)
1983–1986	0.21	0.09
	(4.54)	(0.82)
Telephone price to U.S.		
1979–1982	0.08	−0.44
	(1.41)	(−3.37)
1983–1986	−0.01	−0.27
	(−0.15)	(−2.68)
Telex price from U.S.	−0.56	−0.47
	(−3.78)	(−1.32)
Telex price to U.S.	−0.26	−0.42
	(−1.09)	(−0.76)
Other variable effects		
ln International trade volume	0.08	0.29
	(0.90)	(1.48)
ln Number of European telephones	1.53	0.67
	(12.27)	(2.29)
Size of economic sector		
Agriculture	0.63	0.83
	(2.54)	(1.58)
Restaurants and hotels	0.97	3.45
	(2.01)	(3.24)
Transportation	−0.37	1.04
	(−1.16)	(1.43)
Banking and financial	0.41	1.00
	(2.28)	(2.23)
Manufacturing	1.03	3.07
	(2.55)	(3.18)
Intercept	0.06	−0.07
	(0.85)	(−0.47)
R^2	0.999	0.999

NOTES: Includes country-specific dummy variables. T ratio is in parentheses.

in the previous analysis, and some callers pay more when paying rates for operator-assisted calls. In principle, we may wish to consider average price as a better overall representation of these different prices. We can calculate the average price paid by all calls taken together by dividing the annual billing by the number of minutes billed.[9] Table 5 presents the results of this analysis.

In general, the price coefficients have a similar, or slightly improved, pattern of statistical significance. In addition, where the corresponding coefficients are statistically significant in both specifications, elasticity values are very similar. The price effect on own-price elasticity for calls originating in the United States—the coefficient that was most perplexing in Table 3—is closer to being statistically significantly different from zero at conventional levels of significance, and it is of the expected negative sign. The remaining effects—with respect to telex charges, numbers of telephones, and the like—are very similar to those in the preceding tables. These findings are still consistent with the externalities motivation for calling discussed in Sec. III but not with the arbitrage interpretation. Telex price effects are essentially unchanged when the average telephone price is used.

EFFECTS OF STATING PRICES IN EACH COUNTRY'S CURRENCY

The results just discussed are based on specifications in which the prices are converted to U.S. dollars (after deflating them by the country's GDP deflator). This specification seems especially appropriate when arbitrage is important, but it causes the prices to fluctuate with changes in the exchange rate. If instead, the party placing the call is primarily concerned with the effect on his own bill—that is, the call is either a private good or a good not motivated by arbitrage concerns—then the price should be stated in the currency of the caller.[10]

In Table 6, we report the results of such analysis. Telephone prices are deflated by the country's GDP deflator. To make the currency units comparable to one another, and comparable to the previously

[9]In the FCC traffic data, this variable consists of "Revenue" (retained by the U.S. carrier) plus "Payouts" (the amount paid to foreign carriers under the settlements agreements, divided by the number of minutes). This average is an approximation because it does not include state and federal taxes paid by customers. Furthermore, the amount of total billing to foreign customers is based on estimates provided by ATT in its annual filing with the FCC, Report 41.63, Schedule MT. We are indebted to Ken Stanley of the FCC for assistance in obtaining this information.

[10]Stating the price this way may also be more appropriate when the party is concerned with the externalities generated by the quantity of calls.

Table 5

ESTIMATED COEFFICIENTS WHEN AVERAGE PRICE IS USED AS AN EXPLANATORY VARIABLE

Category	Originating in the U.S.	Terminating in the U.S.
Average price effects		
ln Average telephone price from U.S.		
1979–1982	−0.15	0.02
	(−1.64)	(0.11)
1983–1986	−0.86	−0.53
	(−10.16)	(−2.47)
ln Average telephone price to U.S.		
1979–1982	−0.19	−0.45
	(−3.13)	(−3.04)
1983–1986	−0.09	−0.26
	(−1.82)	(−2.21)
ln Telex price from U.S.	−0.58	0.09
	(−4.80)	(0.27)
ln Telex price to U.S.	0.31	−0.35
	(3.41)	(−1.57)
Other variable effects		
ln International trade volume	−0.09	0.49
	(−1.22)	(2.43)
ln Number of European telephones	1.61	0.91
	(14.90)	(3.45)
Size of economic sector		
Agriculture	1.05	0.61
	(4.61)	(1.21)
Restaurants and hotels	1.91	2.40
	(4.36)	(2.44)
Transportation	−0.11	0.19
	(−0.38)	(0.27)
Banking and financial	0.40	0.79
	(2.41)	(1.93)
Manufacturing	0.26	0.73
	(0.76)	(0.82)
Intercept	0.02	−0.12
	(0.60)	(−0.01)
R^2	0.999	0.999

NOTES: Includes country-specific dummy variables. T ratio is in parentheses.

Table 6

ESTIMATED COEFFICIENTS WHEN TELEPHONE PRICES ARE STATED IN COUNTRY'S CURRENCY

Category	Originating in the U.S.	Terminating in the U.S.
Marginal price effects (ln)		
Telephone price from U.S.		
1979–1982	−0.13	0.22
	(−1.05)	(0.79)
1983–1986	−1.00	−0.35
	(−8.43)	(−1.39)
Telephone price to U.S.		
1979–1982	−0.07	−0.54
	(−1.43)	(−4.85)
1983–1986	−0.01	−0.49
	(−0.21)	(−4.99)
Telex price from U.S.	−0.73	−0.73
	(−5.29)	(−2.40)
Telex price to U.S.	0.30	−0.07
	(2.70)	(−0.27)
Other variable effects		
ln International trade volume	−0.14	−0.08
	(−1.44)	(−0.44)
ln Number of European telephones	1.77	1.15
	(13.51)	(4.18)
Size of economic sector		
Agriculture	0.92	0.40
	(3.84)	(0.85)
Restaurants and hotels	1.50	3.88
	(3.08)	(3.70)
Transportation	−0.53	0.23
	(−1.61)	(0.34)
Banking and financial	0.36	0.89
	(2.10)	(2.07)
Manufacturing	0.27	2.96
	(0.68)	(3.21)
Intercept	−0.00	−0.05
	(−0.06)	(−0.42)
R^2	0.999	0.999

NOTES: Values of country-specific dummy variables and autocorrelation correction are reported in the appendix. T ratio is in parentheses.

reported coefficients, we make a one-time conversion using the purchasing-power parity adjustment estimated by Summers and Heston (1984). We use parities estimated for the year 1979, the first year in our series for this adjustment.

Because this change in price variable affects non-U.S. callers, we expect the biggest effect on calls terminating in the United States. Own-price elasticities for calls terminating in the United States become somewhat more elastic and statistically significant when compared with the results reported in Tables 3 and 5. Own-price elasticity is nearly the same in the earlier period (−0.54, compared with −0.45 to −0.51), and it becomes more elastic from 1983 to 1986 (increasing from approximately −0.30 to −0.49 in Table 6). The cross-price effects for calls originating and terminating in the United States become statistically insignificant in Table 6, whereas the majority of these effects were significant and negative in Tables 3 and 5. Statistical insignificance of these cross-price effects is consistent with an arbitrage motivation for initiating the call.

RESULTS FROM ESTIMATING SHARE EQUATIONS

As we discussed above, we prefer specifications in which the dependent variable is quantity, because we think it better reflects reality and because it is more useful for policy analysis. In Table 7, we report estimates in which the dependent variable is the share of calls originating in the United States for each pairing of the United States with the 17 West European countries. In this analysis we test the effects of using both marginal price per minute and average revenue per minute. The remaining variables are similar in character to those previously employed, but because shares are constrained to lie between zero and one, we normalize these remaining explanatory variables so that the value in 1979 equals 1.0. Because of this rescaling, it is appropriate to compare only patterns of statistical significance with previous estimates.

The share equation using the marginal price produces more consistently statistically significant effects, although the price effects and most other coefficients have a similar pattern in the equation using average price. Concentrating on marginal price, we find that higher prices for calls from the United States reduce the share of calls originating in the United States, and higher prices in other countries increase the share originating in the United States. Telex prices continue to display a pattern consistent with the complementary nature of the service, and a greater number of telephones in a European country increases the share of calls from the United States—suggesting that the greater the number of locations to which the United States can call, the more calls it will place.

Table 7

SHARE EQUATIONS, USING EITHER MARGINAL OR AVERAGE PRICE

Category	Using Marginal Telephone Price	Using Average Telephone Price
Marginal price effects		
Telephone price from U.S.		
1979–1982	−0.21	−0.04
	(−3.01)	(−0.69)
1983–1986	−0.06	−0.07
	(−1.01)	(−1.37)
Telephone price to U.S.		
1979–1982	0.11	0.05
	(5.05)	(1.14)
1983–1986	0.06	0.03
	(3.29)	(1.20)
ln Telex price from U.S.	−0.09	−0.11
	(−1.15)	(−1.44)
ln Telex price to U.S.	0.18	0.12
	(3.20)	(2.24)
Other variable effects		
ln International trade volume	−0.03	−0.08
	(−0.91)	(−1.86)
ln Number of European telephones	0.17	0.12
	(3.70)	(2.62)
Size of economic sector		
Agriculture	0.04	−0.02
	(0.41)	(−0.16)
Restaurants and hotels	−0.32	−0.26
	(−1.44)	(−1.06)
Transportation	−0.33	−0.05
	(−2.27)	(−0.32)
Banking and financial	−0.12	−0.10
	(−1.37)	(−1.06)
Manufacturing	−0.50	−0.27
	(−2.63)	(−1.37)
Intercept	0.06	0.06
	(1.90)	(1.59)
R^2	0.979	0.960

NOTE: Includes country-specific dummy variables. T ratio is in parentheses.

VI. CONCLUSIONS

The data used in this preliminary analysis—while more highly aggregated than we would prefer—suggest some interesting implications for international telephone demand and for associated policy discussions. Below we recapitulate some of our most important findings and sketch the types of policy discussions for which they may be useful. Recall that these results are based on annual data aggregated over business and residential customers and over different rating periods; the results are subject to revision when disaggregated data can be used.

PRINCIPAL EMPIRICAL RESULTS

The specifications that use quantity of calls—measured in minutes—are more satisfactory on statistical grounds than those using share as the dependent variable.

- The demand for calls originating in the United States is almost unitarily elastic with respect to its own price in the period 1983 to 1986, and it is statistically significant. It is generally insignificantly different from zero in the period 1979 to 1982.
- The demand for calls terminating in the United States is inelastic and generally statistically significant.
- Cross-price effects are generally negative but generally not statistically significantly different from zero.

This pattern of own- and cross-price elasticities, when the cross-price elasticities are statistically significant and negative, suggests that telephone calling may contain important elements of complementarity that are consistent with a reciprocal calling motivation. When the cross-price elasticities are not statistically significant, they are consistent with a combination of reciprocal and arbitrage motivations.

The remaining explanatory variables have apparently reasonable effects.

- Telex prices are generally negative, indicating a complementary relationship with telephone calls.
- Increase in number of telephones strongly increases volume of calling, and increase in volume of trade generally increases volume of calling.

- Countries with a greater fraction of employment in sectors that may involve international coordination—agriculture, restaurants and hotels, banking and financial, and manufacturing, but not transportation—have above-average levels of calling.

POLICY RELEVANCE OF THE FINDINGS

Reliable estimates of demand for international calling can be useful in a number of policy applications. They can help to anticipate the nature of traffic growth and probable shifts as prices change. They can be used to examine the efficiency and distributional implications of a variety of pricing reforms—including alternative methods for recovering fixed costs of capital investments. They can be used to identify optimal (welfare-increasing) pricing changes that explicitly take into account the price elasticity of demand of the affected parties.

Reliable demand estimates are also useful for understanding some pricing policies that international telephone carriers have had in place for some time. For example, ATT has for several years employed off-peak discounts in its international telephone rates from the United States to European countries. The accounting settlements between ATT and the foreign carrier do not generally contain a time-of-day feature so that, at some times, the off-peak rate for calling from the United States is lower than the accounting rate that ATT pays the carrier in the country of termination. This policy, on its face, would seem irrational, since at those times each call would generate revenue at the margin that is less than the marginal (out-of-pocket) cost of the call.

However, it is possible that lowering off-peak rates, even below accounting rates, actually increases profits because of the offsetting increase in inbound calling. In the empirical estimates, we found that the price of calls originating in the United States generally has the dominant influence on volume of calls both originating and terminating in the United States. Furthermore, in the period since 1982, the effect of U.S. telephone rates on inbound calls is negative—that is, lowering the price of U.S. calls increases the volume of inbound traffic. Depending on the elasticities within these pricing subperiods and the size of the price change, these off-peak rates below accounting costs may actually increase profits to U.S. carriers and welfare to European callers.

Appendix

ADDITIONAL COEFFICIENTS

Table A.1

VALUES FOR COUNTRY-SPECIFIC DUMMY VARIABLES AND AUTOCORRELATION CORRECTIONS FOR TABLE 3

	Originating in the U.S.		Terminating in the U.S.	
Country	Dummy Variable	Autocorrelation Correction (Rho)	Dummy Variable	Autocorrelation Correction (Rho)
Austria	0.27 (0.83)	0.75	−1.37 (−2.44)	0.23
Belgium	1.13 (6.33)	0.26	−0.24 (−0.63)	0.18
Denmark	0.36 (1.66)	0.56	−0.67 (−1.48)	0.59
Finland	−0.26 (−0.73)	0.74	−1.17 (−1.98)	0.58
France	−0.91 (−13.83)	−0.02	−0.90 (−6.28)	0.00
Greece	1.41 (5.56)	−0.26	0.37 (0.70)	0.43
Ireland	3.57 (10.19)	0.46	0.42 (0.62)	−0.58
Italy	−0.73 (−10.34)	0.17	−1.29 (−9.38)	−0.35
Luxembourg	2.94 (6.20)	0.06	−0.13 (−0.11)	0.65
Netherlands	0.31 (2.74)	0.27	−0.45 (−1.96)	−0.27
Norway	1.39 (6.52)	0.16	0.17 (0.38)	0.26
Portugal	1.35 (3.90)	0.63	−1.62 (−2.48)	0.28
Spain	−0.70 (−6.76)	−0.29	−1.26 (−5.71)	0.27
Sweden	−0.16 (−0.96)	0.64	−0.53 (−2.18)	−0.15
Switzerland	1.33 (8.63)	−0.30	0.05 (0.14)	−0.01
United Kingdom		0.01		−0.17
West Germany	−0.05 (−0.76)	−0.01	−0.44 (−3.21)	−0.41

NOTE: T ratio is in parentheses.

Table A.2

VALUES FOR COUNTRY-SPECIFIC DUMMY VARIABLES AND AUTOCORRELATION CORRECTIONS FOR TABLE 6

	Originating in the U.S.		Terminating in the U.S.	
Country	Dummy Variable	Autocorrelation Correction (Rho)	Dummy Variable	Autocorrelation Correction (Rho)
Austria	0.00	0.70	−1.44	0.23
	(9.86)		(−2.58)	
Belgium	0.01	0.55	0.30	−0.02
	(23.40)		(0.76)	
Denmark	0.00	0.68	−0.78	0.56
	(14.89)		(−1.74)	
Finland	0.01	0.75	−1.31	0.65
	(28.87)		(−2.09)	
France	0.04	−0.04	−0.98	0.11
	(175.54)		(−6.71)	
Greece	0.06	0.07	0.36	0.52
	(261.19)		(0.70)	
Ireland	0.00	0.55	1.24	−0.59
	(9.03)		(1.62)	
Italy	0.00	0.32	−1.25	−0.42
	(1.37)		(−9.22)	
Luxembourg	0.00	−0.12	0.07	0.75
	(0.19)		(0.06)	
Netherlands	0.02	0.27	−0.30	−0.26
	(80.05)		(−1.31)	
Norway	0.00	0.23	0.23	0.19
	(0.58)		(0.51)	
Portugal	0.00	0.60	−1.02	0.22
	(0.01)		(−1.62)	
Spain	0.06	−0.31	−1.21	0.22
	(243.69)		(−5.65)	
Sweden	0.01	0.71	−0.56	0.38
	(33.44)		(−2.08)	
Switzerland	0.01	−0.29	0.03	0.42
	(59.83)		(0.09)	
United Kingdom		0.22		−0.10
West Germany	0.21	−0.07	−0.41	−0.24
	(867.16)		(−3.15)	

NOTE: T ratio is in parentheses.

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