# Demand Elasticities for International Message Telephone Service

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**Abstract**. Using a point-to-point model of toll demand, this paper provides estimates of own-price demand elasticities for international message telephone service. The study improves on previous studies by using more recent data and endogenizing price. Consistent with earlier studies, the demand for IMTS is found to be price inelastic, about –0.28 on average, in the short-run and near unitary elastic, -1.04 on average, in the long run. Both the level and the elasticity of demand are found to positively related to the size of the telephone network. The own-price elasticity of demand for a select group of countries is provided.

## 1.0 Introduction

This study employs a point-to-point model of toll (long distance) demand to estimate own-price demand elasticities for United States originated international message telephone service (IMTS) using country-pair data for 28 countries over the time period 1985-1994. Unlike previous studies, the data used for this empirical study post-dates the 1982 divestiture of the former U.S. telephone monopoly American Telephone & Telegraph (AT&T). In addition, the empirical specification jointly determines the price and quantity of IMTS while earlier studies have treated price as exogenous. While recent studies have estimated only short run demand elasticities, ours estimates both short run and long run demand elasticities. Consistent with earlier studies, the demand for IMTS is found to be price inelastic in the short-run and near unitary elastic in the long run. The effect of telephone

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network size is to both increase the overall level of demand and reduce the own-price elasticity of demand for IMTS between specific country-pairs.

## 2.0 Telecommunications Demand

Our study, as well as most recent models of point-to-point toll demand, follows the empirical framework developed by Larson, Lehman, and Weisman (1988: *LLW*). Prior to the LLW study, empirical models of toll demand were specified such that the quantity of toll service, measured in terms of minutes or calls, was determined primarily by price, income, and the size of the telephone network.[1] The size of the network is an important determinant of demand because the larger the community of market participants that can communicate over a network, the greater should be the demand for the services of that network (Squire, 1973).

LLW were the first to formally account for the *reverse-calling effect* or *call externality*, where the quantity of toll traffic from point B to point A influences the demand for traffic from point A to point B. Thus, there are two types of toll traffic, namely *autonomous traffic* and *induced traffic*. Autonomous traffic is independent of the level of traffic between two points. Induced traffic, conversely, is (in some manner) related to the volume of traffic between two points, i.e., the traffic from A to B is dependent on the traffic from B to A in either a complimentary or substitutable manner. If a call is made from B to A requesting information, such as a price quote, then it is likely that a return call from A to B providing the requested information will be *induced*. In this case, calls from B to A and A to B are *complementary*, since an increase in calls from B to A of this type will result in an increase in the number of calls from A to B. Alternatively, if the purpose of the call is simply to provide of information, then a call from B to A may *substitute* for a call from A to B. In this case, an increase in calls from B to A will reduce the demand for calls from A to B, i.e., they are substitutes.

## 3.0 The Empirical Model

All earlier studies on the demand for IMTS treat prices as exogenously determined. Since the majority of these studies use data prior to the divestiture of AT&T, treating price as exogenous was reasonable given the strict regulation of prices prior to divestiture.[2] The relaxation of price regulation of IMTS carriers, and the increase in competition since divestiture of AT&T, suggests that price should be

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1 For a thorough review of this literature, see Taylor (1994).

2 AT&T's IMTS rates have were regulated by price-cap regulation over this time period, but price-cap regulation gave AT&T far more pricing flexibility than the more rigid regulatory regimes that preceded divestiture.

treated as endogenous in the point-to-point model of IMTS demand. If prices are indeed endogenous, failing to account for the endogeneity could lead to a downward bias in the own price elasticity estimates.

Extending the LLW model to endogenize prices, a four equation structural system is specified:

$$Q_D = f(P_D, Y_D, Q_F, N_F) + e_f \tag{1a}$$

$$Q_F = g(P_F, Y_F, Q_D, N_D) + e_g \tag{1b}$$

$$P_D = h(Q_D, Q_F, W_D) + e_h \tag{1c}$$

$$P_F = k(Q_F, Q_D, W_F) + e_k \tag{1d}$$

where *Q* is the quantity of IMTS minutes, *Y* is gross income, and *N* is the size of the telephone network, *W* us a vector of factors affecting the marginal cost of the carrier and ε is the econometric disturbance term. The subscript *D* and *F* represent *domestic* and *foreign*, respectively.

This simultaneous system can be estimated by two-stage least squares (2SLS). Our attention is restricted to estimates of the own-price elasticity of demand for IMTS, so only equation (1a) is estimated. Since 2SLS is a single equation technique, it is possible to estimate the structural parameters of equation (1a) without estimating the other three structural equations of the system (the reduced forms are estimated). The specification of the system (1a - d) defines the exogenous variables required for two-stage least squares estimation.[3]

Following Larson et al., Appelbe et al., and Acton and Vogelsang,[4] the demand equation (1a) for U.S. originating IMTS is specified as:

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[3] Furthermore, a lack of data on $P_F$, precludes the estimation of equations (1b) and (1d). What variables would enter the price equation are somewhat predictable; however, the expectations regarding the signs of these variables and possible interaction effects is not well understood. Some exploratory work on this topic is presently being conducted by the author.

[4] Acton and Vogelsang (1992) applied the *LLW* point-to-point model to the international toll market, where they investigate the demand for international message telephone service (IMTS) between the U.S. and 17 European countries over the time period 1979-1986. Acton and Vogelsang (AV) specify the dependent variable of the demand equation as the annual quantity of minutes of

$$\ln Q_D = \beta_0 + \beta_1 \ln \hat{P}_D + \beta_2 \ln Y_D + \beta_3 \ln \hat{Q}_F + \beta_4 (\ln \hat{P}_D \cdot \ln TEL_F) + \beta_5 \ln TEL_F + \beta_5 \ln TRADE + \beta_5 \ln Q_{D-1} + \varepsilon \quad (2)$$

where the dependent variable ($Q_D$) is annual aggregate IMTS minutes originating in the United States and terminating in one of 28 foreign countries.[5] Quantity demanded of IMTS is a function of its own-price ($P_D$); income ($Y_D$); the number of telephones in the foreign country ($TEL_F$); the volume of trade between the U.S. and foreign country (*TRADE*); and terminating minutes of IMTS ($Q_F$). The interaction of own-price and the number of telephones ($P_D \cdot TEL_F$) allows the demand curve to shift as well as rotate, producing country specific demand elasticity estimates. Following earlier (time-series) studies on toll demand, a Koyck lag structure is employed where $Q_{D-1}$ is the lagged value of the dependent variable.[6] For the Koyck lag specification, long run demand elasticities are measured by dividing the short run elasticity by one minus the coefficient on the lagged dependent variable. Descriptive statistics of the variables are provided in Table 1.

The price of IMTS ($P_D$) service is measured by average revenue per minute of IMTS service as published in the *Statistics of Communications Common Carriers* (1985-1995). Income ($Y_D$) is measured by real U.S. Gross Domestic Product. All variables expressed in monetary terms have been deflated by the consumer price index. Consistent with economic theory an inverse relationship between quantity and price is expected; a positive sign on income is also expected. The coefficient on terminating traffic ($Q_F$) will be positive if induced traffic is complementary in

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international message telephone service. The own-price elasticity of demand for U.S. originating traffic is estimated to be -0.36, which is consistent with the majority of prior studies on international toll demand. AV do not find a statistically significant relationship between foreign IMTS price and U.S. originating traffic. The estimated income elasticity (where income is measured as Gross Domestic Product) is 1.39, implying international calling is income elastic. Trade volume is included as an exogenous variable but is not found to have a statistically significant-effect on the demand for IMTS. Market size, measured by the number of access lines in each country, is found to have a positive and significant effect on toll demand. The magnitude of the call externality was not estimated by their reduced-form equations.

5 Note that this figure includes both residential and business customers, all types of telephone traffic including facsimile, and is not distinguished by rating period. While it may be desirable to disaggregate the data by a number of categories of consumers and traffic type and rating period, the data are currently not available in a such a disaggregated form.

6 Larson et al. estimate dynamic effects using Almon polynomially-distributed lags. More typical of toll demand models was the Koyck lag specification (Taylor 1994, pp. 315-322).

nature. If telecommunications traffic between two points is more substitutable than complementary, then the expected sign on the coefficients will be negative.

### 3.1 Data

The data set was constructed of annual telephone traffic between the United States and twenty-eight foreign countries over the time period 1985 through 1994. Unlike prior studies, this data covers only the time period after the divestiture of AT&T in 1982. The primary source of data is the *Statistics of Communications Common Carriers* (SOCC) published annually by the Industry Analysis Division of the Common Carrier Bureau of the Federal Communications Commission. Data including international telephone traffic originating and terminating in the U.S. and settlement payments of domestic and foreign carriers are published in the SOCC. Total revenues of domestic carriers for IMTS, and Gross Domestic Product of the U.S. are also published in the SOCC. The sources and descriptive statistics for other variables in the data set are provided in Table 1. The 28 countries and 10 years of data resulted in a sample of 280 observations. Two-years of observations were lost due to lagged variables so that the final regression coefficients are based on 224 observations.

### 3.2 Estimation Issues and Results

In order to estimate the demand for IMTS service, the parameters of equations (2) are estimated using 2SLS where $Q_D$ , $P_D$ , $Q_F$ and $P_F$ are all treated as endogenous. As mentioned earlier, given the lack of data on foreign price the full structural model is not estimated. Since the focus here is on the own-price demand elasticities, only the results from the United States domestic IMTS demand equation are presented.[7]

The structural parameters of the demand equation (2) were estimated in two stages. In the first stage, the reduced forms of $Q_D$ , $P_D$, and $Q_F$ were estimated using standard fixed effects least squares. Fitted values for these endogenous variables were computed by regressing each variable on all current and (one-period) lagged exogenous variables. Lagged values of the endogenous variables were treated as endogenous as well and do not appear in the reduced form equations (Greene, 1990). In the second stage, the fitted values for the endogenous variables and their lags were used to estimate the structural coefficients of the

[7] For purposes of deriving the reduced form equations, the structural equation for $Q_F$ is symmetric to that of $Q_D$. Instruments for $P_D$ and $P_F$ include originating and terminating access charges in the United States, and the average (per minute) settlement rate paid by domestic carriers, the country-pair specific Herfindahl-Hirschman index of concentration, and the consumer price index.

demand equation. The estimated coefficients of this second step are the two-stage least squares estimates.[8]

Due to the time-series component of the data, autocorrelation is anticipated. The hypothesis of first-order autocorrelation is tested using the *Durbin-Watson h statistic (h)*, which is valid for regressions with lagged endogenous variables (Greene, 1990, p. 454). The *h* statistic is approximately normally distributed with unit variance, so that the test for first-order serial correlation can be done by using the normal distribution table. The *h*-statistic for the demand equation is 1.78 which falls below the critical *z* statistic from the normal table of 1.96. Therefore, the null hypothesis of no autocorrelation cannot be rejected in the demand equation at the five-percent level. Due to the cross-sectional element of the data used in this study, heteroskedasticity is a potential problem. Following Larson et al., and Acton and Vogelsang, it is assumed that disturbances are cross-sectionally heteroskedastic and White's heteroskedastic consistent covariance matrix estimator is used to obtain consistent standard errors. The *t*-statistics of the structural parameters are White's *t*-ratios.

### 3.3 Results

The results of estimating equation (2) are presented in Table 2. The estimated $R^2$ is quite high as is expected with time-series data.[9] Most of the variables are of expected sign and statistically significant at the 5% level or better. The coefficient on own-price is negative and significant at the 5 percent level. Because of the interaction of price with the number of access lines, the own-price elasticity of demand is not the coefficient on $P_D$. Rather, the own-price elasticity of demand is estimated by $[(\beta_1 + \beta_4 lnTEL_F)]$. As expected, the positive sign on the interaction term implies that increases in the size of the foreign country's telephone network reduces the own-price elasticity of demand. The interaction term is also statistically significant at the 5 percent level.

Calculating the own-price elasticity of demand at the mean of $\ln TEL_F$ for each cross-section and averaging across cross-section (i.e., countries), the short run own-price elasticity is estimated to be -0.28. This result compares favorably with previous estimates of own-price elasticities for IMTS, including Acton and Vogelsang (1992). Long-run own-price elasticities of demand can be calculated by

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[8] According to Greene, this estimation procedure guarantees consistency but not efficiency at the second stage (Greene 1990, p. 630).

[9] The estimated $R^2$ is the squared partial correlation coefficients of the actual and predicted values of the dependent variables. The $R^2$ were large for the reduced form equations as well, none being below 0.80.

dividing the short-run elasticity estimate by one minus the coefficient on the lagged endogenous variable ($[(\beta_1 + \beta_4 lnTEL_F) / \beta_5]$. The sample average long-run own-price elasticity of demand is -1.04.[10]

Given the interaction of price with the number of telephones, it is possible to calculate country-specific own-price elasticities of demand. These own-price elasticities, both short-run and long run, are reported in Table 3. As shown by the table, the elasticities vary substantially across country-pairs. In some cases, the long run own-price elasticity of demand approaches 2. In others, however, even long-run own-price elasticities are far below unity.

The positive sign of the coefficient on the variable measuring income implies IMTS is a normal good. The income elasticity of demand is estimated as 0.47, meaning IMTS demand is not highly sensitive to changes in income. The reverse calling elasticity is positive and significant at the 10 percent level. While the positive sign implies originating and terminating traffic are complementary at the aggregate level, the coefficient is quite small (0.02). More mature telecommunications networks in the foreign countries increase the domestic demand for originating IMTS to that country. At the sample mean of $\ln P_D$, the market size elasticity is 0.16.[11] While the sign on ln*TRADE* is positive, the variable is not statistically different from zero.

## 4.0 Conclusions

The purpose of this paper is to provide updated and country-specific estimates of the own-price elasticity of demand of international message telephone service. Like earlier studies, we find that the average own-price elasticity of demand for IMTS is inelastic in the short run and approaches unity in the long run. Unlike earlier studies, however, we use data post-dating the divestiture of AT&T and treat price as endogenous. While the topic of this paper is narrowly defined, the importance of improved and current demand elasticity estimates is important in an increasingly global telecommunications marketplace.

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[10] Lande and Blake (1996) estimate a simple least squares equation of IMTS demand over the time period 1975-1994 (20 observations), where quantity is a function of real price and real Gross Domestic Product. All variables in the regression are measured as a three year, weighted average, first-difference. This approach estimates an own-price elasticity of demand for IMTS of -1.5 with an $R^2$ of 0.66, and a Durbin-Watson statistic is 1.46 which is in the indeterminate range.

[11] Acton and Vogelsang (1992) estimate a market size elasticity of 0.47 for U.S. - European country pairs.

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**Table 1.**

**Variable Definitions, Sources, and Descriptive Statistics**

| *Variable* | *Definition* | *Source* | *Mean* | *Standard Deviation.* |
|---|---|---|---|---|
| $Q_D$ | Minutes of International Message Telephone Service Originating in the United States | (1) | 123,000,000 | 132,000,000 |
| $Q_F$ | Minutes of International Message Telephone Service Terminating in the United States | (1) | 61,134,644 | 89,709,220 |
| $P_D$ | Average Revenue of U.S. Carriers per Minute of IMTS | (1) | 1.12 | 0.29 |
| $Y_D$ | U.S. Gross Domestic Product | (1) | 4,797,500,000 | 221,329,100 |
| $TEL_F$ | Telephones in the Foreign Country | (2) | 12,885,370 | 18,382,020 |
| *TRADE* | Trade Volume of U.S. and Foreign Country | (3) | 14,400,000,000 | 23,700,000,000 |

(1) *Statistics Of Communications Common Carriers*, 1985-95

(2) *Statistical Yearbook*, 1893-1994, United Nations and *World Factbook*, Central Intelligence Agency (1995).

(3) *Statistical Abstract of the United States,* Various Years.

Other Sources: *Reference Book: Rates, Indexes, and Household Expenditure for Telephone Services.* Industry Analysis Division, Common Carrier Bureau FCC, May 1993. Data for some of the instruments, including the country-pair specific Herfindahl indices, was provided by the *International Trends Report*, 1995 Special thanks to Linda Blake, Jim Lande, and Katie Rangos in the Industry Analysis Division, Common Carrier Bureau, Federal Communications Commission for helpful assistance with the data.

**Table 2.**

**Two-Stage Least Squares Estimates of Demand Equation**

| *Variable* | *Coefficient* |
|---|---|
| $\ln P_D$ | -0.823 |
| | (0.222)[a] |
| $\ln Y_D$ | 0.473 |
| | (0.191)[a] |
| $\ln TEL_F$ | 0.157 |
| | (0.043)[a] |
| ln TRADE | 0.010 |
| | (0.009) |
| $\ln P_D \cdot \ln TEL_F$ | 0.065 |
| | (0.065)[a] |
| $\ln Q_F$ | 0.021 |
| | (0.012)[b] |
| $\ln Q_{D-1}$ | 0.728 |
| | (0.028)[a] |
| Est. $R^2 = 0.99$ | h Statistic = 1.78 |

[a] Significant at the 5% level.
[b] Significant at the 10% level.

**Table 3.**

**Own-Price Demand Elasticities for IMTS Service**

**(By Country)**

| | *Short-Run*[a] | *Long-Run*[b] | | *Short-Run* | *Long-Run* |
|---|---|---|---|---|---|
| Australia | -0.22 | -0.82 | Jamaica | -0.52 | -1.90 |
| Brazil | -0.20 | -0.72 | Japan | -0.09 | -0.33 |
| China | -0.21 | -0.78 | Korea, Rep. of | -0.21 | -0.77 |
| Colombia | -0.25 | -0.91 | Netherlands | -0.22 | -0.82 |
| Dominican Rep. | -0.46 | -1.69 | Pakistan | -0.39 | -1.42 |
| Egypt | -0.35 | -1.28 | Peru | -0.39 | -1.45 |
| El Salvador | -0.50 | -1.83 | Philippines | -0.37 | -1.37 |
| France | -0.13 | -0.49 | Poland | -0.26 | -0.97 |
| Germany | -0.13 | -0.46 | South Africa | -0.27 | -1.01 |
| Greece | -0.28 | -1.01 | Spain | -0.19 | -0.69 |
| Guatemala | -0.49 | -1.80 | Switzerland | -0.26 | -0.94 |
| Hong Kong | -0.30 | -1.11 | Thailand | -0.35 | -1.30 |
| India | -0.26 | -0.96 | UK | -0.14 | -0.51 |
| Israel | -0.32 | -1.19 | | | |
| Italy | -0.15 | -0.56 | *Average* | -0.28 | -1.04 |

[a] Calculated at the mean value of the $lnTEL_F$ for each country.
[b] Long-run elasticities are calculated by dividing the short-run elasticity estimate by one minus the coefficient on the lagged dependent variable in the demand equation $lnQ_{D-1}$.