

## **Model-Based Price Standards for Terminating International Traffic**

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**DRAFT** (revised)

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Observers around the world have long recognized that traditional prices for terminating international traffic are often irrational. These prices, called settlement rates<sup>1</sup>, vary widely among similarly situated countries. Settlement rates bear little relation to cost, and dramatic reductions in transmission and switching costs have not produced similarly dramatic reductions in settlement rates.<sup>2</sup> Given the arbitrary nature of settlement rates, it is not surprising that most countries do not publicly release their settlement rates.

The most desirable approach to pricing international termination is to have market-driven prices. Only a market for termination services can effectively uncover and evaluate information about the relevant costs for international termination. Only market driven prices can change rapidly and continually in response to changes in cost and technological capabilities. The stark failures of communism and market socialism demonstrate that no administrative price-setting mechanism can simulate market prices or maintain "true cost-based rates".

Nonetheless, price standards for international termination are an important regulatory tool. Given the pervasiveness of market power and sector-specific regulation in telecommunications,

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<sup>1</sup> For historical reasons associated with the bilateral monopoly provision of international service, the term accounting rate is also used. The accounting rate is generally twice the settlement rate.

<sup>2</sup> See *Accounting rate principles for international telephone services*, Recommendation D.140 ITU: Geneva, 1995, and *In the Matter of International Settlement Rates*, NPRM, IB Docket No. 96-261 (1996), para. 7-9.

competition can take many different forms and produce many different results. Price standards for international termination can help regulators evaluate the effectiveness of competition in reducing international termination charges. Moreover, some countries might not adopt pro-competitive reforms. Price standards for international termination can provide the basis for administrative measures to discipline international termination charges when competition is not doing so.

Many economists agree that an appropriate regulatory standard for pricing termination is long run incremental cost. This cost concept focuses on current and future costs of providing a facility or service and recognizes that historical, embedded, or accounting costs may not have any economic significance. Unlike rate-setting exercises under cost-based rate-of-return regulation, a long run incremental cost calculation does not focus on a particular company's actual costs. Long run incremental cost calculations examine the additional cost for any company to provide, in a cost-minimizing way, a facility or service given some initial configuration of assets.

Countries that are pushing aggressively to foster competition in telecommunications have developed detailed cost models to analyze termination pricing. Common costs are a significant issue in these models. The U.K. regulator's models indicate price floors and ceilings to reflect common costs across major network increments and conventional cost allocators for common costs within these major increments. The FCC has focused on pricing network elements rather than network services so as to reduce the amount of common costs to be allocated. In both the United States and the United Kingdom the allocation of common costs remains one of the weaker parts of cost models.<sup>3</sup> Overall, however, the models have benefited from a large amount of data on telecommunication costs and from contributions from a wide range of interested parties.

Developing comparable, reliable cost models for a large number of countries represents a much more daunting task. While the results from the U.S. and U.K. models may be similar, the models differ in fundamental ways. Moreover, cost models are likely to be much more difficult to develop in countries that have made less progress toward liberalization and competition. State-owned telecommunications monopolies have little incentive to track their costs, to minimize their costs, and to report costs truthfully to oversight organizations. In many cases needed data are simply not available.

The issue is more profound than instituting, enforcing, and auditing reporting requirements for telecommunications companies around the world. Economies with less developed markets and legal systems have less well-defined prices for goods and services. The cost of capital becomes more difficult to specify in situations where personal and political connections play a more important role in determining the allocation of capital. Similarly, the price of telecommunications

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<sup>3</sup> See *The Use of Computer Models for Estimating Forward-Looking Economic Costs*, FCC Staff Analysis (Dec. 1996), para. 70; *Reconciliation and Integration of Top Down and Bottom Up Models of Incremental Costs*, Report prepared for OFTEL by NERA (June 1996), Section 2.7.2

equipment becomes more difficult to specify when a state-owned telecommunications service provider is being used to channel government subsidies to an equipment maker via high equipment prices, or when tariffs for importing telecommunications equipment are volatile and subject to case-by-case negotiation. Exchange rate volatility implies a significant additional complicating factor. In addition, the absence of regulators and competitors in such countries implies an absence of informed parties who can scrutinize critically proposed models.

Most importantly, a key goal of cost modeling should be to foster reasoned debate about appropriate price standards. Reasoned debate means debate that identifies relevant facts and clarifies differences in judgement. Because they employ complex algorithms and encompass a large number of parameters, current costing models for domestic interconnection are difficult to discuss and evaluate. Fostering reasoned debate among officials from a large number of countries requires tools that are simpler and clearer than tools that might be used in a domestic context.

This paper proposes a Best Practice Model (BPM) for setting price standards for international termination. Section I discusses four principles that determine the structure of the BPM. Section II presents the BPM and discusses the factors that affect its parameters. Section III sets out possible BPM parameters for U.S. international traffic and the price standards for U.S. international traffic termination that result from these parameters. Section IV offers some concluding observations on how regulators, in the United States and elsewhere, might use the BPM to evaluate and discipline international termination charges.

## **I. Four Principles**

Over 200 territories are nodes in the international telecommunications network. Each territory is distinguished from every other by a myriad of different factors. Yet modern technology for building telecommunications networks is available globally through international trade, and physical laws that govern telecommunications networks do not vary from place to place. The challenge is to develop simple, clear price standards that recognize both common possibilities and the most relevant distinctions among territories.

At the core of the approach in this paper are four principles.

*Principle 1:* The baseline for international termination pricing will be determined, in light of world experience, by the lowest termination prices observed to be consistent with vibrant pro-competitive development of a country's telecommunications sector.

Studying world experience is essential to see what is feasible and what is successful in bringing benefits to consumers. Principle 1 implies that a fact-based analysis of international best practice will determine the baseline for termination pricing.

*Principle 2:* Modeling cross country variations will focus on differences among the factors that

determine the long run incremental cost for terminating international traffic. The incremental cost of terminating international traffic will be analyzed relative to a telecommunications network that efficiently serves domestic telecommunication needs.

The uniqueness of each country could easily lead to ad hoc analyses of price standards on a country-by-country basis. In contrast, total long run incremental cost is a clear, well-defined, and widely recognized cost concept. Principle 2 means that differences among countries will be analyzed in terms of this concept.

*Principle 3:* Modeling cross country variations will use credible, comparable, public information widely available for a large number of countries.

A key challenge for setting price standards for international termination is data. Uninformative, non-comparable numbers are easy to make up. A disciplined, transparent approach requires data that are clear, comparable and objective. Principle 3 means that the model will be limited to such data.

*Principle 4:* The model will have only a small number of parameters -- preferably less than 10 parameters and almost certainly less than 25.

Models with large numbers of parameters are difficult for non-specialists to discuss and evaluate. Moreover, as the number of parameters in the model increase, the possibilities for ad hoc adjustments of the model also increase. Both these problems are particularly relevant in establishing price standards in a multilateral, international context. Principle 4 means that model simplicity will be highly valued.<sup>4</sup>

## **II. Model Structure**

The Best Practice Model (BPM) described in this section incorporates the four principles presented above. The model is country specific: it determines price standards for terminating international traffic from a reference country to destination countries. The model focuses on five key cost drivers for the long run incremental cost of terminating international traffic from a reference country. These cost drivers are:

*1. Total international public switched voice minutes per month between the reference country and the destination country*

Total international traffic is inversely related to the incremental cost per minute of providing international transmission facilities. There are large scale economies in international fibre optic

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<sup>4</sup> For comparisons, cost models being developed for domestic interconnection pricing in the United States and Britain encompass on the order of thousands of parameters.

transmission, as well as scale economies in satellite transponder leasing and loading.

## *2. The time difference between the reference and destination countries*

The greater the time difference between the reference and destination countries, the less impact international traffic is likely to have on peak network load. Peak network load drives network facility requirements. Countries with a greater time difference are also more distant, but international transmission costs are largely distance insensitive.

## *3. The geographic size of the destination country*

The incremental cost of domestic transmission is greater in larger countries.

## *4. The share of a country's telephone lines that are located in the largest city*

For a given size country, the incremental cost of transmission and distribution is lower in countries with a greater geographic concentration of telephone lines.

## *5. The income level of the destination country*

A country's income level is associated with differences in the incremental cost of an expansion in domestic network capacity. Lower income countries generally have lower labor costs than higher income countries but higher capital costs. In addition, lower income countries generally have less well-developed markets and market-supporting institutions.<sup>5</sup>

Thus transactions costs and risks associated with additional business activity are higher in lower income countries.

With the possible exception of international traffic data for some reference countries, comparable data on each cost driver are publicly available from authoritative sources (see Appendix A).

Much of the required data is publicly available globally via the World Wide Web. Thus the model largely fulfills Principle 3. Moreover, in accordance with Principle 2, each of the cost drivers can be directly related to the incremental cost of terminating international traffic.

These cost drivers have been broken down into value groups (see Appendix B) and arranged in Table 1 so that incremental cost increases as one moves up any column of value groups. For each cost driver, the column labeled CW indicates a weighting for the impact on incremental cost of the cost driver falling within the corresponding value group.

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<sup>5</sup> These factors help explain why more international capital does not flow to low income countries to take advantage of low labor costs and high returns to capital.

Three key model parameters are the international traffic termination prices for the lowest cost case, the baseline case, and the highest cost case. The value groups with 0 in the CW column indicate the baseline for the cost model. The baseline international traffic termination price will be, in accordance with Principle 1, the lowest international termination price observed to be consistent with vibrant pro-competitive development of a country's telecommunications sector. The combination of the top value groups in each column represents the highest cost case, and the combination of the bottom value groups in each column represent the lowest cost case. International termination prices for the lowest cost and highest cost cases will reflect relevant facts and expert assessment.

Additional parameters are the values for the CW's, i.e. the cost weights associated with the non-zero cost driver value groups (the shaded squares in Table 1). The CW's associated with the highest cost case are required to sum to 100, and the CW's associated with the lowest cost case are required to sum to -100. In addition, in any column, CW's must increase from the bottom to the top of the column (the zero square cannot be changed). Assigning different cost weights to the cost driver value groups establishes the relative importance of different cost drivers and cost driver values.

For given parameters the BPM produces price standards for terminating international traffic from the reference country. The sum of the cost weights corresponding to a country's cost driver values is that country's total cost score. This cost score is then mapped to a price standard. The mapping is done such that, plus or minus one for a cost score corresponds to a price standard one percent higher or lower, respectively, than the baseline price. Overall, the mapping from cost scores to price standards is not linear but concave, which is consistent with the typical properties of cost functions (see Appendix C).

The BPM is relatively simple. The cost score is a linear combination of a small number of easily interpretable cost characteristics. The mapping from cost scores to price standards takes a relatively simple functional form (a type of exponential spline) with desirable properties. Overall, the model has 16 parameters and thus meets Principle 4.

The BPM is implemented as an Excel spreadsheet. Once the underlying database has been established, the user can enter different parameter values and immediately see how they affect the price standards for all the destination countries.

Table 1 - Parameters for the Best Practice Model

group		CW	
under 30		group	CW
30 - 150		0 - 4	
150 - 1000		4 - 8	<b>0</b>
over 1000	<b>0</b>	8 - 12	
Total Int. Route Traffic (ths mins/month)		Time Shift (hours)	

group		CW		group		CW	
over 750		low income		under 20%		20-35%	<b>0</b>
250 - 750	<b>0</b>	lower middle		35-50%			
70 - 250		upper middle		50-70%			
under 70		high income	<b>0</b>	over 70%			
Size of Country (ths. sq. km)		Country Income Level		Line concentration (% of tel. lines in largest city)			

### III. An Example: Parameters and Results

This section will use the Best Practice Model (BPM) to consider price standards for terminating U.S.-billed international traffic. The BPM can be applied to consider price standards for terminating international traffic from other countries. Some of the underlying data, however, are country specific. The data on total international traffic and on time shifts are specific to the United States. The BPM baseline is also a U.S. specific rate. The price standards computed here are thus specific to the United States and price standards for terminating traffic originating from other countries may differ from those for international traffic originating from the United States.

The BPM baseline is the lowest international termination price observed to be consistent with vibrant, pro-competitive development of a country's telecommunications sector. Sweden and the United Kingdom are two countries experiencing rapid development of their telecommunications sector. The price per minute for terminating U.S. international calls in Sweden (the settlement rate) is 0.06 SDR. In the United Kingdom, settlement rates vary by traffic volume and by carrier. British Telecom's settlement rates are 0.125 SDR and 0.075 for U.S. international traffic below and above a given traffic volume threshold, while the corresponding rates for Mercury are 0.15 SDR and 0.065 SDR. In Germany, which has not yet liberalized basic voice telephony but is moving aggressively to implement reforms, the settlement rate is 0.08 SDR.<sup>6</sup> The Swedish rate of 0.06 SDR will be used as the baseline in the BPM calibration for the United States. The unit of account for the price standards will be the SDR, in accordance with prevailing international practice. However, for convenience the price standards will be listed in U.S. cents.<sup>7</sup>

The BPM also requires estimates of termination prices for the lowest cost and highest cost cases in the model. The lowest cost case and the highest cost case correspond to countries with the characteristics listed at the bottom and top, respectively, of each column in Table 1.<sup>8</sup> Some relevant experience might be recent U.S. state-level interconnection agreements negotiated in the context of the introduction of local competition. The modal price for local call termination in these agreements is \$0.01, with a range from \$0.007 to \$0.019.<sup>9</sup> Using modern optically amplified fibre cables the cost of additional international traffic is very low, as the low circuit utilization rates to major Western European and Asian countries indicate.<sup>10</sup> This means that international circuit costs on high density routes could be significantly less than one cent per minute.<sup>11</sup> With respect to the highest cost case, the average tariff component price (TCP) for

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<sup>6</sup> The settlement rates for Sweden, the United Kingdom, and Germany are rates in effect on December 1, 1996. Settlement rates for Canada via Stentor, a major Canadian carrier, are 11 cents for peak hours, 7 cents for off-peak.

<sup>7</sup> The exchange rate used is 1 SDR = \$1.4482.

<sup>8</sup> Thus the lowest cost case is a country with greater than one million minutes per month of international traffic with the United States, an 8-12 hour time shift relative to the United States, area under 70 thousand square miles, a member of the high income class, and over 70% of its telephone lines located in the largest city.

<sup>9</sup> See Vivian Witkind Davis and Michael E. Clements, "Convergence and Controversy in Early Interconnection Agreements", National Regulatory Research Institute 96-27 (October 1996).

<sup>10</sup> Circuit utilization rates in 1995 to the United Kingdom, Germany, and Japan were 37%, 37%, and 32%, respectively. See FCC International Bureau, *1995 Section 43.82 Circuit Status Data* (December 1996).

<sup>11</sup> AT&T has estimated that BT's cost per minute on TAT-11, an older trans-Atlantic cable



low income countries is 23.4 cents.<sup>12</sup> Note that TCP's include costs for services, such as retail billing, marketing, and collecting, that are not needed for terminating international calls<sup>13</sup>, while cost driver characteristics vary significantly among low income countries.

There is inevitably some uncertainty about what best practice prices would be for the lowest cost and highest cost cases. Facts, such as those presented above, can provide some guidance about reasonable values. The results below consider three different sets of values, presented in Table 2, for the lowest cost and highest cost cases.

Table 2 - BPM Parameters

	lowest cost case -- int'l termination price	highest cost case -- int'l termination price
E1: low estimates	0.01 SDR (\$0.014)	0.12 SDR (\$0.174)
E2: base estimates	0.03 SDR (\$0.043)	0.15 SDR (\$0.217)
E3: high estimates	0.04 SDR (\$0.058)	0.18 SDR (\$0.261)

To calculate price standards from the BPM, one also needs weights (CW's) for the different values of the cost drivers. Tables 3,4, and 5 are filled in with different values for the CW's, chosen in accordance with the rules outlined in the previous section. Variant 1 (Table 3) is the base case. Relative to Variant 1, Variant 2 decreases the importance of a time shift and increases the importance of low-cost country geometry (size and line concentration). Variant 3, relative to Variant 2, shifts weight from low income to high-cost country geometry.

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that does not include optical amplifiers, might be \$.008 per minute. See AT&T Ex Parte *In the Matter of BT North America*, ITC-93-126.

<sup>12</sup> See *In the Matter of International Settlement Rates*, NPRM IB Docket No. 96-261 (released Dec. 19, 1996), and *Foreign Tariffed Components Prices*, a report prepared by the International Bureau, FCC (Dec. 1996).

<sup>13</sup> Benchmark NPRM, para. 42.

Table 3 - BPM Variant 1

group		CW	
under 30	15	group	CW
30 - 150	10	0 - 4	25
150 - 1000	5	4 - 8	<b>0</b>
over 1000	<b>0</b>	8 - 12	-50
Total Int. Route Traffic (ths mins/month)		Time Shift (hours)	

group		CW		group		CW	
over 750	10	low income	40	under 20%	10	20-35%	<b>0</b>
250 - 750	<b>0</b>	lower middle	25	35-50%	-10	50-70%	-15
70 - 250	-10	upper middle	10	over 70%	-25		
under 70	-25	high income	<b>0</b>				
Size of Country (ths. sq. km)		Country Income Level		Line concentration (% of tel. lines in largest city)			

Table 4 - BPM Variant 2

group		CW	
under 30	15	group	CW
30 - 150	10	0 - 4	25
150 - 1000	5	4 - 8	0
over 1000	0	8 - 12	-30
Total Int. Route Traffic (ths mins/month)		Time Shift (hours)	

group		CW		group		CW	
over 750	10	low income	40	under 20%	10	20-35%	0
250 -750	0	lower middle	25	35-50%	-10	50-70%	-20
70 - 250	-15	upper middle	10	over 70%	-35		
under 70	-35	high income	0				
Size of Country (ths. sq. km)		Country Income Level		Line concentration (% of tel. lines in largest city)			

Table 5 - BPM Variant 3

group		CW	
under 30	15	group	CW
30 - 150	10	0 - 4	25
150 - 1000	5	4 - 8	0
over 1000	0	8 - 12	-30
Total Int. Route Traffic (ths mins/month)		Time Shift (hours)	

group		CW		group		CW	
over 750	20	low income	25	under 20%	15		
250 - 750	0	lower middle	15	20-35%	0		
70 - 250	-15	upper middle	5	35-50%	-10		
under 70	-35	high income	0	50-70%	-20		
				over 70%	-35		
Size of Country (ths. sq. km)		Country Income Level		Line concentration (% of tel. lines in largest city)			

Appendices D and E show the price standards, for each of 178 U.S. international traffic destinations, that result from the above parameters. Results are shown for Variants 1, 2, and 3, under estimates E2 for the lowest and highest cost cases (see Table 2). Results are also shown for Variant 1 under the alternative lowest and highest estimates E1 and E3.

Consider the price standards for Canada and Mexico: 13.4 cents and 12.2 cents, respectively. The U.S. settlement rate with Canada is 11 cents for peak period traffic and 7 cents/minute for off-peak traffic. The fact that the price standard for Canada is above the actual rate that U.S. carriers pay suggests that these price standards are relatively loose. Nonetheless, the price standards are rational in terms of cost driver characteristics. Each of these countries is in the 0-4 hours time shift category, hence time differences do not play an important role in shifting the international traffic peak load from the domestic traffic peak load. Canada is a high income country (+0 on cost score) covering a large geographic area (+10 on cost score) and low geographic concentration of telephone lines (+10 on cost score). Mexico, on the other hand, is an upper middle income country (+10 on cost score), covering a large geographic area (+10 on cost score), and with a significant concentration of telephone lines in Mexico City (-10 on cost score). Thus Canada has a total cost score of +20, while Mexico's total cost score is +10. This explains why Canada has a higher price standard for terminating international traffic than Mexico. More generally, countries in the same time zone as the United States will have a higher cost-based price standard than countries on the other side of the globe.<sup>14</sup>

The price standards for the United Kingdom, Japan, and China are 8.7 cents, 6.1 cents, and 9.6 cents, respectively. The United Kingdom's price standard is the same as the Swedish baseline: the United Kingdom covers less area but has a more diffuse distribution of telephone lines than Sweden. The large time shift in international traffic to Japan and China brings down the incremental cost of terminating U.S. international traffic in those countries. On the other hand, China's low income level suggests that the cost of building any needed additional facilities is likely to be higher there than in Japan.

While the BPM price standards depend on the choice of parameters, the effect of different parametrizations appears to be less important than the underlying differences in countries' cost drivers. Table 6 shows summary statistics for the price standards on Variant 1-E2 (tentatively considered the most appropriate parametrization) as well as summary statistics for the differences associated with alternative parametrizations. The baseline price, Swedish termination, is 8.7 cents, while the mean BPM price standard is 9.6 cents. This means that U.S. destinations on average have cost driver values greater than Sweden's, and this difference accounts for the additional 0.9 cents for termination. The alternative parametrizations considered have a mean

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<sup>14</sup> Of course, international transmission costs may be higher for countries that are farther away. The weight attached to the time shift can incorporate distance effects. However, communication costs are essentially distance-insensitive on high traffic routes, and the cost driver for international traffic density can give cost weight to low density routes.

BPM standard from -0.4 cents less to 0.3 cents more. Moreover, the interquartile range for Variant 1-E2 is 3.2 cents, while the interquartile ranges for the differences associated with the different parametrizations are less than or equal to 1.3 cents. Different parametrizations matter, but they do not negate the importance of the underlying differences in cost drivers.

Table 6  
BPM Price Standards for Terminating U.S. International Traffic  
(summary statistics in US cents)

	Mean	SD	Q1	Q2	Q3	Min	Max
Variant 1-E2	9.6	2.6	7.9	9.1	11.1	4.5	18.3
	Distribution of Differences of Given Variant relative to Variant 1-E2						
Variant 2-E2 Differences	-0.1	0.8	-0.5	0	0.5	-1.7	1.8
Variant 3-E2 Differences	-0.3	1.1	-1.0	-0.4	0.3	-2.8	2.4
Variant 1-E1 Differences	-0.4	0.5	-0.4	-0.2	0	-2.7	0
Variant 1-E3 Differences	0.3	0.4	0	0.1	0.3	0	2.4
Note: SD is the standard deviation; Q1, Q2, and Q3 are the three quartiles of the distribution.							

#### **IV. Conclusions**

The Best Practice Model (BPM) offers a transparent, non-discriminatory, cost-based approach to setting price standards for terminating international traffic.<sup>15</sup> In recognition that making the dramatic transition to competition in telecommunications requires a fact-based analysis of reform initiatives and their results, the BPM explicitly references best-practice as its baseline. The BPM also recognizes relevant differences among countries and models how these differences would affect the results of best-practice policies.

Regulators around the world need to develop price standards for international termination.<sup>16</sup> Price standards are necessary to manage the revenue risks associated with foreign carrier entry into international service and with the increasing route and directional volatility of international traffic. They are also necessary so that countries can avoid the wide-ranging economic costs associated with excessive telecommunication prices.

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<sup>15</sup> The model is non-discriminatory in the sense that countries with the same relevant model characteristics have the same price standard.

<sup>16</sup> Multinational organizations and individual countries are increasingly recognizing the need for such standards. The ITU, the OECD, the European Union, Mexico, Sweden, the United Kingdom, and the United States have been exploring ways to rationalize the international settlements system. See *International Settlement Rates*, para. 15-17.

## Appendix A

### Information Sources for Cost Driver Values

#### *a. International in-bound and out-bound traffic on a country-by-country basis*

Source: National telecom authorities. The ITU *World Telecommunication Development Report* gives aggregate country figures. U.S. country-by-country figures have been published for several decades. The U.S. data used is from *1994 Section 43.61 International Telecommunications Data*, FCC Industry Analysis Division. This report is available on the FCC's Web site at the address:

[http://www.fcc.gov/Bureaus/Common\\_Carrier/Reports/FCC-State\\_Link/intl.html](http://www.fcc.gov/Bureaus/Common_Carrier/Reports/FCC-State_Link/intl.html)

#### *b. Time differences*

Source: World time zone web page, <http://tycho.usno.navy.mil/tzones.html>

This source is non-authoritative but similar data can easily be obtained using reference maps or personal inquiries.

#### *c. Geographic size and income class*

Source: The World Bank's *World Development Report 1996*, Appendix. The relevant information is available at the World Bank's web site under the link, *Selected World Development Indicators*, on

the page <http://www.worldbank.org/html/extpb/WDR96PA.html>

#### *d. Share of main lines in the largest city*

Source: *ITU World Telecommunication Development Report, 1995*. An order form for this information is available at the ITU Web site at the address:

[http://www.itu.int/itudoc/gs/subcirc/142e\\_2602.html](http://www.itu.int/itudoc/gs/subcirc/142e_2602.html)



## Appendix B

### Categorization of Values for Cost Drivers

Categorizing cost driver values into a small number of groups is an important way of limiting the number of parameters in the BPM. Internationally recognized value categories with broad application, such as the World Bank's country income classes, are preferable. Such categories are lacking for other cost drivers used in the model. For each of the other cost drivers, the categorization was based on five principles:

1. Value groups should have a relatively even distribution of countries among them.
2. There should be only a small number of value groups, and the value groups should encompass all possible values of the cost driver.
3. Value groups should have thresholds with a low number of significant digits ("round numbers").
4. Value group granularity should be greater where differences in value have a greater effect on cost.
5. Where multiple peaks in the country distribution of values exist, value groups should encompass these modes as much as possible.

The nature of the relationship between the cost driver and incremental cost is most transparent for the total volume of international traffic. The most costly value category for this cost driver is under 30000 minutes of traffic per month. This threshold roughly corresponds to the amount of traffic that could be carried per month on one physical voice-grade circuit.<sup>17</sup> The next value group corresponds to roughly 1-5 physical circuits, while the least costly traffic volume value group (over 1 million minutes per month) roughly corresponds to a load exceeding the capacity of one standard 2.048 Mbps international circuit.<sup>18</sup>

The definition of the cost driver value groups are not considered parameters in the model. They are conventions necessary to impose discipline on the model. As such, any reasons for changing them must be much more compelling than reasons for shifting cost impact weightings among the value groups.

## Appendix C

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<sup>17</sup> See *Foreign Tariffed Component Prices*, FCC International Bureau Report, pp. 7-8.

<sup>18</sup> Ibid.

## Mapping Cost Scores to Price Standards

A mapping from cost scores to price standards should have several properties. First, it should be monotonically increasing with a continuous derivative. Second, it should pass through the points  $(-100, P_L)$ ,  $(0, P_B)$ , and  $(100, P_H)$ , where  $P_L$ ,  $P_B$ , and  $P_H$  are the price standards for the lowest cost case, the baseline (best practice) case, and the highest cost case, respectively. Third, its behavior about the baseline case should not depend on the values chosen for the extreme cost cases. Fourth, the functional form should be as simple as possible.

$P = k_2 e^{k_1 C} + k_0$  A mapping with the desired properties is an exponential spline with one knot at the cost score of zero. Specifically, each of the two spline segments has the functional form given above, where  $k_2$ ,  $k_1$ , and  $k_0$  are parameters determined by the two end-point constraints and the constraint that the slope of the function at  $C=0$  be equal to  $.01P_0$ . This means that a cost score of 1 corresponds to a price standard 1% higher than the baseline price standard. The graph below shows the mapping for the E2 parameter estimates (see Table 2). The cost score can be interpreted as a resource requirement index and the over-all mapping can be interpreted as a cost function. The concavity of the mapping thus reflects the diminishing returns characteristic of cost functions.

### Mapping Cost Scores to Price Standards

