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December 29, 1994

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street NW - Room 222
Washington, D.C. 20554

RE: Ex Parte Meeting
CC Docket No. 94-1

Dear Mr. Caton:

On December 29, 1994, Frank McKennedy, representing the United States Telephone Association (USTA), had delivered to Dr. Anthony Bush of the Common Carrier Bureau Tariff Division the attached information. This information was prepared in response to a request by Dr. Bush and generally provides details of the Total Factor Productivity study filed by USTA in this proceeding.

An original and two copies of this ex parte notice and attachments are being filed in the Office of the Secretary on December 29, 1994. Please include this notice and attached material in the public record of these proceedings.

Respectfully Submitted,

Frank G. McKennedy
Director - Policy Analysis

cc: Dr. Anthony Bush

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

Dr. Bush:

The following are USTA's responses to the information you requested with the exception of items regarding aggregation of the capital accounts, an updated Christensen TFP study and composite depreciation rates, all of which may be available the first week in January.

Book value and replacement value for investment for 1984 benchmark. Also need to explain rationale for benchmark.

The benchmark is for end-of-year 1984.

Rationale for benchmark
The quantity of capital stock for each asset class is calculated using the perpetual inventory capital stock equation:

$$K_t = (1 - \delta) \cdot K_{t-1} + I_t$$

where

K_t = the quantity of capital stock at the end of year t
I_t = the quantity of investment during year t
δ = the economic rate of replacement.

To apply the perpetual inventory equation, a starting value, or benchmark for capital must be calculated. The replacement values we obtained from the LECs represent current value of gross stocks. Though both the current value of gross stock and the quantity of capital stock, K_t, are representations of total plant in service, they are based on different assumptions regarding the relative efficiency of assets as they age. Therefore (as explained below in Question 7), the replacement values needed to be adjusted to represent the benchmark net stock. Replacement values were provided to us for the year 1984. Given that 1984 was the first year of our study, it was a logical candidate for the benchmark year.

Thorough explanation of Local Price Index derivation. How was it derived and the rationale for the method.

The LECs provide comprehensive information on their intrastate rate changes in the Form M report. We use this information to develop price indexes for local service, intrastate access service, and long distance service. In the Form M, the LECs report the impact of rate changes in terms of changes in revenue. Using the same methods employed in previous Bell System total factor productivity studies, these changes in revenue are converted into a percentage

change in the rate level. These percentage changes in the rate level are then used to construct a price index. The following describes the method.
(Response continued on next page)
(Continued from prior page)

The change in the average price level for year t, relative to the price level in year t-1, is determined by three factors: (1) net credits effective for the year; (2) the effective value of any rate changes that occur during the year; and (3) any carryover from the previous year's rate changes (i.e., the difference between the previous year's annualized value of rate changes and effective value of rate changes). The following formula incorporates these three factors:

$$P_t/P_{t-1} = [(R_t/(R_t - C_t))/(R_{t-1}/(R_{t-1} - C_{t-1}))]$$

$$\cdot R_t \,/\, \{R_t - E_t - [(A_{t-1} - E_{t-1})\cdot(R_t/R_{t-1})]\}$$

where

P_t = price level in year t
R_t = reported revenue in year t
C_t = net credits in year t
E_t = effective value of rate change in year t
A_t = annualized value of rate change in year t

The first line of the formula, $[(R_t/(R_t - C_t))/(R_{t-1}/(R_{t-1} - C_{t-1}))]$, adjusts revenues for years t and t-1 by net credits in each year. Once revenues are adjusted for credits, the second line of the formula, $R_t \,/\, \{R_t - E_t - [(A_{t-1} - E_{t-1})\cdot(R_t/R_{t-1})]\}$, represents the computation of a rate index that is the ratio of revenues in year t to revenues in year t, net of rate changes. Essentially, this is a Paasche price index with price changes evaluated at current year quantities.

Examining the components of the denominator of the second line, $R_t - E_t$ represents year t revenues, net of the effective value of rate changes in year t. The data provided in the Form M are stated in terms of the <u>annualized value</u> of each rate change. Thus when the Form M reports a local rate increase of $20 million, this means that with no change in quantities, the rate change will increase revenue annually by $20 million. However, if a rate change is not initiated at the beginning of the year (January 1), booked revenue for that year will only reflect a portion of the annualized value, since the new rate was not in effect for the full year. Since the price indexes we are constructing are intended to represent the average price level for the year, the <u>effective value</u> of the rate change in the first year must be calculated. The effective value is equal to the annual value times the fraction of the year that the new rate was

in effect.

For example, if the $20 million rate change goes into effect halfway through the year (July 1), the effective value will be
(Response continued on next page)

(Continued from prior page)

$10 million, and this will be the magnitude of the rate impact on booked revenue during the first calendar year. During the second calendar year, booked revenue will reflect the full $20 million rate change. In order to construct a price index that correctly converts booked revenue to quantities, the price index must incorporate the effective value of the rate change in the first calendar year, then incorporate the remaining amount of the annualized value (i.e., the carryover) in the second calendar year.

A_{t-1} - E_{t-1} represents the carryover of year t-1 rate changes into year t. This carryover acknowledges that not all rate changes become effective on January 1 and, therefore, have an impact in the following year. R_t/R_{t-1} adjusts the carryover for year t scale (i.e., year t revenues relative to year t-1 revenues).

In summary, the denominator of line 2 represents year t revenues net of rate changes. This is obtained by adjusting R_t for effective rate changes in year t and the carryover of year t-1 rate changes.

Once the change in the price level is computed for each year of the study, an index of annual rate levels can be computed by initializing the index at 1.0 in 1984. The index level for each subsequent year is based on the percentage change in the price level for that year over the previous year.

Exhibit 1 provides sample calculations. Dollar amounts are the same for both the rate increase and decrease examples. Revenues are $10,000 in year t and $9,100 in year t-1. The annualized rate change in year t (A_t, not shown) is $400 and occurs on July 1. Therefore, the rate change for year t is in effect for 50% of that year, producing an effective amount in year t (E_t) of $200 (.5 * 400). Note that the remaining $200 of the year t rate change will become a carryover in year t + 1. In addition, there is a carryover rate change from year t-1 that must be considered in year t. In year t-1, a rate change occurred on June 5 with an annualized value (A_{t-1}) of $400. Thus, in t-1, the rate change was effective for 57.5% of the year, producing an effective rate change in t-1 (E_{t-1}) of $230 (.575 * 400) that was included in the year t-1 change. This leaves a carryover of the t-1 rate change into year t of $170 ($A_{t-1}$ - E_{t-1} = 400 -

230). Credits in both t-1 and t (C_t, C_{t-1}) are $300.

Elaborate on services in nonregulated dollars.

When using Form M data, it is important to make adjustments for changes in accounting definitions. In particular, the mandated accounting revisions in 1988 (USOAR) must be addressed. The primary difference between reported miscellaneous operating revenue through 1987 and reported miscellaneous operating revenue beginning in 1988 is revenue from certain nonregulated services. Beginning in 1988, all revenue from nonregulated services that had joint and common costs with regulated services were reported in miscellaneous operating revenue. Specifically, for the 1988-92 portion of the study, nonregulated revenues are found in account 5280 under miscellaneous revenues.

Before 1988 this was not the case. Prior to USOAR, nonregulated revenues were "below the line" items that went into computing line 17, item 317, Income from nonregulated activities, on Schedule 11 of the Form M. To maintain consistency over the entire study period, the companies were asked to identify the dollars that went into computing line 17, item 317 over the 1984-87 period. The LECs provided Christensen Associates with adjustments for the 1984-87 period in order to put revenues from the two periods (1984-1987 and 1988-1992) on a consistent accounting basis. These adjustments apply to the miscellaneous services category.

List and provide dollar amounts.

The companies did not provide us with service-level detail. Exhibit 2 provides nonregulated revenues reported to us for the 1984-87 period. It is believed that these revenues largely represent nonregulated billing and collection activity and inside wire.

Greater explanation of adjusted revenues versus operating revenues.

Two adjustments were made to operating revenues. As noted in Question 4, miscellaneous revenues were adjusted in the 1984-87 period to account for nonregulated revenues that were not reported as operating revenues on the

Form M until 1988. These adjustments correspond to the totals reported in Exhibit 2. The second adjustment is found in 1984 special access revenues. According to Bellcore, some special access revenues were mistakenly classified as miscellaneous revenues in 1984. The amount of misclassified revenues (in thousands) was $1,113,144. Originally, 1984 reported special access revenue was $990,714. Thus, 1984 special access revenue was increased to $2,103,858 ($990,714 + $1,113,144) and 1984 miscellaneous revenue was reduced by the $1,113,144 adjustment.

Explain how and where billed revenues are used.

Generally, the output quantity indexes are obtained by dividing revenues by a corresponding price index. However, for intrastate access and long distance service, there is a potential mismatch of revenues and price indexes. In both cases, the price index represents the prices paid by customers, while revenue represents the revenue received by the companies. Because of the settlements process, the revenue received by the company (referred to as "booked" revenue) does not equal the amount paid by the customer (referred to as "billed" revenue). Consequently, we obtain quantity indexes for intrastate access and long distance services by dividing billed revenue for these services by the corresponding price index.

Theoretical and practical derivation of economic stock adjustment factors. What is the rationale for them.

We calculate a 1984 benchmark for each asset class, based on the 1984 replacement cost as provided by the LECs. This 1984 replacement cost is a "current cost of gross plant" measure. That is, gross capital stocks of different vintages are repriced to provide a common basis of valuation. However, as noted in Question 2, the quantity of capital stock in any period, K_t, is based the relative efficiency of assets as they age. Therefore, to obtain the quantity of capital stock, it is necessary to adjust the replacement cost for the age distribution of the assets.

The U.S. Bureau of Economic Analysis (BEA) reports the age distribution of the relevant assets for the telecommunications industry. It is also possible to derive the replacement cost for the telecommunications industry with the BEA data. Therefore, by comparing the BEA replacement cost measure to the BEA quantity of capital stock measure, a ratio of quantity of capital stock to replacement cost can be obtained for the industry. This industry ratio is applied to the 1984 LEC replacement cost to obtain benchmark values of the quantity of capital stock for each asset class in our study.

December 29, 1994 Christensen Revised Responses to FCC Data Request

LEC planning cost of capital as opposed to Moody's yield on public utility bonds. Why was Moody's used and not the LEC's cost of capital.

The LECs did not provide us with their planning cost of capital. However, changes in the Moody's yield on public utility bonds, which is a widely cited number, approximates movements in the LECs cost of capital. Our results are robust with respect to the cost of capital.

How did Christensen decide on the separability line between the operating telephone company and the whole company. How was the corporate overhead allocated to the operating telephone company and what was the dollar amount.

Our study represents telephone operating companies as defined by the Form M reporting requirements. Given that the Form M was our primary data source, we relied on FCC rules and regulations that define an operating telephone company as embodied in the Form M reporting requirements.

Railroad TFP results and Christensen filings associated with railroad TFP.

Enclosed.

DATE: **December 29, 1994**

ITEM: **Christensen Associates documents on ICC Railroad Cost Adjustment Factor (RCAF)**

The following documents should provide an informative summary of the RCAF proceedings. Included are the following:

1. October 25, 1982 statement by Caves and Christensen proposing a methodology for a productivity adjustment to RCAF.

2. March 22, 1989 decision by the ICC adopting the productivity adjustment proposed by Caves and Christensen (with some modification).

3. September 15, 1993 decision by the ICC releasing fourth quarter RCAF.

4. October 26, 1993 decision by the ICC modifying the averaging period used to calculate RCAF.

Hopefully these documents will provide a sufficient background of the RCAF proceedings.

BEFORE THE

INTERSTATE COMMERCE COMMISSION

EX PARTE NO. 290 (SUB-NO. 4)

RAILROAD COST RECOVERY PROCEDURES

-- PRODUCTIVITY ADJUSTMENT

VERIFIED STATEMENT

OF

DOUGLAS W. CAVES

AND

LAURITS R. CHRISTENSEN

October 25, 1982

TABLE OF CONTENTS

PAGE

I. The Cost Recovery Index and the Measurement of Productivity Growth 2

II. Railroad Productivity Can Be Reliably Measured and Used to Adjust the Cost Recovery Index 4

III. Derivation of the Proper Productivity Adjustment to the Cost Recovery Index 8

A. The Cost Recovery Concept 9

B. Revenues and Costs 10

C. The Allowed Rate Increase and Adjustment of the Cost Recovery Index 12

D. The Index of Rail Output 14

E. Errors in Measurement of the Unadjusted CRI ...16

IV. Computation of the Productivity Index and the Adjusted Cost Recovery Index with Actual Railroad Data 17

V. The Adjusted Cost Recovery Index Can Be Implemented On A Current Basis 24

VI. A Program to Implement the Adjusted Cost Recovery Index Using a Forecasted Productivity Index 27

VII. Implementation of the Adjusted Cost Recovery Index Without Forecasting 28

Appendix 1. Qualifications and Previous Writings on Railroad Productivity

Appendix 2. Derivation of the Productivity Index

Appendix 3. Computer Programs for Annual Index of Rail Output

Appendix 4. Computation of the Productivity Index Using Historical Data

Appendix 5. Implementation of the Productivity Index on a Current Basis

BEFORE THE INTERSTATE COMMERCE COMMISSION

VERIFIED STATEMENT OF DOUGLAS W. CAVES AND LAURITS R. CHRISTENSEN IN RESPONSE TO THE ADVANCE NOTICE OF PROPOSED RULEMAKING IN EX PARTE 290 (SUB-NO. 4)

RAILROAD COST RECOVERY PROCEDURES - PRODUCTIVITY ADJUSTMENT (49 CFR 1102)

We are Dr. Douglas W. Caves and Dr. Laurits R. Christensen. We are, respectively, Research Associate and Professor of Economics at the University of Wisconsin-Madison. We are also principals of Laurits R. Christensen Associates, Inc., a firm that conducts economic studies for both government and private clients.

We have been actively engaged since 1975 in studying productivity in the U.S. and Canadian railroad industries. Since 1976 our research has been supported by the National Science Foundation. We have published papers based on this research in the American Economic Review, the Quarterly Journal of Economics, the Journal of Political Economy, the Review of Economics and Statistics, the Bell Journal of Economics, and the Southern Economic Journal.

Several of our published papers contain measures of productivity growth for U.S. and Canadian railroads. We also submitted a verified statement on the productivity performance of U.S. railroads in Ex Parte No. 393, Standards for Railroad Revenue Adequacy. This statement was submitted on behalf of the Association of American Railroads.

In addition to our railroad research, we have studied productivity in the air, water, and truck transport industries in the U.S. and Canada. We have also published papers that focus on

the improvement of methodology for productivity measurement. Our most recent papers in this area include a publication in the Economic Journal and a forthcoming publication in Econometrica.

Full details of our qualifications and the professional papers that we have written are contained in our curriculum vitae, which are included in Appendix 1 of this statement.

I. The Cost Recovery Index and The Measurement of Productivity Growth

Under Section 203 of the Staggers Act, railroad rates may be adjusted quarterly through use of a Cost Recovery Index to be developed by the Commission. In its decision in Ex Parte No. 290 (Sub-No. 2), dated April 17, 1981, the Commission adopted a modified version of the so-called "AAR Index" as its Cost Recovery Index. This index measures the changing prices of a specific market basket of railroad productive inputs, such as labor, fuel, materials, etc. The Commission rejected the proposal to modify or correct the Cost Recovery Index for increases in railroad productivity. The Commission did not deny that improvements in productivity take place, but it found that there was no acceptable measure of productivity. The present proceeding is a direct investigation of this question of an acceptable and reliable measure of railroad productivity growth.

We have been asked by a coalition of rail shippers to develop a conceptually sound, practical methodology for adjusting the Cost Recovery Index (CRI) to reflect changes in railroad productivity, and thereby measure more accurately the actual rate increases required to offset railroad cost increases.

Our major conclusions are:

a) Use of the Cost Recovery Index without correction for productivity growth leads to a significant overstatement of the revenues needed to compensate the railroads for increased costs.

b) Reliable and acceptable measures of productivity growth can be constructed from available statistical data, and applied in a timely fashion. Where there is a delay in obtaining the relevant data, productivity growth can be forecast, using routines that we have designed.

c) The specific Productivity Index that we employ is compelled by the objective that revenues must be allowed to increase at the same rate as costs.

d) Using resources that are far more limited in scope than those available to the Commission, we show that it is feasible to accurately forecast productivity growth on an annual basis, and use such forecasts to compute an Adjusted Cost Recovery Index. Alternatively, if it were deemed undesirable to forecast productivity growth, the Cost Recovery Index could be adjusted on a delayed basis when the actual Productivity Index became known.

Section II of our testimony presents the rationale for a sound productivity index and shows that it is possible to derive reliable measures of productivity in the railroad industry. Section III describes our derivation of an index satisfying the objectives of Section 203 of the Staggers Act, as elucidated by

the Circuit Court. Technical materials supporting the derivation are found in Appendix 2. Section IV demonstrates the computation of the Productivity Index, using historical data. In Sections V and VI we discuss how the productivity adjustment can be implemented on a timely basis using data that the railroads currently supply to the Commission and to the U.S. Department of Transportation. Finally, in Section VII we describe how the Cost Recovery Index could be adjusted for productivity growth on a delayed basis using only historical data.

II. Railroad Productivity Can Be Reliably Measured and Used to Adjust the Cost Recovery Index

Productivity is a generic term referring to the efficiency with which inputs are combined to produce outputs. Hence changes in productivity are measured by comparing the growth in outputs to the growth in inputs. If output growth is more rapid than input growth, then productivity rises; if output grows more slowly than input, then productivity falls. In most cases, industries utilize more than one input to produce more than one output. Because not every element of the input bundle grows at the same rate over time, the measurement of input requires an input index. The input index is a weighted average of the rates of increase of the individual input quantities. Similarly, the measurement of output requires an output index. Productivity is then measured by comparing changes in the output index to changes in the input index.

In measuring productivity growth for the railroad industry, investigators have reported a wide range of results. This has been incorrectly interpreted by some observers to mean that it is

not possible to measure productivity growth accurately.[1] In fact an index of railroad productivity is no more difficult to measure than other indexes, such as the Cost Recovery Index, which is an input price index. In the present context the measure of productivity that we derive is compelled by the following three principles:

a) First, we note that the CRI is intended to measure the change in the prices of a broad range of railroad inputs; hence the proper measure of productivity must measure changes in a broad concept of economic efficiency. Thus we seek a measure of productivity that reflects changes in the efficiency with which all rail inputs are used to produce all freight outputs.[2]

b) Second, the productivity adjustment must be consistent with the cost recovery concept as embodied in Section 203 of the Staggers Act. In reviewing the underlying purpose of Section 203 of the Staggers Act, the U.S. Court of Appeals for the D.C. Circuit indicated the following:

> "We agree with the shippers that the principal function of the Section 203 inflationary cost index is to provide a

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1 For Example: "The crux of the Commission's rationale is that available productivity measures are ... unreliable ..." (p. 28 of May 4, 1982 Opinion of the United States Court of Appeals For the District of Columbia).

2 Such productivity measures are referred to as total factor productivity. Principles of measurement of total factor productivity for the rail industry are illustrated in our previous studies that appeared in the Bell Journal of Economics and in the American Economic Review, cited in Appendix 1.

> mechanism for recovering inflation-based costs, not to enhance revenues." (p. 22)

The Court's position is clearly that the purpose of allowing freight rates to be adjusted upward by an index of railroad costs is to permit railroad revenues to increase by as much as costs increase.[3]

c) Third, the productivity measure should use the information contained in the existing Cost Recovery Index. Thus, as shown below, we use the existing CRI in constructing the rail input index.

Using the three principles stated above, we have derived the particular index for determining allowed increases in freight rates. We have determined that index to be the CRI adjusted for a specific productivity index. As we show in the next section, the appropriate productivity index is simply an index of rail freight outputs (with revenue shares as weights) divided by an index of rail inputs (computed as the ratio of railroad costs to the Cost Recovery Index).

We emphasize that the productivity adjustment we propose is required by the three principles stated above: that the productivity measure be a broad measure of economic efficiency; that the adjustment factor be consistent with the cost recovery concept; and that the adjustment make use of the information

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[3] Two interpretations of this position are equally reasonable: first, that there be a dollar-for-dollar pass through of costs to revenues; second, that revenues be allowed to increase by the same percentage that costs increase. For present purposes, we adopt the second interpretation, although the formula would not be greatly altered by adoption of the first.

contained in the existing Cost Recovery Index. The ICC and the D.C. Circuit Court have both recognized that productivity can be an ambiguous notion. In the current proceeding, however, there is agreement as to the cost recovery concept; and thus there should be no ambiguity as to the appropriate productivity concept -- that which reconciles the current Cost Recovery Index with the agreed upon cost recovery concept.

Prior expressions of concern over the accuracy of productivity measurement have focused on the measurement of railroad output. For example the D. C. Circuit Court pointed out the ambiguity in the use of ton-miles:

> "The critical difficulty ... is establishing a proper measure of rail output. Witnesses explained that the conventional measure of railroad output -- the "ton-mile" -- produces distorted estimates of productivity trends. Under the ton-mile measure, one ton carried over ten miles and ten tons carried over one mile are treated as the same amount of railroad output. When the mix of rail traffic shifts to heavier items, like coal, "ton-miles" may increase independent of changes in railroad productivity." (D.C. Circuit Court Opinion, May 4, 1982, p. 28).

It is important to note that the productivity adjustment that we employ is not subject to this concern. In essence the concern is that the appropriate measure of output should not be distorted by changes in composition. Our measure of output is not ton-miles. It is an output index that controls for changes in the composition of output, including the length of haul and the commodity consist, and thus removes the potential distortion that could result from the use of undifferentiated ton-miles as the measure of output. Thus the issue that appeared to be the

chief stumbling block to a widely-accepted, reliable productivity adjustment has been resolved. This is shown in the next section and in Appendix 2.

III. Derivation of the Proper Productivity Adjustment to the Cost Recovery Index

The current Cost Recovery Index is a misnomer. If there is any increase in railroad productivity, the use of the CRI to compute allowed increases in freight rates will lead to an overstatement of the revenues needed to offset cost increases. The reason is easy to understand. The CRI is an index of railroad input prices, not an index of the cost of producing rail output.

This distinction can be illustrated with the use of a simple numerical example. Suppose a railroad hauls one million tons of coal per year, using one unit of labor and one unit of fuel. Moreover suppose that in the base year a unit of labor and a unit of fuel each costs $5000, so that the total cost is $10,000. Further suppose that in the following year the same volume of coal is hauled, but that both labor and fuel prices increase by 20 percent, to $6000. Then the cost recovery index will show an increase to 120 from the base year of 100, and an allowable freight rate increase of 20 percent would be prescribed. But suppose that in the same period, railroad efficiency had increased, so that the same movement requires the input of seven-eighths of a unit of labor and nine-tenths of a unit of fuel. Direct application of the cost recovery index would no longer be justified, and if applied would increase rail freight rates by

more than enough to compensate for the increase in the costs of the movement. In this particular instance, the cost of the movement has increased from $10,000 to $10,650.[4] Actual railroad costs have risen by $650, not $2000, and the properly adjusted cost recovery index is thus 106.50.[5] The allowable freight rate increase should thus be based on the adjusted cost recovery index (106.50) not the unadjusted index (120).

A. The Cost Recovery Concept

The starting point of our derivation of the appropriate productivity adjustment is the cost recovery concept: We are seeking to determine what across-the-board freight rate increase would be required to generate an increase in revenue equal in proportion to the increase in costs. The cost recovery concept can be precisely represented by the following simple equation:

$$(1) \quad \frac{\text{Revenue (1)}}{\text{Revenue (0)}} = \frac{\text{Cost (1)}}{\text{Cost (0)}}$$

Cost (0) represents rail costs in the base period.[6] Revenue (0)

---

4 Seven-eighths of a unit of labor x $6000 plus nine-tenths of a unit of fuel x $6000.

5 To anticipate the derivations to follow, the Adjusted CRI is obtained from division of the CRI by the Productivity Index of 112.68. The latter is the ratio of the index of output (in this case 100) to the index of input (in this case 88.75). The input index is obtained as a weighted average of the input combinations: .875 (with a weight of one-half) and .9 (with a weight of one-half). In the derivations shown below the input index will be calculated as the ratio of the increase in total cost to the Cost Recovery Index.

6 Throughout this verified statement we measure cost as the railroads' outlays for all of the items included in the bundle represented in the Cost Recovery Index. This includes railway operating expenses plus fixed charges.

represents base period rail revenues. Cost (1) represents rail costs in the comparison period. Revenue (1) is the revenue that is needed in the comparison period to make the equality hold. It is the level of revenue that assures revenues and costs change in the same proportion between the base period and comparison period.[7]

B. Revenues and Costs

Revenues in the base period are the sum of revenues on each individual freight movement, or Rates (0) times Rail Output (0). The revenues in the comparison period would be provided by an equal percentage change in all freight rates. That is, the revenues in the comparison period are hypothetical revenues to be yielded by changing all base rates by the same factor. Let us say that the factor for changing the base rates is g. Then Revenue (1) = Rates (0) x g x Rail Output (1).

If we write the foregoing information in equation form we have the following:

---

[7] An example may help to clarify equation (1) as a statement of the cost recovery concept. Suppose that costs increased by 66.5 percent from the base period to the comparison period. Then Cost (1)/Cost (0) = 1.665. The cost recovery concept requires that revenue also increase by 66.5 percent, Revenue (1)/Revenue (0) = 1.665. This is not the same as saying base rates need to increase by 66.5 percent, because the increase in revenues will reflect some change in base rates and some change in freight movements. (Hereafter we use the term "freight movement" to refer to railroad outputs distinguished by commodity and by lenght of freight haul.) Our goal is to determine the required change in base rates. As we show in the following text this requires knowledge of the change in freight movements.

$$(2)\quad \frac{\text{Revenue }(1)}{\text{Revenue }(0)} = \frac{\text{Rates }(0) \times g \times \text{Rail Output }(1)}{\text{Rates }(0) \times \text{Rail Output }(0)}$$

$$= g \times \frac{\text{Rail Output }(1)}{\text{Rail Output }(0)}$$

Note that equation (2) indicates that the ratio of required revenue in the comparison period to actual revenue in the base period is equal to the factor for changing the base rates, g, times an Index of Rail Output. In the next section we will show how to measure this Index of Rail Output. Here we simply note its existence and rewrite equation (2) to convey that fact:

$$(2')\quad \frac{\text{Revenue}(1)}{\text{Revenue}(0)} = g \times \text{Index of Rail Output}$$

The object of the exercise is to find the value of g, the across-the-board change in base rates, i.e., the allowed cost recovery rate increase. We find g through the following steps.

First rewrite equation (2'), putting the allowed rate increase g on the left hand side:

$$(3)\quad g = \frac{\text{Revenue}(1)}{\text{Revenue}(0)} \div \text{Index of Rail Output}$$

Second, recall that required revenues must change in the same proportion as total costs, as shown in equation (1). Substitute this information into equation (3) to obtain equation (4):

$$(4)\quad g = \frac{\text{Cost}(1)}{\text{Cost}(0)} \div \text{Index of Rail Output}$$

Equation (4) is the fundamental result. It states that the

proper rate of increase of base period freight rates is the proportionate increase in costs divided by the Index of Rail Output. Equation (4) provides the allowed rate increase appropriate to recover the increase in rail costs. It is compelled by the requirement that revenues increase by the same proportion as costs.

C. <u>The Allowed Rate Increase and Adjustment of the Cost Recovery Index.</u>

We use equation (4) to demonstrate the proper method of adjustment of the Cost Recovery Index. We rewrite equation (4) by multiplying and dividing its right hand side by the Cost Recovery Index:

$$(5) \quad g = \left[\frac{\text{Cost (1)}}{\text{Cost (0)}} \div \text{Index of Rail Output}\right] \times \frac{\text{CRI}}{\text{CRI}}$$

Now, rearrange terms on the right-hand side to derive:

$$(5') \quad g = \text{CRI} \div \left[\frac{\text{Index of Rail Output}}{\frac{\text{Cost (1)}}{\text{Cost (0)}} \div \text{CRI}}\right]$$

The bracketed term on the right hand side of (5') is a Productivity Index. To see this, note that the numerator is an index of output, while the denominator is an index of input, for it is an index of total costs deflated by the CRI. Hence (5') can be written as:

$$(6) \quad g = \text{CRI} \div \frac{\text{Index of Rail Output}}{\text{Index of Rail Input}}$$

$$= \text{CRI} \div \text{Productivity Index}$$

$$= \text{Adjusted Cost Recovery Index.}$$

Thus we have arrived at the following conclusions:

(a) The allowed increase in base rates, g (hereafter, the "Adjusted Cost Recovery Index") is equal to the Cost Recovery Index divided by the Productivity Index. This is shown above in equation (6).

(b) The Productivity Index is the Index of Rail Output divided by the Index of Rail Input.

(c) The Index of Rail Input is equal to the increase in rail costs divided by the Cost Recovery Index:

$$(7) \quad \text{Index of Rail Input} = \frac{\text{Cost}(1)}{\text{Cost}(0)} \div \text{CRI}$$

(d) Thus, the measurement of the rail Productivity Index and the calculation of the Adjusted Cost Recovery Index follow directly from the cost recovery concept and the existing CRI.[8]

(e) Computation of the Productivity Index requires two sets

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[8] The practice of basing allowable rate increases on input price increases adjusted for productivity growth has been recommended by other economists who have written on regulatory issues. For example, William J. Baumol, writing in the Public Utilities Fortnightly ("Productivity Incentive Clauses and Rate Adjustment For Inflation"), recommends an inflation pass-through for public utility rates, calculated as the excess of a forecasted rate of input price inflation over a forecasted rate of productivity growth [p. 16, PUF July 22, 1982]. Baumol suggests use of the forecasted rather than actual rates of inflation and productivity growth to avoid reducing the incentive of regulated firms to engage in technological and productive improvements. The effect of a productivity correction on incentives is discussed by Dr. George H. Borts in his testimony in this proceeding on behalf of the Western Coal Traffic League and the Consumer Owned Power Coalition. Dr. Borts and we agree that the productivity correction proposed by Baumol, which is identical in concept to the one we propose, will not discourage firms' innovative activities.

of calculations: an Index of Rail Output and an Index of Rail Input. The latter index can be directly calculated from published data on rail costs and the Cost Recovery Index. Thus the only new computation that is required is the Index of Rail Output. This is discussed immediately below.

D. The Index of Rail Output

The Index of Rail Output measures the average increase in freight movements of diverse types between the comparison period and the base period. We demonstrate in Appendix 2 that the proper way to compute this average (consistent with the requirement that revenues and costs grow equiproportionately) is as follows:

$$\text{(8)} \quad \text{Index of Rail Output} = \text{Revenue Share Movement } a(0) \times \frac{\text{Freight Movement } a(1)}{\text{Freight Movement } a(0)}$$

$$+ \text{Revenue Share Movement } b(0) \times \frac{\text{Freight Movement } b(1)}{\text{Freight Movement } b(0)}$$

$$\vdots$$

$$+ \text{Revenue Share Movement } n(0) \times \frac{\text{Freight Movement } n(1)}{\text{Freight Movement } n(0)}$$

Equation (8) indicates that the proper measure of the Index of Rail Output is a weighted average of the proportional increases in all types of freight movements, where the weights are revenue shares in the base period. We emphasize that use of an output index employing revenue shares as weights is compelled by the condition that revenues and costs rise equiproportionately.

We illustrate the computation of the output index by

supposing there are three types of freight movements, with the following characteristics in the base and comparison periods:

Freight Movement	Ton-Miles Base Period	Ton-Miles Comparison Period	Revenue Share in Base Period
a	100,000	105,000	.19
b	1,000,000	1,300,000	.25
c	500,000	510,000	.56
Total	1,600,000	1,915,000	1.00

The rail output index is calculated as a revenue-share weighted sum of ton-mile relatives:

	(1) Ton-Mile Relative [TM(1)/TM(0)]	(2) Revenue Share	[(1) x (2)]
a	1.05	.19	.1995
b	1.30	.25	.3250
c	1.02	.56	.5712
			1.0957 = Output Index

The output index is 1.0957. An index based on ton-miles would be 1.1969 (the ratio of 1,915,000 to 1,600,000). The output index in this example has a smaller value than the unweighted ton-mile index, because the most rapidly growing component (b) has a smaller base year revenue weight (.25) than its importance in the base year ton-mile total (.625). If the mix of rail output shifts to bulk items like coal, the output index will show smaller increases than an index based on total ton-miles. Note that in the foregoing example use of a ton-mile index to compute productivity would result in an <u>overstatement</u> of productivity -- hence the average rate increase required to cover cost increases would be <u>understated</u>. There is no such distortion, however, with