DETERMINATION OF THE X FACTOR FOR THE
REGULATION OF TELEFONICA DEL PERU

A Report to OSIPTEL

By

Christensen Associates

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EXECUTIVE SUMMARY

Introduction

OSIPTEL is responsible for regulating telecommunications service in Peru. According to Clause 9 of the Concession Contract with Telefónica del Perú (TdP), OSIPTEL will establish a price cap regulation plan for TdP after a limited competition period is over. Accordingly, it has retained Laurits R. Christensen Associates, Inc. to review design options and quantify the X factor that will be used in Peru’s telecommunication price cap plans.

Price cap regulation is intended to attain more desirable combinations of company performance and regulatory cost than are possible under traditional forms of regulation, such as cost-of-service or rate-of-return regulation. To the extent that the goal is met, it is possible to attain higher levels of productive and allocative efficiency from a given or reduced level of regulatory cost.¹

Price caps make use of automatic rate adjustment procedures that are established in advance of their operation. The use of such procedures can reduce the frequency and scope of regulatory intervention, and therefore reduce regulatory costs. They also strengthen the regulated firm’s performance incentives to the extent they discourage frequent changes in regulatory rules.

In this report, we review the conceptual framework of price cap regulation, provide the calculation of the X factor for TdP’s price cap formula, and provide our recommendations to OSIPTEL.

¹ Productive efficiency means the firm produces output at the minimum possible cost. Allocative efficiency is determined by the extent to which consumer surplus is enhanced.
The report has four chapters. Chapter 1 presents a conceptual framework and surveys price cap design options. Chapter 2 presents the results of the TFP study that is the basis of the X factor. Chapter 3 presents the calculation of the X factor, and Chapter 4 summarizes our findings and recommendations. In this Executive Summary, we provide an overview of our report and findings.

**Conceptual Framework**

A price cap mechanism effectively sets a ceiling on prices. The price cap index (PCI), which sets a ceiling on the regulated firm’s price changes, has the general formula:

\[ dPCI_j = dI - X \]

where \( dPCI_j \) is the rate of change in the price cap index applicable to industry \( j \), \( dI \) is the growth rate in an inflation measure that is external to (that is, not controlled by) the regulated firm,\(^2\) and the \( X \) factor represents the annual real price decrease that is promised to consumers.

The PCI’s construction depends upon the observation that the trend in the prices charged by a competitive industry is the trend in its unit cost. In a competitive market, the benefits of efforts to slow unit cost growth are passed to customers in the form of slower price growth. Since the industry unit cost trend is insensitive to individual firm actions, companies in competitive markets have strong incentives to slow unit cost growth.

An important undertaking in designing a price cap plan is establishing a value for the X factor. There have been two general approaches to setting the X factor for price cap regulation. They have been referred to as the “American” approach and the “British” approach. The American approach is based on estimating total factor productivity (TFP) and input price

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\(^2\) In many price cap applications, this inflation measure is some economy-wide measure of output inflation such as the Consumer Price Index or the Gross Domestic Product Price Index.
differentials to determine X, and is the approach that is taken in this report. Using the American approach, the X factor is established as:

$$X = (dW_E - dW_{tel}) + (dTFP_{tel} - dTFP_E)$$

The first term on the right hand side of the expression is the difference between the rate of economy-wide input price growth and telephone industry input price growth (the input price differential) and the second term is the difference between the targeted rate of telephone industry total factor productivity growth and economy-wide total factor productivity growth (the TFP differential).

The British approach takes more of a rate-of-return, or cost-of-service approach to establishing the X factor as the X factor is based on forecasts of firm performance such as revenue requirements, rates of return, and expected demand. Regulators often examine detailed data submitted by individual companies in an attempt to determine the efficient cost levels. Indeed, it is fair to call the British approach to price cap regulation “indexed cost of service regulation.” The primary difference between the British approach to price caps and U.S. cost of service regulation is that the former uses indexing methods to extend the period between rate cases. At its best, this can lead to stronger incentives since companies can be assured that gains from performance improvements will be retained for a known period of time. At its worst, regulators can intervene within price cap periods if there are unexpected earnings outcomes.

The establishment of X factor values, whether by the American or British approach, should provide appropriate incentives to the regulated firm and protections and benefits to consumers similar to those found in competitive markets. This includes sufficient risk/reward incentives for the firm, and competitive prices and quality of services for consumers. In our
opinion, the American approach has greater potential to fulfill these requirements than the British approach.

**Latin American Approaches and Experience**

A number of Latin American countries have implemented price cap regulation for their telecommunications industries. Here we provide a brief survey of their experience.

**Argentina**

In 1990, telecommunications price cap plans were inaugurated for Argentina’s major utilities (Telefónica de Argentina S.A., Telecom Argentina Stet France Telecom S.A.).\(^3\) The plans, which separately apply to local calls, domestic long-distance calls, and international long-distance calls, originally contemplated monthly tariff adjustments based on the domestic consumer price index (CPI). The mechanism was changed to adjust prices only twice each year using the U.S. CPI as the price reference.

As shown in Table E.1, the price cap plans have three implementation stages. Each stage has a successively higher X factor.\(^4\) The plans have now entered into the extended exclusivity period, and the corresponding X factor is now being applied.\(^5\)

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\(^4\) We have not been able to identify the criteria by which Argentina obtained its X factors.

\(^5\) See for instance Resolución No. 2465/98 (Pricecap TASA) and Resolución 2466/98 (Pricecap TECO) issued by the Secretaría de Comunicaciones on November 5, 1998.
The companies are allowed a 16% rate of return on fixed assets (ROR). If the ROR exceeds this target level then a tariff reduction, in addition to that required by the price cap mechanism, is warranted. On the other hand, if the ROR falls below the target level, then the company is entitled to compensation in the form of more moderate tariff reductions or, if necessary, outright increases in tariffs.

**Mexico**

With its privatization in 1990, price cap plans began for Teléfonos de México, S.A. (Telmex) and its subsidiary Telefónos del Noroeste S.A. (Telnor).6 The price cap index formula considers the possibility that inflation may be high. The explicit formula, which is to be applied to quarterly price adjustments, is:

\[
\frac{PCI_t}{PCI_{t-1}} = (1 - X) \left[ \frac{I_{t-1}}{I_{t-2}} \right]
\]

---

where $PCI_t$ is the price cap index for year $t$, $X$ is the productivity adjustment factor for the Mexican telecommunications sector, and $I$ is the national consumer price index that is published by the Bank of Mexico.

Mexico’s price cap plan was initially defined for the period 1991-1998 and has now been replaced with a new tariff plan for the period 1999-2002. As indicated by Table E.2, the services covered by the plan are identical in both periods except that, during the first period, the maximum rate of adjustment for local calls was directly specified by SECOM (Secretaría de Comunicaciones).

### Table E.2

<table>
<thead>
<tr>
<th>Phase</th>
<th>Services</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991-1996</td>
<td>Installation charges</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td>Customer charge</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Domestic long distance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>International long distance</td>
<td></td>
</tr>
<tr>
<td>1997-1998</td>
<td>Installation charges</td>
<td>3.0%</td>
</tr>
<tr>
<td></td>
<td>Customer charge</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Local measured calls</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Domestic long distance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>International long distance</td>
<td></td>
</tr>
<tr>
<td>1999-2002</td>
<td>Installation charges</td>
<td>4.5%</td>
</tr>
<tr>
<td></td>
<td>Customer charge</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Local measured calls</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Domestic long distance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>International long distance</td>
<td></td>
</tr>
</tbody>
</table>

The plan presents criteria for updating the productivity adjustment factor. The application of the Mexican price cap formula requires that the initial rates and the $X$ factor be specified with the aid of a long-run incremental cost methodology. These two elements (initial

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7 In the Mexican telco plan the price cap index ratio $\frac{PCI_t}{PCI_{t-1}}$ is labeled the ‘controlling factor’ (Factor Controlador), and denoted $F_t$.

rates and $X$ factor) must be set such that revenue collected from the basic service basket allows the firm to obtain an internal rate of return that is equal to the weighted average cost of capital. Once the initial rates were specified, the productivity factor was then adjusted in order to fulfill this requirement.

**Colombia**

In 1997, the Colombian Telecommunication Regulation Commission (CRT) established the present price cap method for the tariff regulation of Empresa de Telecomunicaciones de Santafé de Bogota (E.T.B) and a group of about 25 other regional and municipal phone companies. The new mechanism was valid for the years 1997-2000. Prior to that, the tariff adjustment was based on an indexing method that accounted for inflation but did not include any kind of productivity offset. The current formula is:

$$\frac{C_{t+1}}{C_t} - 1 = I_t - X$$

where $C_t$ is the annualized component of the long-run average cost per telephone line, calculated for a period equivalent to the expected life span of the system, considering both the existing line capacity and projected expansions; $I$ is the expected economy-wide inflation rate forecast by the Banco de la Republica; and $X$ is the productivity adjustment factor. This formula is used to update the fixed consumption and connection charges of both local and extended-local services.

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9 Among the service flows that are considered relevant for this purpose are: the replacement value of the existing assets, the income flow resulting from new investments, the income and expenditures associated with the regulated services, the life span of the assets used to provide these services, and the terminal values of these assets.

10 Comisión de Regulación de Telecomunicaciones, Resolución 87/97, “Por Medio de la cual se Regula en Forma Integral los Servicios de Telefonía Pública Básica Conmutada (TPBC) en Colombia,” 5 de setiembre de 1997.
The X factor for 1997 was zero. For the period 1998-2000 the X factor was set equal to 2.0%. Information suggests this X factor is still in effect. There is no indication as how this value was obtained.

**Brasil**

Beginning in 1998, price caps were applied to Brasil’s 31 local phone companies and one international long-distance company.\(^\text{11}\) The companies must meet certain guidelines regarding service quality and reliability. The companies’ franchises expire in 2005 but may be extended to 2025 for those companies that comply with certain requirements, including universal service goals.

The indexing formula is identical to the one used to regulate telephone tariffs in Mexico, except that the inflation measure refers to the current instead of the previous period. Another material difference is that price increases that are allowed but unused in one period are not available to the supplier in subsequent periods. Furthermore, Brasilian tariffs are adjusted in intervals of not less than 12 months. Economy-wide inflation is measured by the Consumer Price Index – Internal Supply (Indice Geral de Precos, Disponibilidade Interna) published by the Fundacao Getulio Vargas. Table E.3 summarizes the key features of the Brasilian price cap plans.

Table E.3
Baskets and X Factors of the Brasilian Price Cap Plans

<table>
<thead>
<tr>
<th>Basket</th>
<th>Dates</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic local service</td>
<td>1998-2000</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td>2001-2005</td>
<td>1.0%</td>
</tr>
<tr>
<td>Local network usage</td>
<td>1998-2000</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td>2001</td>
<td>5.0%</td>
</tr>
<tr>
<td></td>
<td>2002</td>
<td>10.0%</td>
</tr>
<tr>
<td></td>
<td>2003</td>
<td>15.0%</td>
</tr>
<tr>
<td></td>
<td>2004-2005</td>
<td>20.0%</td>
</tr>
<tr>
<td>Basic domestic long distance service</td>
<td>1998-2000</td>
<td>2.0%</td>
</tr>
<tr>
<td></td>
<td>2001-2003</td>
<td>4.0%</td>
</tr>
<tr>
<td></td>
<td>2004-2005</td>
<td>5.0%</td>
</tr>
<tr>
<td>Inter-urban network usage</td>
<td>1998-2000</td>
<td>2.0%</td>
</tr>
<tr>
<td></td>
<td>2001-2003</td>
<td>4.0%</td>
</tr>
<tr>
<td></td>
<td>2004-2005</td>
<td>5.0%</td>
</tr>
<tr>
<td>International long distance</td>
<td>1998-1999</td>
<td>5.0%</td>
</tr>
<tr>
<td></td>
<td>2000-2005</td>
<td>15.0%</td>
</tr>
</tbody>
</table>

TFP Measurement for Telefonica del Peru

As discussed above, the X factor is based on TFP and input price differentials between the regulated industry and the economy as a whole. TFP is the ratio of Total Output to Total Input. TFP growth is equal to Total Output growth minus Total Input Growth. Total Output is made up of the various categories of services produced by TdP. Total Input is made up of three basic factors of production used to produce these services: capital; labor; and materials, rents, and services (commonly referred to as materials). Input price is the aggregate price of these factors of production.

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12 The X factor is called the “fator de transferencia” in the Brasilian plan.
13 Charges include the access charge, customer charge, and metered services (pulsos).
14 Tariffs are distinguished according to hour and geographic distance of calls (a total of 24x5 types).
15 Tariffs are distinguished according to hour and geographic distance of calls (a total of 24x5 types).
16 Tariffs are distinguished according to hour and country location (a total of 24x9 types).
Based on data provided by TdP, Christensen Associates conducted a TFP study of TdP’s consolidated operations only for the period 1995-2000. Because of data unavailability, we did not estimate TFP separately for each of the price cap service baskets.\(^\text{17}\)

**Total Output**

Total Output is based on a comprehensive measure of all the services described in TdP’s consolidated income statement, Informacion consolidada TdP. Twelve categories of output are distinguished for TdP. Table E.4 lists the output categories and the method used to obtain the quantity of output for each category. The quantity of Total Output is constructed as an index of the quantities of output for the twelve categories with each category’s revenues serving as weights.

<table>
<thead>
<tr>
<th>Category</th>
<th>Output Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly Access</td>
<td>Number of lines in service</td>
</tr>
<tr>
<td>Measured Local Service</td>
<td>Minutes of Local service</td>
</tr>
<tr>
<td>Other Local Service</td>
<td>Number of lines in service</td>
</tr>
<tr>
<td>Installation</td>
<td>Number of installations</td>
</tr>
<tr>
<td>International Long Distance</td>
<td>Number of International minutes</td>
</tr>
<tr>
<td>National Long Distance</td>
<td>Number of National minutes</td>
</tr>
<tr>
<td>Public Telephones</td>
<td>Number of Public minutes</td>
</tr>
<tr>
<td>Mobile Services</td>
<td>Number of Mobile service lines</td>
</tr>
<tr>
<td>Cable TV</td>
<td>Number of subscribers</td>
</tr>
<tr>
<td>Business Communications</td>
<td>Deflated revenues</td>
</tr>
<tr>
<td>Telephone Directories</td>
<td>Deflated revenues</td>
</tr>
<tr>
<td>Other Services</td>
<td>Deflated revenues</td>
</tr>
</tbody>
</table>

\(^\text{17}\) It is important to note that separate TFP estimates for subsets of TdP’s services would not be based on an economically valid measurement of TFP. This is because, unless the services are produced with no joint and common costs, an economically arbitrary method would need to be employed to allocate joint and common inputs to individual services.
Total Input

The quantity of Total Input is constructed as an index of the quantities of labor, materials and capital input. The costs of labor, materials and capital are used as weights in this index. The cost of Total Input is the sum of labor, materials and capital input costs.

Labor. The quantity of labor is based on consolidated TdP employee counts as in our May 1999 study. TdP provided us with average annual employee counts. To adjust for labor that is capitalized, we take the average number of employees during the year and multiply it by the fraction of total labor expenses that are included in operating expenses.

Materials. Materials input includes all goods and services purchased from other firms for use in the provision of telephone services. The most common approach used for measuring the quantity of materials in productivity research is to deflate materials expense by a price index of materials. For the current TdP study, the cost of materials is computed in the following manner. For the years 1995-1997, the cost of materials is taken from the report Gastos operativos TdP and computed as “total de gastos” less “sueldos y salarios,” less “beneficios del personal,” less “depreciacion y amortizacion.” For the years 1998-2000, the cost of materials is computed from Gastos Operativos TdP Consolidado as “total de gastos” less “personal,” less “depreciacion.” In all years, capitalized labor expense (“trabajo para el immovilizado”) is added to account for the adjustment made to labor expense as described above. The quantity of materials is computed by dividing the cost of materials by the Deflactor del PBI.

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18 While TdP was able to provide a detailed breakdown of employees by type, unfortunately labor expense data was not available by the same breakdown. This expense data would be needed to aggregate the employees by type into an overall labor quantity index.
19 Total operating expense contains one line for total personnel expense and a second line (which acts as a credit) that is the amount of personnel expense going to “own work capitalized.” The personnel expense booked to operating expense is the net of these two amounts.
Capital. The quantity of capital input is determined by the flow of services from plant and equipment used in the provision of telephone service. Each item of plant and equipment is weighted by its relative level of efficiency.

A common approach to measuring capital input is to use the perpetual inventory equation:

\[ K_t = (1 - \delta) \cdot K_{t-1} + I_{t-1} \]

In order to implement the equation, one must develop a time series of investment (I), choose a geometric rate of efficiency decline, and obtain a starting point for the capital input quantity (K).

The data required to implement the perpetual inventory approach to capital input measurement are substantial. In the case of the current TdP study, data on gross additions and a benchmark capital stock figure were not available. Therefore, we use a method similar to the method we employed in our 1999 study. We based the quantities of capital input on the net book value at the end of each year. These end-of-year values are assumed to be equal to the beginning-of-year values for the next year. For the years 1994-1997, the data come from the fixed asset accounts, Activo Fijo. For 1998-2000, the data come from the consolidated accounts, Activo Fijo Consolidado.

The quantity of stock at the end of each year is computed by dividing net book value by a price index based on the adjustment factors used in the book value calculations. In other words, the gross book value of plant at the end of one year is equal to the gross book value of plant at the end of the previous year, revalued by the increase in Wholesale Price Index, plus gross additions, less retirements (properly revalued). Net book value is obtained by subtracting the depreciation balance, which is also revalued yearly using the Wholesale Price Index. We distinguish nine types of capital for TdP:
The theory of capital measurement weights the capital input quantity of each asset class by an estimate of its relative efficiency. This estimate is based on the imputed rental value of a new asset in that class. The Christensen-Jorgenson rental value equation is used to compute service prices. This equation is computed for each of the nine asset categories, \( K_i \), in the study:

\[
q_{i,t}^*K_{i,t-1} = \left(\frac{1}{1 - u_t}\right) * (r_t*p_{i,t-1} + \delta_t*p_{i,t} - (p_{i,t} - p_{i,t-1}))* K_{i,t-1}
\]

where \( q_{i,t}^* \) represents the rental price of the asset \( i \) in year \( t \), \( u_t \) represents the effective income tax rate in year \( t \), \( p_{i,t} \) is the price index of investment category \( i \) in year \( t \), \( r_t \) is the incremental cost of capital in \( t \), and \( \delta_t \) is the geometric rate of replacement for category \( i \).

**Input Price Growth.** The price of Total Input is equal to the cost of Total Input divided by the quantity of Total Input, and the growth in Total Input price (i.e., input price growth) is equal to the growth in Total Input cost minus the growth in Total Input quantity. Both Total Input cost growth and Total Input quantity growth can be computed from the Total Input computations of the TFP study. Total Input cost is the sum of labor, materials and capital costs. As described above, Total Input quantity is a Tornqvist index of the quantities of labor, materials and capital.
TFP Results

Over the 1995-2000 period, average annual growth in Total Output for TdP was 16.3%.

However, it is apparent from Table E.5 that there is a great amount of variation across years.

Table E.5

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly Access</td>
<td>25.8%</td>
<td>13.7%</td>
<td>-5.7%</td>
<td>8.2%</td>
<td>1.7%</td>
<td>8.7%</td>
</tr>
<tr>
<td>Measured Service</td>
<td>26.5%</td>
<td>7.2%</td>
<td>0.6%</td>
<td>9.5%</td>
<td>0.0%</td>
<td>8.8%</td>
</tr>
<tr>
<td>Other Local</td>
<td>25.8%</td>
<td>13.7%</td>
<td>-5.7%</td>
<td>8.2%</td>
<td>1.7%</td>
<td>8.7%</td>
</tr>
<tr>
<td>Installation</td>
<td>-4.8%</td>
<td>-14.0%</td>
<td>-22.3%</td>
<td>5.9%</td>
<td>-39.6%</td>
<td>-14.9%</td>
</tr>
<tr>
<td>International Long Distance</td>
<td>11.6%</td>
<td>15.3%</td>
<td>5.8%</td>
<td>9.3%</td>
<td>-0.8%</td>
<td>8.2%</td>
</tr>
<tr>
<td>National Long Distance</td>
<td>22.5%</td>
<td>13.1%</td>
<td>-0.7%</td>
<td>-6.5%</td>
<td>-7.6%</td>
<td>4.1%</td>
</tr>
<tr>
<td>Public Telephone</td>
<td>16.3%</td>
<td>16.3%</td>
<td>8.8%</td>
<td>16.6%</td>
<td>23.6%</td>
<td>16.3%</td>
</tr>
<tr>
<td>Mobile Service</td>
<td>114.0%</td>
<td>89.3%</td>
<td>45.7%</td>
<td>34.4%</td>
<td>23.2%</td>
<td>61.3%</td>
</tr>
<tr>
<td>Cable TV</td>
<td>167.1%</td>
<td>91.1%</td>
<td>19.1%</td>
<td>7.0%</td>
<td>6.5%</td>
<td>58.2%</td>
</tr>
<tr>
<td>Business Communications</td>
<td>37.0%</td>
<td>16.2%</td>
<td>24.6%</td>
<td>28.0%</td>
<td>23.8%</td>
<td>25.9%</td>
</tr>
<tr>
<td>Telephone Directories</td>
<td>28.5%</td>
<td>43.7%</td>
<td>14.7%</td>
<td>0.3%</td>
<td>-17.3%</td>
<td>14.0%</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>80.1%</td>
<td>89.9%</td>
</tr>
<tr>
<td>Total Output</td>
<td>25.1%</td>
<td>23.1%</td>
<td>9.9%</td>
<td>14.0%</td>
<td>9.3%</td>
<td>16.3%</td>
</tr>
</tbody>
</table>

Table E.6 presents the annual growth rates in the quantities of capital, labor, materials and Total Input, and average annual growth rates for the 1995-2000 period.
Table E.6
TdP Input Quantity Growth Rates

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital</td>
<td>34.7%</td>
<td>18.1%</td>
<td>19.4%</td>
<td>17.1%</td>
<td>8.4%</td>
<td>19.5%</td>
</tr>
<tr>
<td>Labor</td>
<td>-30.9%</td>
<td>3.8%</td>
<td>-3.1%</td>
<td>2.4%</td>
<td>-4.0%</td>
<td>-6.4%</td>
</tr>
<tr>
<td>Materials</td>
<td>23.6%</td>
<td>31.4%</td>
<td>26.9%</td>
<td>-7.6%</td>
<td>-0.7%</td>
<td>14.7%</td>
</tr>
<tr>
<td>Total Input</td>
<td>14.9%</td>
<td>20.3%</td>
<td>19.3%</td>
<td>5.9%</td>
<td>3.6%</td>
<td>12.8%</td>
</tr>
</tbody>
</table>

Capital and materials have similar average growth rates, while labor exhibits a decline over the period. Over the 1995-2000 period, Total Input grew at an average annual rate of 12.8%, with growth lower in the later years.

Table E.7 combines Total Output and Total Input growth to produce TFP growth for TdP over the 1995-2000 period. Over this period, TFP growth averaged 3.5% annually. TdP’s input price growth is also reported in Table E.7. Over the 1995-2000 period, TdP’s input price growth averaged 4.8% annually.

Table E.7
TdP TFP and Input Price Growth

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Output Growth</td>
<td>25.1%</td>
<td>23.1%</td>
<td>9.9%</td>
<td>14.0%</td>
<td>9.3%</td>
<td>16.3%</td>
</tr>
<tr>
<td>Total Input Growth</td>
<td>14.9%</td>
<td>20.3%</td>
<td>19.3%</td>
<td>5.9%</td>
<td>3.6%</td>
<td>12.8%</td>
</tr>
<tr>
<td>TFP Growth</td>
<td>10.2%</td>
<td>2.8%</td>
<td>-9.3%</td>
<td>8.1%</td>
<td>5.7%</td>
<td>3.5%</td>
</tr>
<tr>
<td>Input Price Growth</td>
<td>15.0%</td>
<td>12.7%</td>
<td>-1.9%</td>
<td>15.0%</td>
<td>-17.1%</td>
<td>4.8%</td>
</tr>
</tbody>
</table>

TdP’s Price Cap Formula

In the 1994 Concession Contract TdP signed with OSIPTEL, Annex 3 outlines the parameters of the price cap formula that will apply to TdP. Similar to other Latin American plans, the control factor in the price cap formula is given by:

$$F_n = (1 + X) \frac{IPC_{n-1}}{IPC_{n-2}}$$
Prices are regulated by $F_n$ by requiring the actual price index ratio to be less than or equal to $F_n$:

$$RT_{jn} = \sum \left( \alpha_{ijn-1} \cdot \frac{T_{ijn}}{T_{ijn-1}} \right) \leq F_n$$

where:

- $RT_{jn}$ = Actual Price Index Ratio (Ratio Tope) for service basket “j” during the nth quarter.
- $\alpha_{ijn-1}$ = Weight assigned to service “i” of basket “j” during the previous quarter. It corresponds to service i’s revenue share in the basket j.
- $T_{ijn}$ = Tariff (Tarifa) for service “i” in basket “j” during the nth quarter.
- $F_n$ = Control factor (Factor de Control) of price cap index ratio for the nth quarter.
- $IPC_n$ = Consumer price index (Indice de Precios al Consumidor) at the beginning of the nth quarter published by the Instituto de Estadistica e Informatica (INEI).
- $X$ = Productivity factor.

The X factor in this formula is based on productivity and input price differentials. Define these differentials as follows:

a) TFPD = the difference between the targeted rate of telephone industry total factor productivity growth and economy-wide total factor productivity growth, the TFP differential, $(dTFP_T - dTFP_E)$; and

b) IPD = the difference between the rate of economy-wide input price growth and telephone industry input price growth, the input price differential, $(dW_E - dW_T)$.

---

20 If the TFP differential was computed as $dTFP_E - dTFP_T$ and the input price differential was computed as $dW_T - dW_E$. TFPD and IPD would both be negative and the X factor would be negative.
X Factor Results

The average annual TFP and input price growth rates for TdP are combined with TFP and input price growth rates for the Peruvian economy to produce the X factor for the price cap formula. Because there are no official estimates of Peruvian TFP, we obtained information on TFP growth for the Peruvian economy from a study by Andre A. Hofman. Hofman has produced estimates through 1998 and his basic TFP methods are most consistent with those we employ in the TdP study. For purposes of the current study, we use his average growth estimate for Peru for the most recent period of his study (1994-1998), which he calls “post-recovery.” This period represents Hofman’s estimate of the recent trend rate of growth in Peruvian TFP and adequately matches the period of our TdP study. Over this period, TFP growth for the Peruvian economy averaged 1.3% per year. Over the period of our TdP study, average annual input price growth for the Peruvian economy was 7.9%.

As described above, the differential in TFP growth between TdP and the Peruvian economy and the differential in input price growth between TdP and the Peruvian economy comprise the X factor. These calculations are found in Table E.8.

<table>
<thead>
<tr>
<th>Table E.8</th>
<th>TFP and Input Price Differentials</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TdP</td>
</tr>
<tr>
<td>TFP</td>
<td>3.5%</td>
</tr>
<tr>
<td>Input Price</td>
<td>4.8%</td>
</tr>
</tbody>
</table>

21 Andre A. Hofman, “Economic Growth and Performance in Latin America,” Economic Development Division of the United Nations Economic Commission for Latin America and the Caribbean, No. 54, LC/L 1350, March 2000. Appendix D discusses this study as well as two other studies of Peruvian TFP.
Table E.8 shows that the annual TFP differential is 2.2% and the annual input price differential is 3.2%. The quarterly TFP differential is 0.5% and the quarterly input price differential is 0.8%.22

Using the annual differentials from Table E.8, the value of the annual X factor is -5.4%. If the price cap is to be adjusted quarterly, as indicated in the Concession Contract, the quarterly TFP differential of 0.5% and the quarterly input price differential of 0.8% produce a quarterly X factor of -1.4%.

Given that the X factor is to represent the forward-looking view of what the TFP and input price differentials are likely to be, it must be determined whether the values estimated for TdP over the 1995-2000 period are likely to be good predictors of the future values of these differentials. We believe an annual X factor for TdP of –5.4% as computed by this study to be a challenging, but attainable goal. Although the 1995-2000 period represents events ranging from the privatization of TdP to a year if recession, we believe the 1995-2000 average is a reasonable estimate of expected TdP performance over the next three years. If anything, it may represent a conservative view as TdP’s productivity growth averaged 6.9% over the last two years of the period, 1999-2000.

Table E.9 projects the annual price cap index through the year 2003 and compares it to official inflation forecasts. The calculated annual X factor of –5.4% is used. We have initialized the price cap index at 1.000 in 2000. Comparing the allowed rate changes inferred by the price cap index with the lagged inflation rate23 shows that, while inflation increases every year,

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22 Because we compute logarithmic growth rates, the quarterly growth rates are obtained by dividing the annual growth rates by 4. Moreover, logarithmic growth rates represent continuous compounding.
23 The lagged inflation rate is used because the price cap formula specified by the Concession Contract is based on the lagged inflation rate. See Equation (3.1) above.
allowed changes in TdP rates force reductions in every year. The difference between the lagged inflation rate and TdP’s allowed rate changes is 5.5% every year.

Table E.9
Projection of TdP’s Rates Relative to Inflation

<table>
<thead>
<tr>
<th>Year</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>X Factor</td>
<td>-5.4%</td>
<td>-5.4%</td>
<td>-5.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Projected Inflation Rate</td>
<td></td>
<td></td>
<td></td>
<td>3.0%</td>
<td>2.0%</td>
</tr>
<tr>
<td>Projected Inflation Index</td>
<td>149.33</td>
<td>154.94</td>
<td>159.59</td>
<td>162.78</td>
<td>164.41</td>
</tr>
<tr>
<td>Price Cap Index</td>
<td>1.00</td>
<td>0.982</td>
<td>0.957</td>
<td>0.923</td>
<td></td>
</tr>
<tr>
<td>Inflation Rate (lagged)</td>
<td>3.7%</td>
<td>3.0%</td>
<td>2.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TdP Rate Changes</td>
<td>-1.8%</td>
<td>-2.6%</td>
<td>-3.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>5.5%</td>
<td>5.5%</td>
<td>5.5%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

X Factor Values by Basket

If different X factor values for Baskets C, D, and E are desired, they should be set subject to the condition that the revenue-weighted average of these X factor values equals the overall X factor. A primary reason for desiring different X factor values is to achieve rebalancing of rates between the baskets. The overall X factor estimated here, thus, would put a constraint on the amount of rebalancing that could be achieved between the baskets and it would provide a method for determining tradeoffs between adopting high or low X factor values for particular baskets. However, to avoid arbitrary manipulation of individual basket’s X factors, any rebalancing objectives between baskets should be clearly specified in advance. Absent such information or policy direction, it is our opinion that each basket be assigned the same value of X.

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24 Basket C contains connection charges, Basket D contains monthly access rent and local calls, and Basket E contains domestic and international long distance.
25 Appendix B provides an illustration of basket-specific X factor values.
Our suggestion would be to assign each basket the same X factor value at this time and when the price cap plan is up for review in three years, examine the necessity of assigning different X factor values to each of the baskets. Such an examination should consider the following:

- The need to rebalance rates between baskets. The primary economic consideration here is the relationship between rates and costs: if rates are below incremental costs, from an economic viewpoint these rates should be increased to cover at least incremental costs. However, if there is an overriding policy goal to maintain below-cost rates for certain categories of service (for example, local access), this policy should be explicitly stated and the costs of achieving this policy goal should be explicitly calculated. Therefore, to properly assess the need for any rebalancing and/or the costs of maintaining rates below cost, detailed information on service incremental costs needs to be developed.

- The need for different degrees of pricing flexibility between baskets. Generally, higher X factors would allow less pricing flexibility.

- Differences in the competitive pressures faced by the services in the different baskets. In fact, to the degree that some services are competitive, consideration should be given to removing them from price cap regulation. For example, if the long distance market is competitive, these services should be removed from price cap regulation.

**Future Considerations**

Designing and implementing a price cap plan for TdP has brought up many issues that are key to the success of the plan. Here, we provide some of the important lessons learned from the process of researching and designing the price cap plan for TdP. We have discussed some of these issues above.

TdP’s provision of data was critical for the completion our TFP study and we are grateful to them for their cooperation. Going forward we recommend that the required TdP data be provided in an agreed-upon format on a regular basis so that its provision becomes more
automatic and part of the normal regulatory process. In addition, TFP and input price data for the Peruvian economy should be produced and reported on a regular basis.

The review process for the price cap plan is critical to providing TdP the appropriate incentives for efficient behavior and socially beneficial investments. Obviously, setting the X factor is a key to providing the appropriate incentives to TdP for efficient behavior that mimics the outcome of competitive markets. However, just as important is the review of the plan that is scheduled for 2003 and subsequent reviews of the plan. In order to maximize the benefits of the price cap plan, TdP must feel reasonably assured that the review of the plan will not take away most of the legitimate gains made by TdP. If there is a sense that the regulatory commitment to the plan and its goals are not sufficient, TdP will not perform as expected and Peruvian consumers will not obtain the benefits that are possible under the plan.

The TdP Concession Contract requires OSIPTEL to revise the X factor every three years, which makes the timing predictable, but limits TdP’s incentives for superior performance because of the short period between plan reviews. In general, the longer the period of time the regulated firm has to reap the benefits of efficiency gains, the greater the incentive it has to increase its efficiency.26 Given the shortness of the period between revisions, it would be particularly ill-advised to make large one-time X factor adjustments at the time of revision: such adjustments would further harm performance incentives and would likely create incentives for TdP to engage in strategic behavior.

The use of an industry analysis is potentially problematic in the case of TdP because TdP essentially represents the entire industry. One approach would be to conduct a productivity study of all Latin America telephone companies, and base the industry standard on that study. If

26 Of course, as with competitive markets, efficiency gains must ultimately be passed through to consumers.
this approach is not feasible, one would then want to use a TdP productivity study in such a way that it minimizes the disincentives.

The primary way to minimize the disincentives associated with using a TdP productivity study is to spread out the length of time between a productivity improvement and the point when it is passed on to consumers in the form of lower prices. By spreading out this time period, one establishes a mechanism that mimics competitive markets. In the short run, firms retain all of the benefits of superior performance, but over time these gains become the industry standard and prices in the industry reflect those gains. To accomplish this, we have suggested that consideration be given to using a rolling average approach to update X similar to that used in the U.S. railroad industry’s price cap regulation.

Regardless of the procedures ultimately chosen, revisions of the X factor should be as predictable as possible in terms of both when and how revisions will occur. This will provide TdP with the appropriate incentives and consumers the benefits that are available under a well-designed price cap plan.
CHAPTER 1
REVIEW AND SURVEY OF PRICE CAP OPTIONS

In this chapter, we review the conceptual framework of price cap regulation and survey some of price cap design options. This chapter provides a broad overview of price cap design issues. Thus, some portions of this discussion do not pertain to the price cap plan for TdP that is outlined in the Concession Contract. However, as changes to TdP’s price cap plan are contemplated in the future, such discussions may become useful.

1.1 Conceptual Framework

A price cap mechanism effectively sets a ceiling on prices. It has two basic components: a price cap index (PCI), which sets a ceiling on the regulated firm’s price changes; and an actual price index (API), which measures the regulated firm’s actual prices. This section begins with discussions of how the PCI and API are constructed. It then describes the considerations that determine the “basket” of services that are included within each index, as well as how the price cap plan may be updated over time.

1.1.1 Construction of the Price Cap Index

Although specific applications of price cap regulation vary in their design, the basic formula is given by:\(^{27}\)

\[
dPCI_j = dl - X
\]  

\(^{27}\) As we discuss below, some Latin American price cap plans, including the one to be implemented for TdP, have a slightly different formulation.
where \( dPCI_j \) is the rate of change in the price cap index applicable to industry \( j \), \( dI \) is the growth rate in an inflation measure that is external to (that is, not controlled by) the regulated firm, and the \( X \text{ factor} \) represents the annual real price decrease that is promised to consumers.

The PCI’s construction depends upon the observation that the trend in the prices charged by a competitive industry is the trend in its unit cost. In a competitive market, the benefits of efforts to slow unit cost growth are passed to customers in the form of slower price growth. Since the industry unit cost trend is insensitive to individual firm actions, companies in competitive markets have strong incentives to slow unit cost growth.

Under competitive conditions, the growth in the revenue of the telecommunications industry \((dR_{tel})\) would equal the growth in its cost \((dC_{tel})\):

\[
dR_{tel} = dC_{tel} \quad (1.2)
\]

Because revenue equals output price times output quantity, the rate of revenue change can be decomposed into the rate of output price change \((dP_{tel})\) plus the rate of output quantity change \((dY_{tel})\):

\[
dR_{tel} = dP_{tel} + dY_{tel} \quad (1.3)
\]

Similarly, because cost equals input price times input quantity, the rate of cost change can be decomposed into the rate of input price change \((dW_{tel})\) plus the rate of input quantity change \((dQ_{tel})\):

\[
dC_{tel} = dW_{tel} + dQ_{tel} \quad (1.4)
\]

Combining equations (1.2) through (1.4) implies that, under competitive conditions, output prices will increase at a rate equal to input price inflation minus the rate of total factor productivity improvement:

\[
dP_{tel} = dW_{tel} - (dY_{tel} - dQ_{tel}) = dW_{tel} - dTP_{tel} \quad (1.5)
\]
where \( dTFP_{tel} \) represents the rate of telecommunications total factor productivity growth.

Two general approaches have been used in setting the parameters of equation (1.1). The first approach, which was first implemented by the U.S. Interstate Commerce Commission for the regulation of railroad rates, uses as the inflation measure a price index of industry inputs, and uses as the X factor offset a targeted rate of industry total factor productivity growth. This approach essentially uses equation (1.5) to determine the PCI of equation (1.1).

The second approach is to base the price cap index formula on a general measure of inflation for a whole national economy, such as a gross domestic product price index (GDP-PI) or a retail price index (RPI). Such a method was established by the regulators of U.S. and British telephone carriers. Imitating equation (1.5) for the national economy, the rate of output price growth for the economy \( (dP_E) \) is equal to the rate of input price growth for the economy \( (dW_E) \), less total factor productivity growth for the economy \( (dTFP_E) \):

\[
dP_E = dW_E - dTFP_E
\]  

(1.6)

Combining equations (5) and (6) yields:

\[
dP_{tel} = dP_E - \left[ (dW_E - dW_{tel}) + (dTFP_{tel} - dTFP_E) \right] 
\]  

(1.7)

Using equation (1.7), the allowed rate of change of the PCI would equal the rate of general price inflation in the whole economy less an adjustment factor (the X factor), where the adjustment factor equals: a) the difference between the rate of economy-wide input price growth and telephone industry input price growth; and b) the difference between the targeted rate of telephone industry total factor productivity growth and economy-wide total factor productivity growth.

In some price cap plans, the targeted rate of total factor productivity growth is based on the trend rate of historical total factor productivity growth, obtained through a total factor
productivity study. In other plans, the targeted rate is obtained by adding a “consumer productivity dividend” to the historical rate of total factor productivity growth. This consumer productivity dividend (or “stretch factor”) reflects an expected difference between future and historical productivity growth. In general, there is very little evidence that can be used to reliably predict the future rate of productivity growth. The usual procedure is to forecast future productivity trends from past trends. The consumer productivity dividend, by contrast, is an entirely subjective quantity that is determined through a political process.

In applications of the economy-wide inflation approach, the change in the PCI often includes a Z factor that adjusts the PCI to reflect events that: a) affect the regulated firm’s costs; b) are not due to the firm’s managerial decisions; and c) are not captured by the other elements of the price cap mechanism. For example, a Z factor adjustment would be desirable when a new tax is applied to the telephone industry: such a tax would have a negligible impact on the economy-wide inflation rate and would not have been taken into account when setting the X factor. The Z factor would be the allowed percentage increase in the price cap index due to this new tax.

Table 1.1 summarizes how the components of the PCI, as per equation (1.1), are set under the two approaches. The Industry Input Price Approach is the better approach in theory because it more accurately reflects factors that are that are directly relevant to the regulated industry. In practice, however, this approach is burdened by intense data requirements and by the need to specially calculate an industry-specific input price index. The Economy-Wide Inflation Approach therefore has the virtue of relative simplicity: it requires less data; it relies on an economy-wide inflation measure that is already calculated for other purposes; and it is applicable to situations (such as in Peru) where there are small numbers of suppliers. The
Economy-Wide Inflation Approach has been almost universally adopted by in telecommunications price cap plans throughout the world.

### Table 1.1

<table>
<thead>
<tr>
<th>Factor</th>
<th>Industry Input Price Approach</th>
<th>Economy-Wide Price Inflation Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>I: inflation</td>
<td>industry input prices</td>
<td>economy-wide price inflation (e.g., GDPPI)</td>
</tr>
<tr>
<td>X: offset</td>
<td>industry TFP</td>
<td>industry vs. economy input price and TFP differentials</td>
</tr>
<tr>
<td>Z: other</td>
<td>---</td>
<td>exogenous events affecting industry costs</td>
</tr>
</tbody>
</table>

#### 1.1.2 Baskets and Other Pricing Restrictions

One of the key benefits of price caps is that, relative to more traditional forms of regulation, they permit greater pricing flexibility to meet competitive challenges. This is particularly important in an industry such as telecommunications with increasing competition and rapidly changing technology.

The pricing flexibility afforded by price cap regulation is also beneficial when making a transition from a traditional regulatory regime under which prices have been badly misaligned with costs or market conditions. As an alternative to immediately realigning prices, a price cap plan makes it possible to redesign prices and services gradually and automatically. Because a price cap plan typically limits some overall price level rather than the prices of individual services or rate elements, it is possible to change the prices of different services and rate elements by different percentage amounts. This variation in the rate of price change is fully consistent with the practice and experience of fully competitive markets.

But this rate flexibility can create social and political problems if unrestricted. Under plausible circumstances, the firm that is regulated by a price cap can profitably cut prices for more price-elastic services, raise them for less price-elastic services, and still remain under the
price cap constraint. Increasing the relative prices of price-inelastic services can promote allocative efficiency but is detrimental to the interests of the customers who purchase these services.

To protect the interests of vulnerable customer groups, price cap plans are often accompanied by a variety of restrictions on how the regulated firm may adjust prices over time. The three main mechanisms for exercising such restrictions are service baskets, price floors, and side conditions. Each of these is discussed below.

1.1.2.a. Service Baskets

A “basket” is a group of services that is subject to its own price cap. Such a group of services has its actual price index (API),\(^2\) which is restricted to not exceed its own price cap index (PCI). Within the basket, some individual prices can increase more rapidly than the PCI as long as other prices in the basket increase less rapidly than the PCI, so that the resulting API does not exceed the PCI.

The purpose of baskets is to provide pricing flexibility while protecting certain customer groups from high prices. For example, if residential and business customers were placed in the same basket, the regulated firm might raise residential prices substantially while reducing business prices. This would be permissible, as long as the weighted average of the price changes (i.e., the API) satisfied the price cap. By putting business and residential services in different baskets, the firm would not be able to use the business price reductions to balance the residential price increases; and residential customers would be assured that their prices will not rise more rapidly than their PCI.

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2\(^8\) The actual price index is an index of the prices of a subset of services provided by the regulated firm.
Generally, the number and composition of the baskets will be based on the types of customers served by the firm. Limiting the number of baskets increases pricing flexibility, while increasing the number of baskets provides greater price protection for vulnerable customer groups. The number of baskets should also depend, however, on the homogeneity of services: similar services should generally be in the same basket, while dissimilar services should generally be in different baskets.

New products and services can pose special problems for price cap design. According to one view, new services should not be regulated if the pre-existing alternatives are still available to customers. According to another view, a new product or service should go into the basket of related existing services and should be incorporated into the API computations, not in its year of introduction, but at the next annual filing.

1.1.2.b. Price Floors

To minimize the possibilities for cross-subsidization and predation, each individual service may be subject to a price floor that is equal to its incremental cost. Setting the price floor of a service at its incremental cost assures that the regulated firm will have a non-negative contribution on the service, that the regulated firm will not subsidize the service through its charges on other services, and that the firm cannot engage in predatory pricing against its competitors. It may be true, however, that the price floor may not add much protection since the firm would lose money by pricing below incremental cost.

1.1.2.c. Side Conditions

“Side conditions” are another way to restrict pricing flexibility. The limits imposed by side conditions typically apply to the weighted average of prices for the group of services subject
to the side conditions, not to the individual rate elements comprising the group. For example, the U.S. Federal Communications Commission’s (FCC’s) price cap plans for telecommunications firms applied side conditions of plus or minus 5% (relative to PCI growth) to annual changes in specified groups of prices. In general, however, the upper and lower limits of price changes do not have to be equal to one another.

Side conditions are primarily an adjunct to baskets. Specifically, side conditions allow plans to be designed with fewer baskets than they would otherwise need. There are many situations in which such side conditions may be justified. For example:

- There may be concern that individual customers within a basket may constitute a set of “captive ratepayers” who have no feasible alternatives to the service provided by the regulated firm. A safeguard that can be employed on behalf of these customers is pricing bands. For example, the annual rate increases for individual services may be limited to be no more than the annual increase in the PCI plus 5%.

- Because growth in customer charges relative to volumetric charges can disadvantage smaller-volume customers, some plans use a side condition to limit the regulated firm’s ability to hike individual rate elements. For example, the annual escalation in the monthly charge may be limited to the growth rate in the PCI plus 5%.

1.1.3 Price Cap Plan Review and Adjustments

The parameters of price cap plans must be occasionally revised. The index of exogenous prices (input prices or economy-wide inflation) will ordinarily not need revision except (in unusual cases) to improve its basic construction. Revisions will therefore focus on the X factor.

To encourage regulated firm performance, revisions in the X factor should not attempt to capture high profits of individual firms but should instead, as in a competitive market, attempt to capture for consumers the general improvement in the performance of the whole industry.

Where there are many similar regulated firms, it may be possible to base revisions in the X factor
upon improvements in the industry’s total factor productivity. In such cases, the regulated firms indirectly “compete” with one another, so that firms that perform well are rewarded with high profits while firms that perform poorly receive low profits and may eventually be forced out of business.

Under circumstances where the regulated firm has few peers, there will be temptation to adjust the X factor so that the regulated firm enjoys “normal” profits. This sort of adjustment will blunt the incentives for the regulated firm to perform well, as the regulator will, in effect, raise the X factor hurdle for good performers and lower the hurdle for poor performers. In this sort of situation, it is best for the X factor to be fixed for a set number of years so that the regulated firm can be assured of enjoying the fruits of its performance for at least that period of time.

Regardless of the circumstances, however, revisions of the X factor should be as predictable as possible in terms of both when and how revisions will occur. Depending on industry circumstances, this may be accomplished through automatic adjustment mechanisms, as with the U.S. railroad industry, or through regularly scheduled revisions according to well-specified criteria.

1.1.4 Service Quality Provisions

Quality is an attribute of service that matters to customers in both competitive and unregulated markets. Because price caps may encourage utilities to cut costs in ways that compromise service quality, price cap plans should generally include provisions for regulated firms to maintain or improve quality.
Service quality incentives customarily take the form of a plan that rewards or penalizes a utility depending on its measured quality of service relative to the service standards. In addition to the quality indicators and service standards described above, an incentive plan must therefore include *quality valuation* and *award mechanisms*.

*Quality valuation* may be performed through three basic methods. One relies on proxy data related to the service attribute. For example, the value of having to wait for a field service representative can be approximated according to the customer’s lost wages (*i.e.*, the opportunity cost of the average customer’s time). Proxy prices have the advantage of simplicity, but they can also be imprecise and bear a tenuous link to actual service valuations.

A second method relies on market-based measures for the value of service. For energy utilities, for example, the difference between firm and interruptible rates can provide market-based data that reflect the value that customers place on service reliability. Another example is a hedonic price index, which can be developed by regressing market prices on identifiable quality attributes. These indexes reflect the notion that differences in market prices are due to implicit markets for individual product characteristics. Market-based methods have the advantage of being conceptually sound; but they can also be controversial, are often not well-understood, and can produce divergent estimates of underlying quality valuations. In addition, the application of hedonic methods to utility prices is awkward since the prices are set by regulators and therefore may reflect policy considerations rather than market forces.

A third method of valuing quality is to rely on customer surveys, including conjoint analysis. The primary advantage of this approach is that surveys can be tailored to focus on specific aspects of services. It is then possible to consider some aspects of service quality that are not easily handled using the other two methods. The main disadvantage is that survey results
generally reflect subjective perceptions rather than actual consumer behavior. In addition to being subject to manipulation, hypothetical customer valuations may not be a good guide on how consumers would react in markets, especially for quality characteristics with which customers have little experience.

Award mechanisms determine the adjustments in rates or the payments to customers that are warranted by the achieved level of service quality. In principle, awards and penalties should reflect the customers’ values and costs of each service attribute. Important design issues include the symmetry of these awards and penalties – actual service quality short of the benchmark may warrant a penalty while actual quality better than the benchmark may warrant a reward – and the allocation of benefits between the company and its customers.

1.2 Approaches And Experience

In this section we provide a survey of Latin American price cap plans. In particular, we review the plans in Argentina, Mexico, Colombia, and Brasil.

1.2.1 Argentina

In 1990, telecommunications price cap plans were inaugurated for Argentina’s major utilities (Telefónica de Argentina S.A., Telecom Argentina Stet France Telecom S.A.). The plans, which separately apply to local calls, domestic long-distance calls, and international long-distance calls, originally contemplated monthly tariff adjustments based on the domestic consumer price index (CPI) and, if necessary, a weighted average of the Argentine CPI and the rate of devaluation of the local currency. But with the advent of a currency board in 1991 (Ley

de Convertibilidad de 1991) and the immediate Peso-US dollar parity, the mechanism was changed to adjust prices only twice each year using the U.S. CPI as the price reference.

As shown in Table 1.2, the price cap plans have three implementation stages. Each stage has a successively higher X factor. The plans have now entered into the extended exclusivity period, and the corresponding X factor is now being applied.

### Table 1.2

**Stages of the Argentina Price Cap Plans**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Conditions</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transition period (1991-1992)</td>
<td>prices are adjusted to achieve a 16% rate of return on fixed assets by the end of the period</td>
<td>0%</td>
</tr>
<tr>
<td>Exclusivity period (1993-1997)</td>
<td>franchises are the sole providers in their service territory</td>
<td>2%</td>
</tr>
<tr>
<td>Extended exclusivity period (1998- )</td>
<td>franchises may remain sole providers for another three years if markets are not yet competitive</td>
<td>4%</td>
</tr>
</tbody>
</table>

The companies are allowed a 16% rate of return on fixed assets (ROR). If the ROR exceeds this target level then a tariff reduction, in addition to that required by the price cap mechanism, is warranted. On the other hand, if the ROR falls below the target level, then the company is entitled to compensation in the form of more moderate tariff reductions or, if necessary, outright increases in tariffs.

A rate rebalancing program was implemented concurrently with the inauguration of the price cap mechanism. Differential tariff reductions were used to achieve the desired rate rebalancing. Specifically, during the transition period, real local residential call prices could not increase while real domestic long-distance rates were reduced about 5% per annum. During the following exclusivity period, real domestic long-distance rates were reduced by 10-20% per annum. Apparently, the rebalancing effort has been fairly successful in drastically reducing the

---

30 We have not been able to identify the criteria by which Argentina obtained its X factors.
31 See for instance Resolución No. 2465/98 (Pricecap TASA) and Resolución 2466/98 (Pricecap TECO) issued by the Secretaría de Comunicaciones on November 5, 1998.
prices of long-distance service, so that focus of rate reductions in the extended exclusivity period will concentrate on local urban rates.

Installation charges are not part of the basket of services subject to a price cap. Instead, providers must gradually reduce these charges until they correspond to the international cost of a mature network (estimated at about US $250).

### 1.2.2 Mexico

With its privatization in 1990, price cap plans began for Teléfonos de México, S.A. (Telmex) and its subsidiary Telefónos del Noroeste S.A. (Telnor). The price cap index formula considers the possibility that inflation may be high. The explicit formula, which is to be applied to quarterly price adjustments, is:

\[
\frac{PCI_t}{PCI_{t-1}} = (1 - X) \left[ \frac{I_{t-1}}{I_{t-2}} \right]
\]

(1.9)

where \( PCI_t \) is the price cap index for year \( t \), \( X \) is the productivity adjustment factor for the Mexican telecommunications sector, and \( I \) is the national consumer price index that is published by the Bank of Mexico. Equation (1.9) indicates that the real price cap index (relative to the economy-wide price level in the previous period) must decrease by an amount equal to the productivity adjustment factor \( X \).

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33 In the Mexican telco plan the price cap index ratio \( \frac{PCI_t}{PCI_{t-1}} \) is labeled the ‘controlling factor’ (Factor Controlador), and denoted \( F_t \).

34 This formula is somewhat different than the formula presented in Equation (1.1) above. However, for relatively low values of \( X \), (1.1) and (1.9) produce equivalent results. A more detailed discussion can be found in Appendix A.
Mexico’s price cap plan was initially defined for the period 1991-1998 and has now been replaced with a new tariff plan for the period 1999-2002.\(^{35}\) As indicated by Table 1.3, the services covered by the plan are identical in both periods except that, during the first period, the maximum rate of adjustment for local calls was directly specified by SECOM (Secretaría de Comunicaciones).

<table>
<thead>
<tr>
<th>Phase</th>
<th>Services</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991-1996</td>
<td>Installation charges</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td>Customer charge</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Domestic long distance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>International long distance</td>
<td></td>
</tr>
<tr>
<td>1997-1998</td>
<td>Installation charges</td>
<td>3.0%</td>
</tr>
<tr>
<td></td>
<td>Customer charge</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Local measured calls</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Domestic long distance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>International long distance</td>
<td></td>
</tr>
<tr>
<td>1999-2002</td>
<td>Installation charges</td>
<td>4.5%</td>
</tr>
<tr>
<td></td>
<td>Customer charge</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Local measured calls</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Domestic long distance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>International long distance</td>
<td></td>
</tr>
</tbody>
</table>

The plan presents criteria for updating the productivity adjustment factor. The application of the Mexican price cap formula requires that the initial rates and the $X$ factor be specified with the aid of a long-run incremental cost methodology. These two elements (initial rates and $X$ factor) must be set such that revenue collected from the basic service basket allows the firm to obtain an internal rate of return that is equal to the weighted average cost of capital.\(^{36}\)


\(^{36}\) Among the service flows that are considered relevant for this purpose are: the replacement value of the existing assets, the income flow resulting from new investments, the income and expenditures associated with the regulated services, the life span of the assets used to provide these services, and the terminal values of these assets.
Once the initial rates were specified, the productivity factor was then adjusted in order to fulfill this requirement.

Both the old and new price cap plans have some side conditions whose purpose is to help achieve a degree of rate rebalancing. For instance, the plan stated that annual residential installation charges were to be reduced by a certain amount on January 1, 1995 and by an additional amount on January 1, 1996. There are also some rate escalation restrictions. For example, after an increase of 14.16% following the overall rate adjustment in March 1999, all the long distance tariffs remained fixed for the rest of 1999. More drastically, commercial installation charges were not modified.

1.2.3 Colombia

In 1997, the Colombian Telecommunication Regulation Commission (CRT) established the present price cap method for the tariff regulation of Empresa de Telecomunicaciones de Santafé de Bogota (E.T.B) and a group of about 25 other regional and municipal phone companies. The new mechanism was valid for the years 1997-2000. Prior to that, the tariff adjustment was based on an indexing method that accounted for inflation but did not include any kind of productivity offset. The current formula is:

\[
\frac{C_{t+1}}{C_t} - 1 = I_t - X
\]

where \( C_t \) is the annualized component of the long-run average cost per telephone line, calculated for a period equivalent to the expected life span of the system, considering both the existing line capacity and projected expansions; \( I \) is the expected economy-wide inflation rate forecast by the

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37 Comisión de Regulación de Telecomunicaciones, Resolución 87/97, “Por Medio de la cual se Regula en Forma Integral los Servicios de Telefonía Pública Básica Conmutada (TPBC) en Colombia,” 5 de setiembre de 1997.
Banco de la Republica; and $X$ is the productivity adjustment factor. This formula is used to update the fixed consumption and connection charges of both local and extended-local services.

The $X$ factor for 1997 was zero. For the period 1998-2000 the $X$ factor was set equal to 2.0%. Information suggests this value is still in place. There is no indication as how this value was obtained.

A key characteristic of the Colombian utilities is that their tariff systems (sanctioned by Colombian law) incorporate the use of subsidies and transfers. Non-business customers are grouped into six socioeconomic categories, and tariffs are basically set so that high-income categories plus commercial and industrial customers subsidize the low-income categories. The CRT requires that operators calculate cost based or ‘neutral’ tariffs for the middle income category, and then use a “contribution factor” wedge to determine the levels of the other categories’ tariffs.

1.2.4 Brasil

Beginning in 1998, price caps were applied to Brasil’s 31 local phone companies and one international long-distance company. The companies must meet certain guidelines regarding service quality and reliability. The companies’ franchises expire in 2005 but may be extended to 2025 for those companies that comply with certain requirements, including universal service goals.

The indexing formula is identical to the one used to regulate telephone tariffs in Mexico, except that the inflation measure refers to the current instead of the previous period. Another

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material difference is that price increases that are allowed but unused in one period are not
available to the supplier in subsequent periods. Furthermore, Brasilian tariffs are adjusted in
intervals of not less than 12 months. Economy-wide inflation is measured by the Consumer
Price Index – Internal Supply (Indice Geral de Precos, Disponibilidade Interna) published by the
Fundacao Getulio Vargas. Table 1.4 summarizes the key features of the Brasilian price cap
plans.

<table>
<thead>
<tr>
<th>Basket</th>
<th>Dates</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic local service[^39]</td>
<td>1998-2000</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td>2001-2005</td>
<td>1.0%</td>
</tr>
<tr>
<td>Local network usage</td>
<td>1998-2000</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td>2001</td>
<td>5.0%</td>
</tr>
<tr>
<td></td>
<td>2002</td>
<td>10.0%</td>
</tr>
<tr>
<td></td>
<td>2003</td>
<td>15.0%</td>
</tr>
<tr>
<td></td>
<td>2004-2005</td>
<td>20.0%</td>
</tr>
<tr>
<td>Basic domestic long distance[^40]</td>
<td>1998-2000</td>
<td>2.0%</td>
</tr>
<tr>
<td></td>
<td>2001-2003</td>
<td>4.0%</td>
</tr>
<tr>
<td></td>
<td>2004-2005</td>
<td>5.0%</td>
</tr>
<tr>
<td>Inter-urban network usage[^41]</td>
<td>1998-2000</td>
<td>2.0%</td>
</tr>
<tr>
<td></td>
<td>2001-2003</td>
<td>4.0%</td>
</tr>
<tr>
<td></td>
<td>2004-2005</td>
<td>5.0%</td>
</tr>
<tr>
<td>International long distance[^42]</td>
<td>1998-1999</td>
<td>5.0%</td>
</tr>
<tr>
<td></td>
<td>2000-2005</td>
<td>15.0%</td>
</tr>
</tbody>
</table>

The regulator (Agencia Nacional de Telecomunicacoes – ANATEL) may revise tariffs in
response to special circumstances that are beyond the firm’s direct control. Among the
qualifying events are:

- unilateral modification of the franchise contract by ANATEL;

[^39]: The X factor is called the “fator de transferencia” in the Brasilian plan.
[^40]: Charges include the access charge, customer charge, and metered services (pulsos).
[^41]: Tariffs are distinguished according to hour and geographic distance of calls (a total of 24x5 types).
[^42]: Tariffs are distinguished according to hour and geographic distance of calls (a total of 24x5 types).
[^43]: Tariffs are distinguished according to hour and country location (a total of 24x9 types).
• modification in the tax code after the contract is signed, which may affect (positively or negatively) a firm’s profitability;

• unusual events (supervenientes) that may result in a verifiable alteration of the company’s costs;

• a specific change in legislation that has a direct impact on the firm’s revenues (receitas); and

• a change in legislation that benefits the company.

The price caps also have side conditions for tariff escalation. In the local basic service basket, the maximum yearly increase of any single basket item is 9.0%. In the domestic and international long distance baskets, the maximum yearly increase of any individual item is 5.0%.
CHAPTER 2

ESTIMATION OF TOTAL FACTOR PRODUCTIVITY FOR TdP

The purpose of this chapter is to perform a total factor productivity (TFP) study that will form the basis for the X factor in Telefonica del Peru’s (TdP) price cap plan. We use standard, widely accepted methodology for estimating TFP and apply it to data supplied by TdP. The period of the study is 1995 to 2000.

In Section 2, we describe the methodology used to estimate TFP. In Section 3, we present the TFP and input price results for TdP. Section 4 describes how TFP and input price growth are used to produce the X factor. Section 5 presents the computation of the X factor for TdP’s price cap index and Section 6 presents our conclusions and recommendations.

2.1 TFP Measurement

TFP is the ratio of Total Output to Total Input. TFP growth is equal to Total Output growth minus Total Input Growth. Total Output is made up of the various categories of services produced by TdP. Total Input is made up of three basic factors of production used to produce these services: capital; labor; and materials, rents, and services (commonly referred to as materials). In the following sections, we describe how Total Output and Total Input are computed. Since input price growth plays a role in determining the X factor, we also describe how we compute TdP’s input price growth from the results of our TFP computations.
Based on data provided by TdP, Christensen Associates conducted a TFP study of TdP’s consolidated operations only. The time frame of the study is 1995-2000.\textsuperscript{44} Because of data unavailability, we did not estimate TFP separately for each of the price cap service baskets.\textsuperscript{45}

2.1.1 Total Output

Since telephone companies provide a wide range of services, measuring Total Output is complex. There are three steps in constructing a measure of Total Output. The first step is to distinguish the different categories of services provided and calculate the revenue generated from each category. The second step is to construct a quantity index for each service category. If a service category is relatively homogeneous, one can either compute its quantity index directly from a physical measure of output, or one can compute it indirectly by dividing service category revenue by the price of the service, i.e., a “deflated revenue” approach.\textsuperscript{46} When a service category represents a heterogeneous mix of services, physical output measures are not likely to capture all dimensions of category output. Instead, a deflated revenue approach to measuring output is likely to be a more accurate measure, assuming that an accurate index of the service category’s prices can be constructed. The third step is to aggregate the service category quantity indexes using an economic indexing approach.

\textsuperscript{44} 1994 was not included in the study because of missing data. Among the missing data are the following: (1) revenue data were missing for other local, (2) physical measures were missing for a number of output categories, (3) there were no 1993 end-of-year (EOY) employee counts (which are needed to get an average level of labor input in 1994), and (4) net plant data for EOY 1993 were unavailable (which are needed to get capital input in 1994).

\textsuperscript{45} It is important to note that separate TFP estimates for subsets of TdP’s services would not be based on an economically valid measurement of TFP. This is because, unless the services are produced with no joint and common costs, an economically arbitrary method would need to be employed to allocate joint and common inputs to individual services.

\textsuperscript{46} A homogeneous service may be a bundled service. What is relevant for productivity analysis is whether there is a single billing unit for the bundled service (or a reasonable proxy thereof) and whether there is a physical measure for that billing unit. For example, residential primary exchange service is a bundled service of access and local calling. The physical measure that corresponds to the billing unit is number of residential lines.
In our current study, Total Output is based on a comprehensive measure of all the services described in TdP’s consolidated income statement, Informacion consolidada TdP.

Twelve categories of output are distinguished for TdP. Table 2.1 lists the output categories and the method used to obtain the quantity of output for each category.47

<table>
<thead>
<tr>
<th>Category</th>
<th>Output Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly Access</td>
<td>Number of lines in service</td>
</tr>
<tr>
<td>Measured Local Service</td>
<td>Minutes of Local service</td>
</tr>
<tr>
<td>Other Local Service</td>
<td>Number of lines in service</td>
</tr>
<tr>
<td>Installation</td>
<td>Number of installations</td>
</tr>
<tr>
<td>International Long Distance</td>
<td>Number of International minutes</td>
</tr>
<tr>
<td>National Long Distance</td>
<td>Number of National minutes</td>
</tr>
<tr>
<td>Public Telephones</td>
<td>Number of Public minutes</td>
</tr>
<tr>
<td>Mobile Services</td>
<td>Number of Mobile service lines</td>
</tr>
<tr>
<td>Cable TV</td>
<td>Number of subscribers</td>
</tr>
<tr>
<td>Business Communications</td>
<td>Deflated revenues</td>
</tr>
<tr>
<td>Telephone Directories</td>
<td>Deflated revenues</td>
</tr>
<tr>
<td>Other Services</td>
<td>Deflated revenues</td>
</tr>
</tbody>
</table>

As a general rule, a physical output measure, such as number of lines or minutes of use, must be a reasonable indicator of the billing units used to generate revenue for it to be a reliable output measure for a particular revenue category. Physical output measures for many of TdP’s revenue categories were reasonably well matched to the corresponding revenue category. However, three output categories use a deflated revenue measure of output. The quantities of Business Communications48 and Other Services are obtained by dividing their respective revenue by the implicit price index for other telecommunications services. The implicit price index is

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47 After the deadline for receipt of data, TdP provided us with data on minutes of use for Mobile Services. However, as explained in Appendix C, there are inconsistencies in the data provided and, therefore, we continue to use number of Mobile Service lines as the measure of output for this category.

48 While the number of rented circuits was a potential physical measure of output for Business Communications, we determined that it was not appropriate for our purposes. This measure does not adequately capture the likely increases in circuit capacity that have occurred over time. Therefore, using the number of rented circuits as a measure of output
computed as a Tornqvist price index of the prices for TdP’s ten other output categories. The quantity of Telephone Directories is obtained by dividing Telephone Directory revenue by the consumer price index.49

The twelve output categories are aggregated into an overall quantity index of Total Output. The Fisher Ideal index was used to aggregate output in this case because the “Other” category had no output for the 1995-1997 period and only enters into the computation of Total Output beginning in 1998. 50

2.1.2 Total Input

The quantity of Total Input is constructed as a Tornqvist index of the quantities of labor, materials and capital input. The costs of labor, materials and capital are used as weights in this index. The cost of Total Input is the sum of labor, materials and capital input costs. In this quantity would understate the growth in Business Communications output.

49 Indice De Precios Promedio Mensual En Lima Metropolitana.
50 The Tornqvist index and Fisher Ideal index have very similar properties—both are “superlative” index numbers—and often produce identical results. The advantage of the Fisher index (and the reason it was chosen in this particular case) is that incomplete series can be easily incorporated into the index. Defining Q as total output, p_i as the price of good i and q_i as the quantity of good i, the logarithmic change version of the Tornqvist quantity index is given by:

\[
\ln \left( \frac{Q_t}{Q_{t-1}} \right) = \sum_{i=1}^{n} w_i \ln \left( \frac{Q_{i,t}}{Q_{i,t-1}} \right)
\]

where:

\[
w_i = \frac{w_{i,t} + w_{i,t-1}}{2}
\]

\[
w_{i,t} = p_{i,t} q_{i,t} / \sum p_{i,t} q_{i,t}
\]

The Fisher Ideal index has the form:

\[
\frac{Q_t}{Q_{t-1}} = \left( \frac{\sum_{i=1}^{n} p_{i,t-1} \cdot q_{i,t}}{\sum_{i=1}^{n} p_{i,t-1} \cdot q_{i,t-1}} \right) \cdot \left( \frac{\sum_{i=1}^{n} p_{i,t} \cdot q_{i,t}}{\sum_{i=1}^{n} p_{i,t} \cdot q_{i,t-1}} \right)
\]

47
section we describe how labor, materials and capital input are constructed. We also describe how the input price growth is computed from the results of the TFP study.

2.1.2.a Labor Input

In general, the quantity of labor input in TFP studies is determined by employee hours worked, weighted by relative compensation levels of various grades of labor. The cost of labor input includes wages, salaries and benefits paid to employees. In the telephone industry, a substantial amount of employee hours are devoted to the installation of plant and equipment. These installation hours are “capitalized” as part of the plant and equipment, and once the plant and equipment is put in service, are included in the capital measure. In order to avoid double counting of these installation hours, they should be excluded from the measures of labor quantity and labor cost.

There are two approaches normally taken to compute the quantity of labor input in TFP studies. The first approach is to calculate hours worked for different employee groups, distinguished by such factors as occupation and experience. The hours worked are then aggregated into a quantity of Total Labor input using an index number formula, such as the Tornqvist index, weighting the various employee groups by their compensation shares. The second approach is to construct a price index of labor and divide labor compensation (as defined above) by that price index.

For the current study, neither a detailed breakdown of hours worked nor a set of labor price indexes were available. Therefore, the quantity of labor is based on consolidated TdP employee counts. TdP provided us with average annual employee counts. To adjust for labor that is capitalized, we take the average number of employees during the year and multiply it by the fraction of total labor expenses that are included in operating expenses.\[51\]

\[51\] Total operating expense contains one line for total personnel expense and a second line (which acts as a credit) that is
Our measure of labor cost includes wages and salaries, benefits and social insurance contributions. From this sum, the amount of capitalized labor expense is deducted. For the years 1995-2000, the information for wages and salaries (“sueldos y salaries”), benefits (“beneficios del personal”) and capitalized labor expense (“trabajo para el immovilizado”) come from Gastos Operativos TdP. For the years 1998-2000, this information comes Gastos Operativos TdP Consolidado. During these years, wages, salaries and benefits are combined as “personal” expenses. For all years, information on social insurance contributions (“participacion de trabajadores”) comes from “Informacion consolidada TdP.”

2.1.2.b Materials Input

Materials input includes all goods and services purchased from other firms for use in the provision of telephone services. The most common approach used for measuring the quantity of materials in productivity research is to deflate materials expense by a price index of materials. In some instances, the price index is based on prices actually paid by the company for materials. In other instances company-specific prices are unavailable, and the price of materials is proxied by a general index of inflation, such as the Consumer Price Index or the Gross Domestic Product Price Index (GDPPI).52 We use the GDPPI, “Deflactor del PBI.”53

For the current TdP study, the cost of materials is computed in the following manner. For the years 1995-1997, the cost of materials is taken from the report Gastos operativos TdP and computed as “total de gastos” less “sueldos y salarios,” less “beneficios del personal,” less the amount of personnel expense going to “own work capitalized.” The personnel expense booked to operating expense is the net of these two amounts.

52 In our studies of the U.S. Local Exchange Carriers, we have used the Gross Domestic Product Price Index as a proxy for materials prices.

53 While TdP provided us with some detail on materials expense, the absence of detailed price indexes does not allow us to use the additional level of detail.
“depreciacion y amortizacion.” For the years 1998-2000, the cost of materials is computed from Gastos Operativos TdP Consolidado as “total de gastos” less “personal,” less “depreciacion.” In all years, capitalized labor expense (“trabajo para el immovilizado”) is added to account for the adjustment made to labor expense as described above. The quantity of materials is computed by dividing the cost of materials by the Deflactor del PBI.

2.1.2.c Capital Input

i. Capital Input Methodology

The quantity of capital input is determined by the flow of services from plant and equipment used in the provision of telephone service. Each item of plant and equipment is weighted by its relative level of efficiency. The theory of capital measurement\textsuperscript{54} distinguishes two sources of differences in asset efficiency: differences in efficiency across vintages and differences in efficiency across asset classes.

Efficiency of Assets Across Vintages. Within each asset class (i.e., a type of asset such as switching or circuit equipment), the efficiency of plant and equipment is a function of its age, or vintage. The theory of capital measurement generally employs an “efficiency function” to measure the efficiency of an asset, relative to its efficiency when it was new. We will denote the efficiency function by $\phi$. Hulten\textsuperscript{55} notes that three types of efficiency functions have generally been employed in measuring capital input: the one-hoss shay pattern, the straight-line pattern,


and the geometric pattern. He also notes that most empirical studies of depreciation support the use of the geometric function over the one-hoss shay or straight-line function.\textsuperscript{56}

The geometric pattern is based on the assumption that the productivity of an asset decreases at a constant percentage rate. This pattern has the form:

\[
\varphi_1 = 1, \varphi_2 = 1 - \delta, \varphi_3 = (1 - \delta)^2, \varphi_4 = (1 - \delta)^3, \ldots \tag{2.1}
\]

where $\delta$ is the rate of efficiency decline. Numerous productivity studies have employed this assumption, including previous studies of the U.S. telephone industry performed by Christensen Associates.

There are two sources for the decline in the efficiency of an asset as it ages. First, the asset may produce fewer services as it ages. Second, an asset may require more labor or materials (e.g. more maintenance) to provide the same level of services. For a cohort of assets (i.e. assets of the same asset class and the same vintage) there is a third source of efficiency decline, namely the retirement of assets. Retirement of a cohort of assets will generally occur over a number of years. As individual assets are removed from production, their contribution to the cohort will also be removed, and the overall productivity of the cohort will be reduced.

The quantity of capital input for the asset class is constructed by multiplying the quantity of plant and equipment in each cohort by its efficiency parameter, then summing over cohorts:

\[
K_t = \sum_i \varphi_i \cdot I_{t-i} \tag{2.2}
\]

where $K_t$ is the quantity of capital input in year $t$ and $I_{t-i}$ represents the quantity of plant and equipment in cohort $i$ in year $t-i$. It should be noted that $K_t$ is the beginning-of-year (BOY) stock.\textsuperscript{57}

\textsuperscript{56} Hulten (1990) p.142.

\textsuperscript{57}
When the geometric pattern is used, the computation of capital input quantity for a particular asset class is greatly simplified. In such a situation, the quantity of capital input can be obtained from the following recursive equation:

\[
K_t = (1 - \delta) \cdot K_{t-1} + I_{t-1}
\]  

(2.3)

In practice, this recursive equation, known as the perpetual inventory equation, is widely used to construct the quantity of capital stock. In order to implement the equation, one must develop a time series of investment \(I\), choose a geometric rate of efficiency decline, and obtain a starting point for the capital input quantity.

**Efficiency of Assets Across Asset Classes.** The theory of capital measurement weights the capital input quantity of each asset class by an estimate of its relative efficiency. This estimate is based on the imputed rental value of a new asset in that class. To impute the rental value of an asset, one can use the equilibrium relationship between the acquisition price of an asset and the present value of future rental values of that asset. In equilibrium, the acquisition price is equal to the present value of all future returns to the asset. The future returns to the asset are equal to the implicit rental value of the asset, less property taxes and taxes on corporate income. Using the observed market acquisition prices for assets over time, and by manipulating the equilibrium equation, one can calculate the implicit rental value as a function of the acquisition prices.

To illustrate how one estimates the implicit rental value, we will derive the implicit rental value from the equilibrium equation, assuming that there are no taxes. In such a case, the acquisition price of a new asset at time \(t\) is equal to the present value of all future rental values:

\[\text{As discussed below, the beginning-of-year stock in year } t, K_t, \text{ is assumed to be equal to the end-of-year stock in } t-1, K_{t-1}.\]
\[ p_t = \sum_{s=1}^{\infty} \left( \frac{1}{1 + r} \right)^s \cdot w_{t+s,s} \]  

(2.4)

where \( p_t \) represents the acquisition price of a new asset at time \( t \), \( w_{t+s,s} \) represents the implicit rental price of an \( s \)-year old asset in year \( t+s \), and \( r \) represents the opportunity cost of capital. Since the relative efficiency of an asset declines geometrically as it ages, its implicit rental price also declines geometrically. Therefore the equation can be rewritten:

\[ p_t = \sum_{s=1}^{\infty} \left( \frac{1}{1 + r} \right)^s \cdot (1 - \delta)^{(s-1)} \cdot w_{t+s,0} \]  

(2.5)

One can then manipulate this equation to solve for \( w_{t,0} \), the implicit rental price of a new asset in year \( t \):

\[ w_{t,0} = r \cdot p_{t-1} + \delta \cdot p_t - (p_t - p_{t-1}) \]  

(2.6)

Christensen and Jorgenson have derived and implemented the implicit rental price equation when taxes are present.\(^\text{58}\) In an economy with corporate income and property taxes, the implicit rental price equation is:

\[ w_{t,0} = \left( \frac{1 - uz - k}{1 - u} \right) \left[ r \cdot p_{t-1} + \delta \cdot p_t - (p_t - p_{t-1}) \right] + \tau \cdot p_t \]  

(2.7)

where \( u \) is the income tax rate, \( z \) is the present value of one-dollar’s worth of future tax depreciation, \( k \) is the investment tax credit rate, and \( \tau \) is the rate of property taxation.

Weighting different asset classes by their imputed rental value is different from weighting them by their acquisition cost. Assets with short lives will have a rental value that is a higher fraction of their acquisition cost than assets with long lives. This is because assets with short

lives have relatively few years to recoup the initial cost of their purchase, consequently these assets must provide a higher level of services for those years they are productive.

ii. Empirical Application to TdP Data

The data required to implement the perpetual inventory approach to capital input measurement are substantial. In the case of the current TdP study, data on gross additions and a benchmark capital stock figure were not available. Therefore, we based the quantities of capital input on the net book value at the end of each year. These end-of-year values are assumed to be equal to the beginning-of-year values for the next year. For the years 1994-1997, the data come from the fixed asset accounts, Activo Fijo. For 1998-2000, the data come from the consolidated accounts, Activo Fijo Consolidado.

The quantity of stock at the end of each year is computed by dividing net book value by a price index based on the adjustment factors used in the book value calculations. In other words, the gross book value of plant at the end of one year is equal to the gross book value of plant at the end of the previous year, revalued by the increase in Wholesale Price Index, plus gross additions, less retirements (properly revalued). Net book value is obtained by subtracting the depreciation balance, which is also revalued yearly using the Wholesale Price Index.

A closer look at TdP’s methodology reveals that it has some similarities to the perpetual inventory equation. The methodology appears to be based on the assumption that the Wholesale Price Index accurately represents changes in the prices paid for new telephone plant and equipment over time (the acquisition price). Under this assumption, one can divide the net book value in each year by the Wholesale Price Index and obtain the following equation:

\[
\tilde{K}_{i,t} = (1 - d_{i,t}) \tilde{K}_{i,t-1} + I_{i,t-1}
\]  

(2.8)
where $\tilde{K}_t$ represents the quantity of capital implicit in the accounting methods (i.e. beginning-of-year real net book value given by previous years’ end-of-year value), $d_t$ is the reduction in the quantity of capital due to depreciation and retirements, and $I_t$ is the quantity of gross additions. Once again, the information available does not allow one to distinguish the quantity of gross additions from the quantity reduction due to depreciation and retirements. We distinguish nine types of capital for TdP:

- Land
- Buildings
- Central Plant
- Transmission Plant
- Cable and Access
- Other Telephone Equipment
- Furniture
- Vehicles
- Other Equipment

Because the book value data for 1994 and 1995 are not as detailed as the data for subsequent years, we had to make imputations for some of the asset categories in those years. In particular, telephone plant was disaggregated into central plant, transmission plant, cable and access, other telephone plant equipment, and other equipment based on 1996 shares for these categories. Also, the consolidated balance sheets, which are used to compute capital stocks for the years 1998-2000, did not have as much detail on telephone plant. The estimates for central plant, transmission plant, and cable and access are based on the book values reported in the non-consolidated TdP balance sheets. The difference between the total telephone plant in the consolidated plant and the amounts assigned to these three telephone plant categories is assigned

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59 The retirements in question are valued at their net book value.
to other telephone plant. An exception to this rule occurs in 2000. The utility balance sheet for that year shows a 1.1 million soles reduction in central plant, but the consolidated plant sheet does not appear to have a similar reduction. Consequently, we add an additional 1.1 million soles to central plant before residually determining other telephone plant.

Because of some extremely large increases in capital stocks in some years, we base the quantity of capital input on a mid-year estimate of capital stock, rather than the quantity of stock at the end of the previous year. This allows increases in the capital stock to contribute to capital input during the year instead of at the end of the year. The mid-year estimate is obtained by averaging the quantity of stock at the end of the previous year and the quantity of stock at the end of the current year.

The Christensen-Jorgenson rental value equation is used to compute service prices. This equation is computed for each of the nine asset categories in the study:

\[ q_{i,t} K_{i,t-1} = \frac{1}{1 - u_t} \left( \frac{r_t p_{i,t-1} + \delta_i (p_{i,t} - p_{i,t-1})}{K_{i,t-1}} \right) \] (2.9)

where \( q_{i,t} \) represents the rental price of the asset \( i \) in year \( t \), \( u_t \) represents the effective income tax rate in year \( t \), \( p_{i,t} \) is the price index of investment category \( i \) in year \( t \), \( r_t \) is the incremental cost of capital in \( t \), and \( \delta_i \) is the geometric rate of replacement for category \( i \).

The rate of return is based on the costs of equity and debt provided by TdP, and are weighted by the weights provided by TdP.\(^{60}\) The depreciation rates are based on information contained in the 1997 audited financial statement,\(^{61}\) which was also used to get the depreciation rates in our 1999 study. The depreciation rates of 0% for land, 3% for buildings, 10% for furniture, and 20% for vehicles come directly from that document. Our estimate for other

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\(^{60}\) The U.S. dollar denominated costs of equity and debt are adjusted for exchange rate changes.

\(^{61}\) Telefonica del Peru, Indiciadores Financieros, December 31, 1997.
equipment is 15%, which is the mid-point of the 10-20 percent range listed in that statement. The depreciation rates for the different types of telephone plant are inferred from that report based on the amount of net plant depreciated at the various rates. The resulting estimates are central plant 10%, transmission plant 7.6%, cable and access 6.58%, and other telephone equipment 5%. All taxes are assumed to be income taxes.

2.1.2.d Input Price Growth

The price of Total Input is equal to the cost of Total Input divided by the quantity of Total Input, and the growth in Total Input price (i.e., input price growth) is equal to the growth in Total Input cost minus the growth in Total Input quantity. Both Total Input cost growth and Total Input quantity growth can be computed from the Total Input computations of the TFP study. Total Input cost is the sum of labor, materials and capital costs. As described above, Total Input quantity is a Tornqvist index of the quantities of labor, materials and capital.

2.2 TFP Results

The TFP calculations for TdP are found in the Excel workbook, Preliminary TFP.xls. This workbook contains the computation of TFP as well as the data provided by TdP, upon which the computations are based.

Table 2.2 presents annual growth rates for the twelve categories of output and for aggregate Total Output over the 1995-2000 period.62 Average annual growth rates over this period are also provided. Over the 1995-2000 period, average annual growth in Total Output for TdP was 16.3%. However, it is apparent from Table 2.2 that there is a great amount of variation across years.

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62 The first growth rate for the period is the 1996 over 1995 growth rate.
Table 2.2
TdP Output Growth Rates

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly Access</td>
<td>25.8%</td>
<td>13.7%</td>
<td>-5.7%</td>
<td>8.2%</td>
<td>1.7%</td>
<td>8.7%</td>
</tr>
<tr>
<td>Measured Service</td>
<td>26.5%</td>
<td>7.2%</td>
<td>0.6%</td>
<td>9.5%</td>
<td>0.0%</td>
<td>8.8%</td>
</tr>
<tr>
<td>Other Local</td>
<td>25.8%</td>
<td>13.7%</td>
<td>-5.7%</td>
<td>8.2%</td>
<td>1.7%</td>
<td>8.7%</td>
</tr>
<tr>
<td>Installation</td>
<td>-4.8%</td>
<td>-14.0%</td>
<td>-22.3%</td>
<td>5.9%</td>
<td>-39.6%</td>
<td>-14.9%</td>
</tr>
<tr>
<td>International Long Distance</td>
<td>11.6%</td>
<td>15.3%</td>
<td>5.8%</td>
<td>9.3%</td>
<td>-0.8%</td>
<td>8.2%</td>
</tr>
<tr>
<td>National Long Distance</td>
<td>22.5%</td>
<td>13.1%</td>
<td>-0.7%</td>
<td>-6.5%</td>
<td>-7.6%</td>
<td>4.1%</td>
</tr>
<tr>
<td>Public Telephone</td>
<td>16.3%</td>
<td>16.3%</td>
<td>8.8%</td>
<td>16.6%</td>
<td>23.6%</td>
<td>16.3%</td>
</tr>
<tr>
<td>Mobile Service</td>
<td>114.0%</td>
<td>89.3%</td>
<td>45.7%</td>
<td>34.4%</td>
<td>23.2%</td>
<td>61.3%</td>
</tr>
<tr>
<td>Cable TV</td>
<td>167.1%</td>
<td>91.1%</td>
<td>19.1%</td>
<td>7.0%</td>
<td>6.5%</td>
<td>58.2%</td>
</tr>
<tr>
<td>Business Communications</td>
<td>37.0%</td>
<td>16.2%</td>
<td>24.6%</td>
<td>28.0%</td>
<td>23.8%</td>
<td>25.9%</td>
</tr>
<tr>
<td>Telephone Directories</td>
<td>28.5%</td>
<td>43.7%</td>
<td>14.7%</td>
<td>0.3%</td>
<td>-17.3%</td>
<td>14.0%</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>80.1%</td>
</tr>
<tr>
<td>Total Output</td>
<td>25.1%</td>
<td>23.1%</td>
<td>9.9%</td>
<td>14.0%</td>
<td>9.3%</td>
<td>16.3%</td>
</tr>
</tbody>
</table>

Table 2.3 presents the annual growth rates in the quantities of capital, labor, materials and Total Input, and average annual growth rates for the 1995-2000 period.

Table 2.3
TdP Input Quantity Growth Rates

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital</td>
<td>34.7%</td>
<td>18.1%</td>
<td>19.4%</td>
<td>17.1%</td>
<td>8.4%</td>
<td>19.5%</td>
</tr>
<tr>
<td>Labor</td>
<td>-30.9%</td>
<td>3.8%</td>
<td>-3.1%</td>
<td>2.4%</td>
<td>-4.0%</td>
<td>-6.4%</td>
</tr>
<tr>
<td>Materials</td>
<td>23.6%</td>
<td>31.4%</td>
<td>26.9%</td>
<td>-7.6%</td>
<td>-0.7%</td>
<td>14.7%</td>
</tr>
<tr>
<td>Total Input</td>
<td>14.9%</td>
<td>20.3%</td>
<td>19.3%</td>
<td>5.9%</td>
<td>3.6%</td>
<td>12.8%</td>
</tr>
</tbody>
</table>

Capital and materials have similar average growth rates, while labor exhibits a decline over the period. Over the 1995-2000 period, Total Input grew at an average annual rate of 12.8%, with growth lower in the later years.

Table 2.4 combines Total Output and Total Input growth to produce TFP growth for TdP over the 1995-2000 period. Over this period, TFP growth averaged 3.5% annually. TdP’s input
price growth is also reported in Table 2.4. Over the 1995-2000 period, TdP’s input price growth averaged 4.8% annually.

<table>
<thead>
<tr>
<th>Table 2.4</th>
<th>TdP TFP and Input Price Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Output Growth</td>
<td>25.1%</td>
</tr>
<tr>
<td>Total Input Growth</td>
<td>14.9%</td>
</tr>
<tr>
<td>TFP Growth</td>
<td>10.2%</td>
</tr>
<tr>
<td>Input Price Growth</td>
<td>15.0%</td>
</tr>
</tbody>
</table>
CHAPTER 3
THE X FACTOR FOR TdP’S PRICE CAP PLAN

In this chapter, we describe the price cap formula that will regulate TdP as outlined in the 1994 Concession Contract. Based on the results of the TFP study presented in Chapter 2, we then discuss the establishment of the X factor for TdP’s price cap plan.

3.1 TdP’s Price Cap Formula

In the 1994 Concession Contract TdP signed with OSIPTEL, Annex 3 outlines the parameters of the price cap formula that will apply to TdP. Similar to other Latin American plans, this specification is a variant of the type of inflation-adjusted formula used for telecommunications price cap regulation in Argentina, Mexico and Brazil. The control factor in the price cap formula is given by:

\[ F_n = (1 + X) \times \frac{IPC_{n-1}}{IPC_{n-2}} \] \hspace{1cm} (3.1)

Prices are regulated by \( F_n \) by requiring the actual price index ratio to be less than or equal to \( F_n \):

\[ RT_{jn} = \sum (\alpha_{ijn-1} \times \frac{T_{ijn}}{T_{ijn-1}}) \leq F_n \] \hspace{1cm} (3.2)

where:

- \( RT_{jn} \) = Actual Price Index Ratio (Ratio Tope) for service basket “j” during the nth quarter.
- \( \alpha_{ijn-1} \) = Weight assigned to service “i” of basket “j” during the previous quarter. It corresponds to service i’s revenue share in the basket j.
- \( T_{ijn} \) = Tariff (Tarifa) for service “i” in basket “j” during the nth quarter.
- \( F_n \) = Control factor (Factor de Control) of price cap index ratio for the nth quarter.
\[ IPC_n \] = Consumer price index (Indice de Precios al Consumidor) at the beginning of the nth quarter published by the Instituto de Estadistica e Informatica (INEI).

\[ X \] = Productivity factor.

As we demonstrate in Appendix A, the X factor in this formula is based on productivity and input price differentials. Define these differentials as follows:

c) TFPD = the difference between the targeted rate of telephone industry total factor productivity growth and economy-wide total factor productivity growth, the TFP differential, \( (dTFP_T - dTFP_E) \); and

d) IPD = the difference between the rate of economy-wide input price growth and telephone industry input price growth, the input price differential, \( (dW_E - dW_T) \).

Therefore, the X factor is given by:

\[ X = TFPD + IPD \]  \hspace{1cm} (3.3)

If the TFP differential is computed as \( (dTFP_E - dTFP_T) \) and the input price differential is computed as \( (dW_T - dW_E) \), the X factor would have the opposite sign.

\subsection*{3.2 X Factor Results}

The average annual TFP and input price growth rates for TdP reported in Table 2.4 above are combined with TFP and input price growth rates for the Peruvian economy to produce the X factor for the price cap formula. Because there are no official estimates of Peruvian TFP, we obtained information on TFP growth for the Peruvian economy from a study by Andre A. Hofman.\(^{63}\) Hofman has produced estimates through 1998 and his basic TFP methods are most consistent with those we employ in the TdP study. For purposes of the current study, we use his

\(^{63}\) Andre A. Hofman, “Economic Growth and Performance in Latin America,” Economic Development Division of the United Nations Economic Commission for Latin America and the Caribbean, No. 54, LC/L 1350, March 2000. Appendix D discusses this study as well as two other studies of Peruvian TFP.
average growth estimate for Peru for the most recent period of his study (1994-1998), which he
calls “post-recovery.” This period represents Hofman’s estimate of the recent trend rate of
growth in Peruvian TFP and adequately matches the period of our TdP study. Over this period,
TFP growth for the Peruvian economy averaged 1.3% per year.

Input price growth for the Peruvian economy is obtained by combining Peruvian TFP
growth with economy-wide output price growth (in this case, represented by the Lima IPC). Over the period of our TdP study, the Lima IPC grew at an average annual rate of 6.6%.

Therefore, average annual input price growth for the Peruvian economy was 7.9% over this
period (= 1.3% + 6.6%).

As described above, the differential in TFP growth between TdP and the Peruvian
economy and the differential in input price growth between TdP and the Peruvian economy
comprise the X factor. These calculations are found in Table 3.1.

<table>
<thead>
<tr>
<th></th>
<th>TFP</th>
<th>TdP</th>
<th>Peru</th>
<th>Annual Differential</th>
<th>Quarterly Differential</th>
</tr>
</thead>
<tbody>
<tr>
<td>TFP</td>
<td>3.5%</td>
<td>1.3%</td>
<td>2.2%</td>
<td>0.5%</td>
<td></td>
</tr>
<tr>
<td>Input Price</td>
<td>4.8%</td>
<td>7.9%</td>
<td>3.2%</td>
<td>0.8%</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.1 shows that the annual TFP differential is 2.2% and the annual input price
differential is 3.2%. The quarterly TFP differential is 0.5% and the quarterly input price
differential is 0.8%. This produces an annual X factor of –5.4% and a quarterly X factor of
–1.4%.

---

64 Based on the condition that output price growth equals input price growth less TFP growth, input price growth can be
obtained by summing output price growth (the IPC in this case) and TFP growth.
65 Alternative studies of Peruvian TFP are discussed in Appendix D.
66 Because we compute logarithmic growth rates, the quarterly growth rates are obtained by dividing the annual growth
rates by 4. Moreover, logarithmic growth rates represent continuous compounding.
Table 3.2 projects the annual price cap index through the year 2003 and compares it to official inflation forecasts. The calculated annual X factor of –5.4% is used. We have initialized the price cap index at 1.000 in 2000. Comparing the allowed rate changes inferred by the price cap index with the lagged inflation rate shows that, while inflation increases every year, allowed changes in TdP rates force reductions in every year. The difference between the lagged inflation rate and TdP’s allowed rate changes is 5.5% every year.

<table>
<thead>
<tr>
<th></th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>X Factor</td>
<td></td>
<td>-5.4%</td>
<td>-5.4%</td>
<td>-5.4%</td>
<td></td>
</tr>
<tr>
<td>Projected Inflation Rate</td>
<td></td>
<td>3.0%</td>
<td>2.0%</td>
<td>1.0%</td>
<td></td>
</tr>
<tr>
<td>Projected Inflation Index</td>
<td>149.33</td>
<td>154.94</td>
<td>159.59</td>
<td>162.78</td>
<td>164.41</td>
</tr>
<tr>
<td>Price Cap Index</td>
<td></td>
<td>1.00</td>
<td>0.982</td>
<td>0.957</td>
<td>0.923</td>
</tr>
<tr>
<td>Inflation Rate (lagged)</td>
<td></td>
<td>3.7%</td>
<td>3.0%</td>
<td>2.0%</td>
<td></td>
</tr>
<tr>
<td>TdP Rate Changes</td>
<td></td>
<td>-1.8%</td>
<td>-2.6%</td>
<td>-3.6%</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td></td>
<td>5.5%</td>
<td>5.5%</td>
<td>5.5%</td>
<td></td>
</tr>
</tbody>
</table>

67 The lagged inflation rate is used because the price cap formula specified by the Concession Contract is based on the lagged inflation rate. See Equation (3.1) above.
CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

In this concluding chapter, we provide our recommendation for the value of the X factor for the regulation of TdP. We also analyze alternative methods of establishing the value of the X factor, discuss issues relating to the review and updating of the X factor, investment incentives under price cap regulation, and the measurement of Peruvian TFP and input price growth. We also comment on establishing individual X factor values for service baskets, the use of Z factors in price cap plans, and other issues that may come to light when TdP’s price cap plan is reviewed in three years. We conclude with a discussion of issues that are likely to be considered when the price cap plan is reviewed in 2003 and subsequent years.

4.1 The X Factor for TdP

4.1.1 Recommended Value of X

Our study measures TdP’s performance over the 1995-2000 period. It measures TdP’s total factor productivity over the twelve service categories described in Chapter 2. Because the inputs used to produce TdP’s outputs consist of a significant amount of joint and common inputs, there is no economically appropriate method to estimate TFP for only the services that will be regulated by the price cap plan. Therefore, while TdP’s set of outputs include services such as Mobile services and Cable TV, they appropriately belong in the measurement of TdP’s total factor productivity.

There is precedent for using a total factor productivity study to establish an X factor that applies to only a subset of the services measured by the TFP study. TFP studies that have been
conducted in the United States and Canada for the purpose of establishing X factors are based on “total company” measures of output and input. However, only a subset of the firm’s services are typically regulated by these plans. Furthermore, these services are divided between regulatory jurisdictions—in the case of the United States there are state and interstate jurisdictions. Thus, not only are the regulated services a subset of the company’s total set of services, they are regulated under different jurisdictions. However, the TFP studies are not separated by services or by regulatory jurisdiction: the overall TFP results are used to set the X factor.

Given that the X factor is to represent the forward-looking view of what the TFP and input price differentials are likely to be, it must be determined whether the values estimated for TdP over the 1995-2000 period are likely to be good predictors of the future values of these differentials. We believe an annual X factor for TdP of -5.4% as computed by this study to be a challenging, but attainable goal. Although the 1995-2000 period represents events ranging from the privatization of TdP to a year if recession, we believe the 1995-2000 average is a reasonable estimate of expected TdP performance over the next three years. If anything, it may represent a conservative view as TdP’s productivity growth averaged 6.9% over the last two years of the period, 1999-2000.68

4.1.2 Consistency with Policy Guidelines on Telecommunications

The Policy Guidelines on Telecommunications underscore the importance of the X factor in generating proper incentives for the expansion of telecommunications services in Peru. This is highly correlated with the importance of the X factor in providing appropriate infrastructure

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68 We have included both TFP and input price differentials in the computation of the X factor because the evidence suggests that, going forward, there will likely be a non-zero input price differential. Conversely, there is no evidence that over the initial three-year price cap period, the input price differential is likely to disappear. Moreover, we are not proposing a consumer productivity dividend for expected productivity gains under price cap regulation.
investment incentives. Such incentives are affected not only by the initial setting of the value of
the X factor, but also by subsequent review of the X factor and, generally, the price cap plan.
We discuss the first issue in this subsection and the review and changing of the X factor and
other plan parameters in the following subsection.

Price cap regulation is intended to attain more desirable combinations of company
performance and regulatory cost than are possible under traditional forms of regulation, such as
cost-of-service, or rate-of-return regulation. To the extent that the goal is met, it is possible to
attain higher levels of productive and allocative efficiency from a given or reduced level of
regulatory cost.69

There have been two general approaches to setting the X factor for price cap regulation.
They have been referred to as the “American” approach and the “British” approach. The
American approach is based on estimating TFP and input price differentials to determine X and
is the approach that is taken in this report. The British approach takes more of a rate-of-return,
or cost-of-service approach to establishing the X factor.

The laws privatizing British utilities provided little guidance for choosing X. Although
the British approach recognized the advantages of having an external basis for rate regulation, it
did not include a full articulation of the basis for “just and reasonable” price trends. The basis
for setting X factors in initial price controls was often ill-defined, and the basis for updating the
controls was hardly discussed at all. There was also little consideration of how benefits would
be shared during the price control regime. The lack of a well-defined framework has given
British regulators considerable discretion in determining X factors. Over time, the desire to

69 Productive efficiency means the firm produces output at the minimum possible cost. Allocative efficiency is
determined by the extent to which consumer surplus is enhanced.
share benefits has led the British approach of price caps to closely resemble a cost of service, rate of return approach.  

The British approach has evolved into one where the X factor is based on forecasts of firm performance such as revenue requirements, rates of return, and expected demand. Regulators often examine detailed data submitted by individual companies in an attempt to determine the efficient cost levels. Indeed, it is fair to call the British approach to price cap regulation “indexed cost of service regulation.” The primary difference between the British approach to price caps and U.S. cost of service regulation is that the former uses indexing methods to extend the period between rate cases. At its best, this can lead to stronger incentives since companies can be assured that gains from performance improvements will be retained for a known period of time. At its worst, regulators can intervene within price cap periods if there are unexpected earnings outcomes. There have, in fact, been several such occurrences, including the unscheduled price reviews by Offer in 1995 and by Oftel in 1991. The Water Regulator has also intervened between scheduled reviews to request “voluntary” rate restraint by utilities.

One particular consequence is that the British approach is sensitive to forecasts. Forecasts of capital spending have been particularly uncertain, and companies’ abilities to keep

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70 A regulatory admission that there is no explicit framework for evaluating appropriate X factor and benefit-sharing magnitudes and approaches comes from the most recent review of the price cap plan for British Airways. After listing a whole host of possible influences, the CAA admits that “The value of X flows from all the factors discussed... above. It has no internal logic of its own” (p. 29).

71 Some British observers agree with this assessment. For example, Dieter Helm of Oxford University has written that “The British RPI-X regulatory system was designed to improve upon the perceived failures of the U.S. (rate of return) system. Over time, however, the two have increasingly converged”. Indexing can, in principle, extend the regulatory lag between cost of service rate cases but, “in practice, these (rate review) periods are open to regulatory chiseling and intervention”. See Deiter Helm, “British Utility Regulation: Theory, Practice, and Reform,” Oxford Review of Economic Policy, 10(3): 36.

their capital spending below forecast is more often interpreted negatively as evidence of misleading information submitted before a plan rather than superior performance in restraining capital spending. The use of forecasts in British price cap plans has led one long-time observer of British regulated industries to claim that these ratemaking methods are more reminiscent of state planning than competitive markets.  

The establishment of X factor values, whether by the American or British approach, should provide appropriate incentives to the regulated firm and protections and benefits to consumers similar to those found in competitive markets. This includes sufficient risk/reward incentives for the firm, and competitive prices and quality of services for consumers. The profit motive for efficient behavior, including profit-maximizing investment, behavior is enhanced when there is reasonable assurance that retroactive ratemaking will not happen: i.e., there needs to be a regulatory commitment that the firm will be able to benefit from efficient behavior and not penalized for efficient behavior. Sappington and Weisman have noted the importance of this commitment.  

[W]hen a regulatory plan permits opportunities for recontracting (that is, revising the terms of the original regulatory plan, explicitly or implicitly), any recontracting that benefits the regulated firm is likely to generate considerable scrutiny. Recognizing that rulings favorable to its financial interests are unlikely when opportunities for recontracting exist, the regulated firm will rationally adjust its behavior. In particular, if the firm believes that substantial cost reductions will likely call forth more stringent performance standards under future regulatory regimes, it may be less inclined to achieve substantial cost reductions. Similarly, if the firm suspects that lucrative earnings derived

73 In comments filed in 1995 in connection with the update of the British Gas plan, Professor George Yarrow stated that the methods used to determine price controls evoked “a sense of *deja vu*”. The methods used for updating price controls “were the sorts of exercises that much preoccupied those interested in the pricing and investment problems of nationalized industries under the old regime. The errors involved were generally very large indeed – not least because long-run costs are subjective, as was stressed by Stephen Littlechild in his critique of these methods in the 1970s (*The Fallacy of the Mixed Economy*, IEA, 1978). The ‘cash flow’ (i.e., NPV) approach... would represent an unwelcome trend toward re-regulation and a form of central planning. In particular, it involves the regulator in very close monitoring of investment programmes and in the details of the financing of those programmes.”

from product innovations will result in restricted potential for future earnings, the firm’s incentives to improve its product offerings will be dampened.

Just as regulators must be able to deliver all promised rewards for superior performance, they must also be able to impose all threatened penalties for inferior performance. If they cannot, inappropriate incentives may be created for the firm to improve measured short-term performance. For instance, under an incentive scheme where the firm retains a sizable fraction of realized cost savings, the firm may be tempted to restrict maintenance activities unduly if it perceives a high probability that it will not be held accountable for the excessively rapid depreciation of plant and equipment that occurs sometime in the future.

Frankly, the American approach has greater potential to fulfill these requirements than the British approach. In essence, the British approach represents a type of rate-of-return regulation that borders on micro-managing the regulated company and is more susceptible to retroactive ratemaking than is the American approach. One consequence of the British approach to price caps is that it imposes higher regulatory costs than the U.S. approach.

Under a price cap mechanism that sets prices according to a combination of external data and automatic adjustment mechanisms, the regulated firm can expect: a) that superior performance will be accompanied by higher profits; and b) that regulation will not penalize superior performance by reducing prices and thereby depriving shareholders of profits. Moreover, the price cap mechanism provides guaranteed price reductions to consumers. The combined effect of these attributes is a regulatory process that, in spite of lower cost, can strengthen performance incentives and provide consumer benefits by making price restrictions less sensitive to company actions. The potential benefits from price regulation are therefore increased, and price cap plans can be designed so that a significant share of the expected performance improvements are distributed to consumers through reductions in the real prices that they pay for regulated firm services.
4.1.3 Revisions to TdP’s X Factor

In principle, revisions to the X factor should be as predictable as possible in terms of both when and how revisions will occur. Moreover, revisions should be isolated as much as possible from the actions or influence of interested parties. In this respect, it is our opinion that the “American” approach to establishing and updating the X factor provides advantages over the “British” approach.

The TdP Concession Contract requires OSIPTEL to revise the X factor every three years, which makes the timing predictable, but limits TdP’s incentives for superior performance because of the short period between plan reviews. In general, the longer the period of time the regulated firm has to reap the benefits of efficiency gains, the greater the incentive it has to increase its efficiency.\(^75\) Given the shortness of the period between revisions, it would be particularly ill-advised to make large one-time X factor adjustments at the time of revision: such adjustments would further harm performance incentives and would likely create incentives for TdP to engage in strategic behavior.

The guiding principle in setting the X factor, either initially or in subsequent revisions, is that the X factor should represent the expected industry level of performance for the upcoming period. If a firm under price cap regulation represents a small part of the industry, an industry productivity analysis would provide an industry standard. Furthermore, it would not create disincentives for the firm, since its actions would not materially affect the productivity study results. However, if the firm represents a large proportion of the industry, there is the possibility that, if not careful, using an industry study would create a disincentive for the firm. This is because improved firm performance would be reflected in higher industry productivity, which

\(^75\) Of course, as with competitive markets, efficiency gains must ultimately be passed through to consumers.
would then lead to a higher X factor. In the limit, if the firm represented the entire industry, an industry study would effectively be a study of the firm.

The use of an industry analysis is potentially problematic in the case of TdP because TdP essentially represents the entire industry. One approach would be to conduct a productivity study of all Latin America telephone companies, and base the industry standard on that study. If this approach is not feasible, one would then want to use a TdP productivity study in such a way that it minimizes the disincentives.

The primary way to minimize the disincentives associated with using a TdP productivity study is to spread out the length of time between a productivity improvement and the point when it is passed on to consumers in the form of lower prices. By spreading out this time period, one establishes a mechanism that mimics competitive markets. In the short run, firms retain all of the benefits of superior performance, but over time these gains become the industry standard and prices in the industry reflect those gains.

One approach to spreading out the gains would be to adopt the rolling average mechanism employed for the U.S. railroads. This mechanism establishes the X factor based on a five-year moving average of total factor productivity growth, with a two-year lag before data are entered into the moving average. The two-year lag was chosen largely for data availability reasons. For example, total factor productivity performance in 2001 will start to be averaged in during the year 2003. That performance will be included in the average through 2007.

One factor promoting strong performance incentives in a rolling average approach to setting the X factor is that the regulated firm has nothing to gain from “gaming” the formula. That is, the firm can only manipulate the X factor in its favor by foregoing productivity gains. But it has little incentive to do so because a one-year reduction in productivity reduces X by only
a fraction of that decline at some point in the future, whereas current profits immediately reflect the full impact of lower productivity growth.

One last issue is the degree to which the X factor can be set automatically to insulate the process from political pressure. Generally, there is a considerable amount of political pressure to pass any realized productivity improvements through immediately to customers, in the form of lower rates. In such circumstances the commission can reduce disincentives by passing these benefits on to customers in a graduated manner. In this context, the 1993 OFTEL decision offers a reasonably good set of criteria for updating the X factor:

Because of my wish to encourage BT to seek improved efficiency, I do not favour a one-off price cut at the start of a new price control period. I prefer a system under which high profits earned towards the end of one price control can be continued into the next, subject to the erosion brought about by the new price cap. The incentive effects of this approach are desirable.

Again, this can be accomplished by using a rolling-average approach to setting the X factor.

4.1.4 Investment Incentives Under Price Caps

In principle, a well-designed price cap plan will provide the best combination of firm incentives and consumer protections than other regulatory regimes. According to Sappington and Weisman, incentive regulation provides superior performance incentives relative to other forms of regulation.77

Incentive regulation can help encourage infrastructure investment by allowing the regulated firm to benefit financially from successful investments. Rate-of-return regulation places a ceiling on the financial return from investment, regardless of the social value or profitability of the investment. Furthermore, regulators sometimes force the firm to bear the costs associated with failed investment projects. Consequently, a firm that operated under rate-of-return regulation can face limited upside potential and sizeable downside risk from its investment. Such an unfavorable risk-reward structure

77 Sappington and Weisman, pp. 314-315.
can dull incentives for investment. By allowing greater opportunity for financial gains from successful investments, incentive regulation can enhance incentives for investment. They also report that empirical research has not demonstrated any negative effects due to incentive regulation and has generally supported this assessment.\(^7\)

There is no systematic evidence that incentive regulation has had undesirable impacts on the key performance indicators in the telecommunications industry. Prices have generally decreased or remained unchanged. Productivity, universal service, and profit levels have also increased or remained at historic levels. There is some evidence that incentive regulation promotes infrastructure development, and there is no evidence that incentive regulation has triggered significant reductions in operating costs. Overall, the empirical evidence to date, while largely consistent with theoretical predictions, does not justify definitive conclusions about the effects of incentive regulation, however. Additional research is required.

As we have stated above, we believe the “American” approach to setting the X factor provides the best regulatory structure for enhancing performance incentives and also provide necessary protection to consumers.

4.1.5 Measurement of Peruvian TFP and Input Price Growth

Important components of the X factor depend on the measurement of Peruvian total factor productivity. We have had to rely on research papers to obtain the necessary information on Peruvian TFP. As described in Appendix D, we have reviewed three studies of Peruvian TFP that produce similar results. While we believe the studies we used are reliable, a better solution would be for this information to be published regularly. Ideally, this would be a government-sponsored series. However, if this is not possible or likely, OSIPTEL may consider developing and maintaining a Peruvian TFP series.

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\(^7\) Sappington and Weisman, p. 327.
4.2 X Factor Values by Basket

If different X factor values for Baskets C, D, and E\textsuperscript{79} are desired, they should be set subject to the condition that the revenue-weighted average of these X factor values equals the overall X factor. A primary reason for desiring different X factor values is to achieve rebalancing of rates between the baskets. For example, if it is determined that connection charges are too low in Basket C, while long distance rates in Basket D are too high, then a relatively lower X factor value could be set for Basket C than for D. This would allow rates for connection charges to increase more rapidly than long distance rates. However, the weighted average of the X factor values for Baskets C, D and E would be constrained by the overall value of the X factor. The overall X factor estimated here, thus, would put a constraint on the amount of rebalancing that could be achieved between the baskets and it would provide a method for determining tradeoffs between adopting high or low X factor values for particular baskets.

However, to avoid arbitrary manipulation of individual basket’s X factors, any rebalancing objectives between baskets should be clearly specified in advance. Absent such information or policy direction, it is our opinion that each basket be assigned the same value of X.\textsuperscript{80}

Our suggestion would be to assign each basket the same X factor value at this time and when the price cap plan is up for review in three years, examine the necessity of assigning different X factor values to each of the baskets. Such an examination should consider the following:

- The need to rebalance rates between baskets. The primary economic consideration here is the relationship between rates and costs: if rates are below incremental costs, from an economic viewpoint these rates should be increased to cover at least

\textsuperscript{79} Basket C contains connection charges, Basket D contains monthly access rent and local calls, and Basket E contains domestic and international long distance.

\textsuperscript{80} Appendix B provides an illustration of basket-specific X factor values.
incremental costs. However, if there is an overriding policy goal to maintain below-cost rates for certain categories of service (for example, local access), this policy should be explicitly stated and the costs of achieving this policy goal should be explicitly calculated. Therefore, to properly assess the need for any rebalancing and/or the costs of maintaining rates below cost, detailed information on service incremental costs needs to be developed.

- The need for different degrees of pricing flexibility between baskets. Generally, higher X factors would allow less pricing flexibility.

- Differences in the competitive pressures faced by the services in the different baskets. In fact, to the degree that some services are competitive, consideration should be given to removing them from price cap regulation. For example, if the long distance market is competitive, these services should be removed from price cap regulation.

4.3 Z Factor Adjustments

The price cap formula will sometimes include the possibility of Z factor adjustments to reflect events that: a) affect the regulated firm’s costs; b) are not due to the firm’s managerial decisions; and c) are not captured by other elements of the price cap mechanism. For example, a Z factor adjustment would be desirable when a new tax is applied to the telephone industry. Such a tax would have a negligible impact on the economy-wide inflation rate and would not have been taken into account when setting the X factor. The Z factor would then be the allowed percentage increase in the price cap index due to this new tax.

Because, Z factors introduce a degree of interpretation and discretion into the price cap formula, it is important that there are well-defined criteria by which Z factors will be set and updated. For example, in the U.S. Federal Communications Commission’s (FCC’s) price cap plan for U.S. local exchange carriers (LECs), the FCC has determined that certain exogenous costs are eligible for Z factor treatment. The FCC has defined exogenous costs as costs that are incurred by the LEC that are caused by administrative, legislative or judicial requirements beyond LEC control and that are not otherwise reflected in the price cap index.81

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Because of the potential for controversy surrounding the determination of Z factor adjustments, Z factor adjustments should only be used under very special circumstances in the price cap regulation of TdP. The only time Z factor adjustments should be allowed is when there are significant, widely-recognized, and widely agreed upon exogenous changes that would have a significant impact on TdP’s performance. Moreover, it should be recognized that, to the extent OSIPTEL considers the use of Z factor adjustments, they are symmetric. That is, not only should exogenous events that negatively impact TdP be considered for Z factor adjustment, but exogenous events that benefit TdP should also be considered for Z factor treatment.

4.4 Additional Price Cap Features

There are other features of price cap plans that are not currently part of the TdP price cap plan as outlined in the Concession Contract, but that may be considered by OSIPTEL or other interested parties in future reviews of the plan. These features include additional pricing restrictions, earnings sharing mechanisms, and service quality incentives. These features were described in Chapter 1 as price cap plan design options. We provide our assessment of these features in this section.

4.4.1 Additional Pricing Restrictions

To protect customers, it may be necessary to divide customers and services into baskets that limit the price changes applicable to those customers and services; and it may be necessary to impose additional “side conditions” on rate elements. Limiting the number of baskets and side conditions increases pricing flexibility for the regulated firm, while increasing the number of baskets and side conditions provides greater price protection for vulnerable customer groups. Therefore, there is a tradeoff between the degree of pricing flexibility the firm has and the
perceived need to protect certain customer groups. The 1994 Concession Contract specifies three service baskets: connection charges; monthly line rental and local calls; and domestic and international long distance.

While we believe this is a sufficient number of baskets, OSIPTEL should determine whether the current basket structure provides sufficient protections for various groups of customers and/or services, such as business versus residential customers. For example, is there concern that the current basket structure may lead to large rate decreases for business customers at the expense of large rate increases for residential customers? Or, is there concern that there will be unwanted realignment of domestic and international long distance rates? If OSIPTEL believes additional safeguards are necessary to protect certain groups of customers and/or services, this should be accomplished by imposing side conditions within the existing basket structure, not by creating additional baskets. Similarly, to the extent services under price cap regulation become subject to effective competition, OSIPTEL may consider deregulating these services and removing them from the price cap.

4.4.2 The Use of an Earning Sharing Mechanism

Because earnings sharing mechanisms blunt incentives and because their purpose may be achieved through appropriate revisions of the X factors, inclusion of such mechanisms in telecommunications price cap plans appears to be undesirable. This notion is supported by the fact that many telecommunications price cap plans have eliminated the inclusion of any sort of ESM. We recommend against including an ESM in the TdP price cap plan.
4.4.3 Service Quality Considerations

To protect consumers, TdP’s price cap plan should be accompanied by service quality monitoring that assures that cost-cutting does not undermine the quality of service that is enjoyed by customers. In fact, a number of service quality provisions were outlined in the 1994 Concession Contract. Included among these service quality provisions were the following:

- replacement of manual switching centers with automatic switching centers
- compliance with the “Expansion and Modernization Plan”
- reduction in the waiting time for service connections
- reduce the number of faults reported by users
- improve fault repair response time
- increase the percentage of completed calls
- improve the performance of operator-assisted calls
- interconnect all areas having more than 500 inhabitants
- improve domestic and international long-distance call completions

Because the technological opportunities available to TdP will allow simultaneous cost reductions and quality improvements, we believe the service quality program outlined in the Concession Contract is sufficient to meet service quality standards. In addition to regular monitoring of service quality performance, we recommend that service quality goals and performance be evaluated at the time of TdP’s price cap review in 2003.

4.5 Future Considerations

Designing and implementing a price cap plan for TdP has brought up many issues that are key to the success of the plan. In this section, we provide some of the important lessons
learned from the process of researching and designing the price cap plan for TdP. We have
discussed some of these issues above. Important for the ongoing success of the plan are the
ability to efficiently collect data that are required to set the X factor and the process of reviewing
and updating the plan.

TdP’s provision of data was critical for the completion our TFP study and we are grateful
to them for their cooperation. Going forward we recommend that the required data be provided
in an agreed-upon format on a regular basis so that its provision becomes more automatic and
part of the normal regulatory process. In addition, TFP and input price data for the Peruvian
economy should be produced and reported on a regular basis.

The review process for the price cap plan is critical to providing TdP the appropriate
incentives for efficient behavior and socially beneficial investments. Obviously, setting the X
factor is a key to providing the appropriate incentives to TdP for efficient behavior that mimics
the outcome of competitive markets. However, just as important is the review of the plan that is
scheduled for 2003. In order to maximize the benefits of the price cap plan, TdP must feel
reasonably assured that the review of the plan will not take away most of the legitimate gains
made by TdP. If there is a sense that the regulatory commitment to the plan and its goals are not
sufficient, TdP will not perform as expected and Peruvian consumers will not obtain the benefits
that are possible under the plan.

Therefore it is important to establish how the plan and, in particular, the X factor be
updated in three years and in subsequent reviews. In reviewing the performance of the plan it
may be tempting to adjust the X factor based on TdP’s profits. However, a review and an
adjustment of the X factor that focuses primarily on TdP’s profitability will blunt the incentives
for TdP to perform efficiently and invest in its infrastructure. In other words, TdP should not be
penalized for performing well given that other standards such as service quality and infrastructure investment are being met.

As we have stated above, one approach would be to conduct a productivity study of all Latin America telephone companies, and base the industry standard on that study. This would provide a more external benchmark to adjust the plan by and would not have the detrimental effects of making adjustments primarily on the basis of TdP’s own performance.

If this approach to updating the X factor is not feasible, one would then want to use a TdP productivity study in such a way that it minimizes the disincentives. In this regard, we believe that OSIPTEL should give serious consideration to a rolling-average X factor as a method of updating the X factor. We believe that a rolling average approach would achieve a number of desirable goals in the price cap regulation of TdP. Foremost, it would minimize the disincentives that could exist by using TdP data to set the X factor. In addition, a rolling-average approach would make X factor updates mechanistic and automatic, thus insulating the determination of the X factor as much as possible from political pressures. Of course, OSIPTEL would need to consider how such a mechanism could be implemented in a way that fulfills the 1994 Concession Contract requirement of a price cap review by OSIPTEL every three years.

Regardless of the procedures ultimately chosen, revisions of the X factor should be as predictable as possible in terms of both when and how revisions will occur. This will provide TdP with the appropriate incentives and consumers the benefits that are available under a well-designed price cap plan.
APPENDIX A

THE X FACTOR IN THE PRICE CAP FORMULA

The objective of the price cap is to target price increases to increases in inflation and a targeted rate of increase in total factor productivity. If inflation is based on a general measure of inflation, such as the IPC, then the relationship between the price cap index and the general measure of inflation is:

\[
    dPCI = dIPC - \left[ (dW_E - dW_{tel}) + (dTFP_{tel} - dTFP_E) \right] 
\]  

(A.1)

where \( W_E \) is the rate of economy-wide input price growth, \( W_{tel} \) is the rate of telecommunications input price growth, \( dTFP_{tel} \) is the target rate of telecommunications TFP growth, and \( dTFP_E \) is the rate of economy-wide TFP growth. The first term in the square brackets is the input price differential (IPD) and the second term is the TFP differential (TFPD). The sum of IPD and TFPD are the X factor:

\[
    X = IPD + TFPD
\]  

(A.2)

If the input price differential is computed as \( dW_{tel} - dW_E \) and the TFP differential is computed as \( dTFP_E - dTFP_{tel} \) the IPD and TFPD would have the opposite signs, as would the X factor:

\[
    -X = -IPD + (-)TFPD
\]
APPENDIX B

ILLUSTRATION OF BASKET-SPECIFIC X FACTOR VALUES

This appendix illustrates some of the tradeoffs in establishing individual X factor values for Baskets C, D, and E. As stated in this Report, if different X factor values for Baskets C, D, and E are desired, they should be set subject to the condition that the revenue-weighted average of these X factor values equals the overall X factor. However, to avoid arbitrary manipulation of individual basket’s X factors, any rebalancing objectives between baskets should be clearly specified in advance. Absent such information or policy direction, it is our opinion that each basket be assigned the same value of X.

Given this caveat, we illustrate how the selection of X factor values for some baskets affect the value of X for other baskets. In particular, we will illustrate different assumptions on Baskets C and E and see how this affects the value of the X factor for Basket D. These values are for illustration purposes and do not represent recommendations by Christensen Associates.

<table>
<thead>
<tr>
<th>Overall X = -5.4%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>D</strong></td>
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<tr>
<td>-7.9%</td>
</tr>
<tr>
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</tr>
<tr>
<td>-5.4%</td>
</tr>
<tr>
<td>-3.4%</td>
</tr>
</tbody>
</table>

The first line illustrates the value for Basket D when the value of the X factors for both Baskets C and E are set equal to 0%. The second row sets the value of Basket C at 3% and E at 2%. The third row sets the value of Basket C at 0% and Basket E at the overall value of the X factor. Finally, the last row sets the value of Basket C at 0% and Basket E at 10%.
APPENDIX C
MOBILE OUTPUT ANALYSIS

We have analyzed the Mobile output and revenue data provided by TdP and, in our opinion, there are some anomalies in the data that need to be explained before we would consider changing our measurement of Mobile output in the TFP model from a measure based on Mobile lines to a weighted average of Mobile lines and Mobile traffic (i.e., minutes of use). The table below presents our analysis.

The first thing to notice is that Mobile line revenue growth increased at a lower rate than Mobile traffic revenue growth over the 1995-2000 period (33.1% vs. 48.5%), while Mobile line growth grew almost twice as fast as Mobile traffic growth (61.3% vs. 33.5%). This means that the implicit price of Mobile lines has been falling at an average annual rate of –28.2%, while the implicit price of Mobile traffic has been increasing at an average annual rate of 15%.

Furthermore, in 1998, Mobile lines grew 45.7%, but Mobile revenue declined by –25.4%. Also in 1998, Mobile traffic output fell by –23.6%, but Mobile traffic revenue increased by 17.6%. These results indicate inconsistencies in the data. The obvious problems in 1998 highlight this.

Using these anomalous Mobile output results in the calculation of TFP produces a reduction in 1995-2000 average annual TFP growth for TdP from 3.5% to 0.8%. This reduces the TFP differential from 2.2% to –0.5%. This implies that TFP growth for the Peruvian economy grew faster on average than did TdP’s TFP growth over this period. These results are not reasonable, particularly when they are to be used in setting a forward-looking X factor for the high-tech telecommunications industry. The X factor in this instance is reduced to –2.7%.
<table>
<thead>
<tr>
<th></th>
<th>Average 1995-2000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Output Growth</strong></td>
<td></td>
</tr>
<tr>
<td>Mobile Lines</td>
<td>61.31%</td>
</tr>
<tr>
<td>Mobile Traffic</td>
<td>33.50%</td>
</tr>
<tr>
<td><strong>Revenue Growth</strong></td>
<td></td>
</tr>
<tr>
<td>Line Revenue</td>
<td>33.13%</td>
</tr>
<tr>
<td>Traffic Revenue</td>
<td>48.48%</td>
</tr>
<tr>
<td><strong>Implicit Price Growth</strong></td>
<td></td>
</tr>
<tr>
<td>Line</td>
<td>-28.18%</td>
</tr>
<tr>
<td>Traffic</td>
<td>14.97%</td>
</tr>
</tbody>
</table>
APPENDIX D

TOTAL FACTOR PRODUCTIVITY GROWTH IN THE PERUVIAN ECONOMY

In order to determine the rate of TFP growth in the Peruvian economy, we conducted a literature review on the subject. Our literature review turned up three papers that discuss the rate of TFP growth in Peru during the 1990’s. The three papers are:


Of these three papers, Hofman provides the most detailed and systematic look at Peruvian total factor productivity performance. His methods are fully documented, and Hofman kindly provided the underlying data used in his analysis. In the following paragraphs, we discuss the basic features of his analysis, compare his methods to our own productivity methods, and report his results. We then report the results of the other studies and compare them with those obtained by Hofman.

Hofman uses constant dollar Gross Domestic Product to represent the quantity of output. He distinguishes three basic factor inputs: capital, labor, and land. To develop a quantity measure of capital input, he first distinguishes three types of capital: nonresidential structures, residential structures, and equipment. He uses the perpetual inventory equation to construct estimates of capital stock from data on investment. In the perpetual inventory equation, he

82 The methods used in this report are the same as those he employed in his more comprehensive study The Economic Development of Latin America in the Twentieth Century, (Edward Elgar; Cheltenham, UK) 2000.
assumes straight-line depreciation, with lifetimes of 50 years for residential structures, 40 years for nonresidential structures, and 15 years for equipment. To estimate the quantity of labor input, Hofman uses a variety of data sources to estimate the number of hours worked by the labor force (employees plus the self-employed). His estimate of the quantity of land input is based on the area of land in use.

The next step in the analysis is to estimate labor income, land income, and capital income. These income shares are used to weight the quantities of labor, land, and capital in constructing the quantity of total input. Hofman estimates the labor income of the self-employed and adds that estimate to the reported compensation of employees to get his estimate of labor income. Relying on the results of detailed data available for the Mexico and Argentina economies, Hofman estimates that land income in Peru equals ten percent of gross domestic product. Capital income is residually determined from Gross Domestic Product and labor and land income. Based on these methods, the average capital share is 33%, the average labor share is 57%, and the average land share is 10%.

Using these methods Hofman estimates the rate of total factor productivity growth for various sub-periods. He divides the post-1950 period into three sub-periods: the base period (1950-1980), the crisis period (1980-1990), and the post-crisis period (1990-1998). He further sub-divides the post-crisis period into a post-crisis recovery period (1990-1994) and a post-crisis growth period (1994-1998). Hofman notes that most Latin American economies have either slow economic growth or an economic contraction during the 1980’s, including Peru. In the early 1990’s Peru had an opportunity to make large increases in productivity as it approached its productivity capacity. Later in the 1990’s the opportunities for productivity gains were somewhat less.
The following table shows the results of Hofman’s analysis for the 1990-1998 period and the post-crisis recovery period.

<table>
<thead>
<tr>
<th></th>
<th>Average Annual Growth Rates</th>
<th>1990-1998</th>
<th>Post-Crisis Recovery Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Growth</td>
<td></td>
<td>4.5%</td>
<td>4.1%</td>
</tr>
<tr>
<td>Total Input Growth</td>
<td></td>
<td>2.6%</td>
<td>2.8%</td>
</tr>
<tr>
<td>Capital Growth</td>
<td></td>
<td>2.8%</td>
<td>3.6%</td>
</tr>
<tr>
<td>Labor Growth</td>
<td></td>
<td>2.9%</td>
<td>2.8%</td>
</tr>
<tr>
<td>Land Growth</td>
<td></td>
<td>0.1%</td>
<td>0.6%</td>
</tr>
<tr>
<td>TFP Growth</td>
<td></td>
<td>2.0%</td>
<td>1.3%</td>
</tr>
</tbody>
</table>

In many respects the methods used by Hofman are consistent with the methods we employed in measuring TdP total factor productivity. In both studies, the capital stocks are based on a breakdown of assets into major categories and on assumptions that depreciation is straight line. Hofman’s stocks are developed using the perpetual inventory method, while the TdP stocks are based on the reported net book value, but the methods used to develop the net book valuation are highly consistent with the perpetual inventory method. Hofman’s labor input estimates are based on hours worked. The TdP labor input estimates are based on the average number of employees, which is used as a proxy for hours worked. Hofman includes land as a factor input, as does the TdP study. Finally, the weights assigned to the different inputs are based on the costs of those inputs. Because the average rate of TFP growth for the 1994-1998 period is not affected by the post-crisis recovery, and because that period substantially overlaps the period of the TdP analysis, we believe that that average growth rate is the best estimate to use in establishing the X factor.

Vallejos and Valdivia look at total factor productivity growth for a number of subperiods, including the 1990-1998 period. While their methods and data sources are not as detailed as
Hofman’s, their results are fairly similar. The following table shows the Vallejos-Valdivia estimates of output, input, and productivity growth over the 1990-1998 period.

<table>
<thead>
<tr>
<th>Average Annual Growth Rates</th>
<th>1990-1998</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Growth</td>
<td>4.7%</td>
</tr>
<tr>
<td>Total Input Growth</td>
<td>2.9%</td>
</tr>
<tr>
<td>Capital Growth</td>
<td>2.9%</td>
</tr>
<tr>
<td>Labor Growth</td>
<td>2.9%</td>
</tr>
<tr>
<td>Land Growth</td>
<td>----</td>
</tr>
<tr>
<td>TFP Growth</td>
<td>1.8%</td>
</tr>
</tbody>
</table>

(We inferred the labor and capital growth rates from the published contributions of labor and capital and the published capital and labor shares.)

As noted in the table, one significant difference between the Vallejos-Valdivia study and the Hofman study is that the former does not include land as a factor input. A second major difference is that the Vallejos-Valdivia does not attempt to weight labor and capital based on income shares, but rather bases the weights on a Cobb-Douglas regression. This regression-based approach is not consistent with standard TFP measurement practices. The derived weights look substantially different than those derived from Hofman’s income shares. Capital has a weight of 69% while labor has a weight of 31%. However, since capital and labor have the same growth rates during this period, the substantially different weights do not have an impact on the measured rate of total input or on TFP. Comparing the two studies, one sees that Vallejos-Valdivia show a slightly higher rate of output growth, the same rate of labor input growth, a slightly higher rate of capital growth, and a slightly lower rate of TFP growth. Vallejos and Valdivia do not show separate TFP estimates for the post-crisis recovery period.
Finally, the Vega-Centeno paper uses econometric time series techniques to estimate the rate of productivity growth for various subperiods, including the period 1990-1996.\(^{83}\) Surprisingly, he estimated that productivity declined over that time period, at an average annual rate of 0.43% per year. The econometric techniques that he employs are not standard in total factor productivity analysis, and one might suspect that these techniques might be the reason for his results. Fortunately, he provides the underlying data in an Appendix to his paper. Using his underlying data on gross domestic product, the economically active population, and his estimates of the capital stock, one can determine what more conventional methods would produce. To facilitate a comparison with Hofman, we use Hofman’s estimate of land input and Hofman’s factor shares.

<table>
<thead>
<tr>
<th>Average Annual Growth Rates</th>
<th>1990-1996</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Growth</td>
<td>4.9%</td>
</tr>
<tr>
<td>Total Input Growth</td>
<td>3.1%</td>
</tr>
<tr>
<td>Capital Growth</td>
<td>4.9%</td>
</tr>
<tr>
<td>Labor Growth</td>
<td>2.8%</td>
</tr>
<tr>
<td>Land Growth</td>
<td>0.1%</td>
</tr>
<tr>
<td>TFP Growth</td>
<td>1.8%</td>
</tr>
</tbody>
</table>

Thus the Vega-Centeno data are also broadly consistent with Hofman’s.

\(^{83}\) In his paper, Vega-Centeno uses a different naming convention, and calls this the 1991-1996 subperiod. He does this because the first annual growth rate that goes into his calculation is the growth rate between 1990 and 1991. In order to maintain consistency with our own work and that of the other authors we review, we refer to this subperiod as the 1990-1996 subperiod.


Laurits R. Christensen, Philip E. Schoech, and Mark E. Meitzen, “Productivity of the Local Operating Telephone Companies Subject to Price Cap Regulation,” May 1994.


Comisión de Regulación de Telecomunicaciones, Resolución 87/97, “Por Medio de la cual se Regula en Forma Integral los Servicios de Telefonía Pública Básica Commutada (TPBC) en Colombia,” 5 de setiembre de 1997.


