WHO BENEFITS FROM ECONOMIC REFORM: 
THE CONTRIBUTION OF PRODUCTIVITY, PRICE CHANGES 
AND FIRM SIZE TO PROFITABILITY

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Denis Lawrence¹, Erwin Diewert² and Kevin Fox³

Abstract

With the increasing pace of infrastructure reform in most countries there has been considerable debate about who has benefited from reform: is it shareholders, consumers, employees or taxpayers? Concurrent changes in output and input prices, productivity and firm size have made answering this question difficult. This paper uses a new indexing method allowing changes in a firm’s gross return to capital to be broken down into separate effects due to productivity change, price changes and growth in the firm’s size. This allows us to construct a series of ‘what-if’ scenarios where the separate contribution of productivity, output and input price changes and changes in firm size can clearly be seen. This in turn allows us to calculate the distribution of the benefits of productivity improvements between consumers, labour and shareholders. The methodology will be of interest to consumers, utilities, shareholders and regulators and could form the basis of a new approach to utility regulation.

Key Words

Index number theory; profit function decompositions; productivity growth; returns to shareholders, customers and workers; translog profit function; regulation of utilities.

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Who Benefits From Economic Reform: The Contribution of Productivity, Price Changes and Firm Size to Profitability

1 INTRODUCTION

With the increasing pace of infrastructure reform in most countries there has been considerable debate about who has benefited from reform: is it shareholders, consumers, employees or taxpayers? Concurrent changes in output and input prices, productivity and firm size have made answering this question difficult. This paper uses a new indexing method allowing changes in a firm’s gross return to capital to be broken down into separate effects due to productivity change, price changes and growth in the firm’s size.

The gross return to capital is the difference between the revenue from outputs produced and the cost of non–capital inputs (labour, materials, services, etc). The gross return to capital has to cover the cost of depreciation and provide a residual return on the firm’s assets. Changes over time in the value of a firm’s gross return to capital can arise from three sources:

- growth in the size of the enterprise – as the capital stock becomes larger, a larger dollar value return to capital will be necessary just to maintain a constant rate of return;
- improvements in productivity – more output is produced from a given quantity of inputs leading to more revenue and more profits; and
- price changes – if output prices increase by less than input prices then the firm’s gross return to capital will fall (with the benefit going to the firm’s consumers and/or input suppliers).

In reality, these three factors usually all occur at the one time making it difficult to attribute changes in the value of the gross return to capital to a particular cause. Indeed, until now there has been no accurate way of separating and quantifying these influences. People have tried to approximate the contribution of price changes by looking at what the gross return to capital would have been this year using last year’s prices applied to this year’s quantities. However, this simple approach still confuses the contributions of growth and relative price changes and will be more inaccurate the longer the time period considered due to flaws in the assumed indexing procedure.

Furthermore, in the presence of inflation, we need to conduct the analysis in terms of real price changes to estimate the full extent of benefits passed on to consumers and input suppliers. This is because consumers and input suppliers benefit from the extent to which their price changes diverge from the rate of inflation, not to the extent of their nominal price changes.

To provide accurate measures of the contribution of growth, productivity and changes in output and input prices to changes in Telstra’s gross return to capital, we have developed an economic methodology based on the work of Diewert and Morrison (1986) and Fox and Kohli (1998). This work explained changes in an economy’s GNP resulting from productivity and terms of trade changes and changes in factor endowments. We have translated this to the firm level to explain
changes in the firm’s real gross return to capital due to growth in the quantity of the firm’s capital stock, productivity change, and changes in real output and real input prices.

This allows us to construct a series of ‘what-if’ scenarios where the separate contribution of productivity, output and input price changes and changes in firm size can clearly be seen. This in turn allows us to calculate the distribution of the benefits of productivity improvements between consumers, labour and shareholders. The methodology will be of interest to consumers, utilities, shareholders and regulators and could form the basis of a new approach to utility regulation.

The methodology is outlined in the following section while in the third section of the paper the methodology is illustrated using data on Australia’s major telecommunications carrier covering the period 1984 to 1994.

2. METHODOLOGY

Diewert and Morrison (1986) and Fox and Kohli (1998) have developed a method for explaining changes in an economy’s GNP resulting from productivity and terms of trade changes and changes in factor endowments. In this paper we translate and adapt this methodology to the level of the individual firm.

Let \( p^t \geq 0 \) denote a price vector for period \( t \) prices, so that \( p^t = \{p_1^t, ..., p_N^t\} \), where there are \( N \) variable net outputs, or “netputs”, denoted by \( y^t = \{y_1^t, ..., y_N^t\} \), and where \( y_i > 0 \) implies that the \( i \)th good is an output, while \( y_n < 0 \) implies that the \( n \)th good is a variable input. Also, let \( k^t \) denote the quantity of capital at time \( t \), which is taken to be exogenously given, or ‘quasi-fixed’ in the short-run.

Consider a general representation of a profit function for a firm, \( \pi \), at time \( t \), as follows:

\[
\pi = \max_{y^t} \{ p^t \cdot y^t : (y^t, k^t, t) \in S' \}
\]

where \( S' \) is the production possibility set at time \( t \).

Further, we define profit as the gross operating surplus, so that \( \pi = rk \), where \( r \) is the gross rate of return to capital which includes depreciation as well as the net return to capital. Assuming competitive maximising behaviour and constant returns to scale, we have \( p \cdot y = rk = 0 \), or \( p \cdot y = rk = \pi \), and we can solve for \( r \) which gives us the ex post gross rate of return on capital.

Following Diewert and Morrison (1986), we define the following total capital productivity index to capture the effect on the firm of a change in productivity between periods \( t - 1 \) and \( t \):

\[
R^{t,t-1} \equiv \left[ \frac{\pi(p^{t-1}, k^{t-1}, t)}{\pi(p^{t-1}, k^{t-1}, t-1)} \cdot \frac{\pi(p^t, k^t, t)}{\pi(p^t, k^t, t-1)} \right]^{1/2},
\]

where the first ratio in the brackets is an index of productivity change using period \( t-1 \) reference netput prices and input quantities, while the second ratio is a competing index of productivity change.
which uses period $t$ reference net output prices and input quantities. As it is unclear which of these two indexes is to be preferred, a geometric mean is taken as in (2). It should be noted that this productivity index differs from the usual TFP indexes in that its denominator is only the rate of growth of capital rather than the rate of growth of capital and labour as in normal value added TFP or rather than the rate of growth of capital, labour and intermediates as in gross output TFP. Consequently, it will tend to produce higher productivity growth rates as we are dividing by a smaller denominator.

To operationalise the theoretical productivity index in (2) we need to specify a functional form for $\pi$. The conditions which define a profit function with constant returns to scale are that it is (i) a nonnegative function, (ii) positive homogeneous of degree one in $p$, (iii) convex and continuous in $p$ for every fixed $k$, (iv) positive homogeneous of degree one in $k$, (v) nondecreasing in $k$ for every fixed $p$, and (vi) concave and continuous in $k$ for every fixed $p$ (Diewert 1973). We consider the case where the log of $\pi$ in (1) has the translog form (Christensen, Jorgensen and Lau 1973; Diewert 1974; Russell and Boyce 1974), so that

$$\ln \pi = \alpha_0' + \sum_{i=1}^{N} \alpha_i' \ln p_i + \frac{1}{2} \sum_{i=1}^{N} \sum_{j=1}^{N} \alpha_{ij} \ln p_i \ln p_j + \ln k$$

where $\alpha_{ij} = \alpha_{ji}$, for $i, j = 1, \ldots, N$, and the following restrictions hold so that the functional form in (3) is homogeneous of degree one in $p$: $\sum_{i=1}^{N} \alpha_i = 1$, $\sum_{i=1}^{N} \beta_i = 0$, and $\sum_{i=1}^{N} \alpha_{ij} = 0$. This translog profit function is ‘flexible’ in the sense that it can approximate an arbitrary, twice continuously differentiable function to the second order (Diewert 1974; p 113).

Diewert and Morrison (1986) exploited the translog identity of Caves, Christensen and Diewert (1982) to prove a relationship between the translog functional form and the Törnqvist (1936) index formula, which they suggested for decomposing the growth in domestic product for a trading economy. In the current context, we have the following theorem.

**Theorem 1** If the functional form for a firm’s profit function, $\pi$, is translog as defined by (3) in periods $t-1$ and $t$, and there is competitive profit maximising behaviour in both periods, then the productivity index in (2) is exactly equal to a Törnqvist implicit net output quantity index divided by the capital stock growth between periods $t-1$ and $t$.

The proof is given in the appendix.

Using Theorem 1, we have

$$R_{t,t-1} = \frac{\Gamma_{t,t-1}}{P_{t,t-1}^{t-1} K_{t,t-1}}$$

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4 See Fox and Kohli (1998) for an application and extension of this method using Australian data. For other applications and further details of the GDP approach, see Kohli (1990, 1991).
where the implicit net output index is given by \( \Gamma_{t,t-1} = \sum_{i} \frac{p_i y_i}{\frac{p_i y_i}{p_i y_i}} \), where

\[
\Gamma_{t,t-1} = \sum_{i} \frac{p_i y_i}{\frac{p_i y_i}{p_i y_i}}
\]

which is an index of the rate of growth in gross operating surplus,

\[
P_{t,t-1} = \exp \left[ \sum_{i} \frac{1}{2} s_i^t + s_i^{t-1} \ln \left( \frac{p_i^t}{p_i^{t-1}} \right) \right]
\]

which is a Törnqvist price index, where \( s_i = (p_i y_i)/(p \cdot y) \) is the profit share of netput \( i \), and

\[
K_{t,t-1} = k^t / k^{t-1}.
\]

In a similar fashion to the productivity index in (2), we can relate the Törnqvist indexes in (6) and (7) to the translog profit function defined in (3). Consider the following theoretical netput price index:

\[
P_{t,t-1} = \left[ \frac{\pi(p^t, k^{t-1}, t-1)}{\pi(p^{t-1}, k^{t-1}, t-1)} \frac{\pi(p^t, k^t, t)}{\pi(p^{t-1}, k^{t-1}, t)} \right]^{1/2}
\]

In a similar fashion to Theorem 1, it can be shown that if \( \pi \) has the translog form in (3) in each period, then the index in (8) is exactly equal to the Törnqvist price index in (6).

Also, consider the following theoretical input (capital) quantity index:

\[
K_{t,t-1} = \left[ \frac{\pi(p^{t-1}, k^t, t-1)}{\pi(p^{t-1}, k^{t-1}, t-1)} \frac{\pi(p^t, k^t, t)}{\pi(p^{t-1}, k^{t-1}, t)} \right]^{1/2}
\]

It can be easily shown that if \( \pi \) has the translog form in (3) in each period, then the index in (9) is exactly equal to the capital quantity index in (7).

Note that the price index in (6) is an index which incorporates changes in both output and variable input prices. Hence, it can be thought of as a “terms of trade” index for a firm, as it is essentially an index of output prices (a firm’s exports) relative to variable input prices (a firm’s imports).

It is also possible to consider the effect on profits of individual price changes, i.e., for good \( m \), we consider the change in the price of good \( m \) while holding everything else constant:

\[
P_{m,t-1} = \left[ \frac{\pi(p^{t-1}_m, ..., p^{t-1}_m, p^{t-1}_m, k^{t-1}, t-1)}{\pi(p^{t-1}_m, k^{t-1}, t-1)} \frac{\pi(p^t, k^t, t)}{\pi(p^{t-1}_m, ..., p^{t-1}_m, p^{t-1}_m, k^t, t)} \right]^{1/2}
\]

Exploiting the same relationship with the translog functional form in (3) as above, we get the following Törnqvist price change index for good \( m \):
Using (11), it is easy to show that
\[ \prod_m^{N} P_{m}^{t,t-1} = P^{t,t-1} \]
so that it is possible to decompose the aggregate price index, \( P^{t,t-1} \), into individual price indexes. It is also possible to decompose \( P^{t,t-1} \) to get price indices for groups of goods, eg it is possible to separate input and output price changes.

Finally, using (4), (5), (6) and (7), we note that
\[ \Gamma^{t,t-1} = R^{t,t-1} \cdot P^{t,t-1} \cdot K^{t,t-1} \]
so that \( R^{t,t-1}, P^{t,t-1} \) and \( K^{t,t-1} \) give the effects of productivity change, price change and change in the endowment of capital, on the change in gross operating surplus. In other words, the right-hand side of (13) gives a decomposition of changes in gross operating surplus, \( \Gamma^{t,t-1} = r^{t} k^{t} / r^{t-1} k^{t-1} \), which can be further decomposed into individual, or group, price effects using (12). Dividing both sides of (13) by the growth in the capital stock, \( K^{t,t-1} = k^{t} / k^{t-1} \), yields a decomposition of the growth in the gross rate of return on capital, \( r^{t} / r^{t-1} \), which may be useful in some contexts. The indexes \( R^{t,t-1} \) and \( P^{t,t-1} \) (and subcomponents), do not change as they are invariant to the units of measurement, ie from (2) and (8) it is clear that changing from profits to per unit profits does not alter the respective contributions from productivity and price change.

In the real price change analysis reported here, both the left hand side of (13) and the net output price term on the right hand side are divided by the following term:
\[ CPI^{t,t-1} = cpi_{t} / cpi_{t-1} \]

where \( cpi \) is the consumer price index. This produces the following:
\[ \Gamma^{t,t-1} / (cpi^{t} / cpi^{t-1}) = R^{t,t-1} P_{1}^{t,t-1} P_{2}^{t,t-1} K^{t,t-1} / (cpi^{t} / cpi^{t-1}) \]
\[ = [\pi(p', k', t) / cpi^{t}] / [\pi(p^{t-1}, k^{t-1}, t - 1) / cpi^{t-1}] \]
\[ = R^{t,t-1} P_{1}^{t,t-1} P_{2}^{t,t-1} K^{t,t-1} / (cpi^{t} / cpi^{t-1}) \]
\[ = R^{t,t-1} P_{1}^{t,t-v} P_{2}^{t,t-v} K^{t,t-1} \]
where \( P_{m}^{t,t-v} \) is the same as the price term in (10) except that nominal prices \( p' \) are replaced by real prices \( p' / cpi' \).
3 TELSTRA’S GROWTH, PRODUCTIVITY AND PRICE CHANGES

In this and the following section we illustrate the application of the methodology using a database on Australia’s largest telecommunications company, Telstra, published in Appendix 3 of Bureau of Industry Economics (1995). The database covers the years 1980 to 1994 although in this paper we limit coverage to the 11 years from 1984 to 1994. It contains data on the values and quantities of 7 outputs (telephone calls, telephone services in operation, telephone connections, telegrams/faxpost, telex services in operation, telex calls and other network services) and 3 inputs (labour, capital and other inputs).

The 11 year time period covered by this study was one of considerable change and reform for Telstra which went from being a government owned monopoly to facing its first competition from Optus in 1992 and from Vodafone in 1993. While Telstra remained in government ownership throughout this period there was considerable structural reform and downsizing of the organisation. The former Telecom Australia which handled domestic telecommunications was merged with the Overseas Telecommunications Commission to form the full service carrier Telstra and labour numbers fell by around 25 per cent from 87,000 in 1986 to 66,000 in 1994.

Estimating the economic quantity and user cost of the capital stock of a large, capital intensive, network based enterprise like Telstra is always problematic. In the current database the BIE estimated the quantity of the capital stock by using the perpetual inventory method to update and backdate a 1986 estimate of the market value of Telstra’s capital stock. Telstra’s estimated capital stock actually decreased by 5 percent between 1984 and 1994 as a result of structural reform and technical change.

While the BIE calculated an explicit annual user cost of capital, in this study the annual cost of using capital inputs is taken to be the gross return to capital (the difference between the revenue from outputs produced and the cost of non–capital inputs such as labour, materials and services). The gross return to capital has to cover the cost of depreciation and provide a residual return on the firm’s assets.

Telstra’s total factor productivity (TFP) measures the efficiency with which Telstra converts inputs into outputs. It differs from the total capital productivity concept of equation (2) in that it is measured as an index of total output quantity formed from the 7 output components relative to total input quantity formed from the 3 input components (labour, capital and intermediates). Changes in the quantities of individual outputs and inputs are combined using revenue and cost shares, respectively. From figure 3.1 and table 3.1, we see that Telstra’s TFP increased by 92 percent between 1984 and 1994 and by 47 percent between 1990 and 1994. This means that in 1994 a typical unit of Telstra’s input was able to produce 47 per cent more output than it was just 5 years earlier in 1990.
and 92 per cent more than it could have a decade earlier. This is a truly dramatic rate of productivity growth.

**Figure 3.1: Telstra's Total Factor Productivity and Capital Quantity, 1984–1994**

![Graph showing Telstra's TFP and capital quantity from 1984 to 1994.](image)

*Source: Estimates based on BIE (1995) database*

In terms of trend growth rates, Telstra’s TFP increased by around 5 percent per annum over the 11 year period although it increased by 9.8 per cent annually for the last five years. This is substantially higher than the productivity growth for the economy as a whole and resulted from the combined effects of technological change and substantial restructuring and downsizing within Telstra. If all the benefits of this exceptionally high level of productivity growth had been retained by Telstra it would have led to a large increase in Telstra’s gross return to capital. However, the effects of technological change, increasing competition and regulation put significant downward pressure on Telstra’s output prices in the latter years.

We present changes in Telstra’s average nominal output and input prices in figure 3.2 and table 3.1. The estimate of the overall price Telstra receives for its output increased by 34 percent between 1984 and 1991 but then declined substantially. In fact, by 1994 it was 6 percent below what it was in 1984. Over the same 11 year period, the consumer price index increased by 70 per cent. This means that our estimate of the average real price of Telstra’s output – the overall price it charges to telecommunications consumers relative to the rate of inflation – declined by 76 per cent over the 11 year period. At the same time, however, the estimates of Telstra’s nominal input prices outpaced inflation. Telstra’s total inputs price index increased roughly 38 per cent more than the consumer price index.
If Telstra had passed on the full extent of its average input price increases to consumers then, all else unchanged, its gross return to capital would clearly have been much higher over the decade.

Changes in real prices are important because they provide a more accurate guide to the extent different groups benefit from price changes. In a time of inflation, consumers benefit from price changes that are below the rate of inflation, i.e., where the real price of the product they are purchasing has fallen. Conversely, labour only benefits from wage increases to the extent that those increases exceed the rate of inflation, i.e., when real wages have increased, not to the extent of their nominal wage increase. Labour also only benefits to the extent that the real wage increase applies to a standardised unit of labour abstracting from increases in skill levels and qualifications over time. The average real price of Telstra’s output fell steadily over the decade.

The estimated real labour price also remained relatively constant between 1984 and 1991 but by 1994 it was 24 percent higher than it was a decade earlier. However, with the information available we have been unable to adjust for either the skill increases that occurred with technological change or the compositional changes that occurred with downsizing. Consequently, our estimates of real wage increases overstate the benefits going to labour.

Table 3.1: **Telstra’s TFP, average nominal output and input price indexes, 1984 to 1994**

<table>
<thead>
<tr>
<th>Year Ending 30 June</th>
<th>Capital quantity</th>
<th>Total Factor Productivity</th>
<th>Total Output Price</th>
<th>Consumer Price Index</th>
<th>Total Inputs Price</th>
<th>Labour Input Price</th>
</tr>
</thead>
</table>
4 SOURCES OF CHANGE IN TELSTRA’S GROSS RETURN TO CAPITAL

It is clear from the preceding section that, other things being equal, the size of Telstra’s real gross return to capital will have:

- decreased somewhat from the reduction in the amount of capital used by Telstra;
- increased substantially from Telstra’s high rate of productivity growth;
- decreased substantially from changes in Telstra’s average real output prices; and
- decreased from changes in the average real price Telstra pays for its labour (although part of this reflects increasing skill levels and compositional change within the Telstra workforce).

Since we deal with the actual quantity of capital, labour and materials and services each period, there will be an approximate one–to–one correspondence between the changes in the gross return to capital we report for each of the scenarios and pre–tax profits. This is because none of the scenarios involve changes to the quantity of inputs and hence depreciation always remains the same. Changes to output quantities and prices (and labour prices) are then directly translated into changes in the gross return to capital and, because depreciation is unchanged, (approximately) into pre–tax profits.

In the remainder of the paper we use the term productivity to refer to the total capital productivity concept outlined in equation (2).

Looking first at the 11 year period up to 1994, we present year–to–year percentage changes in the real gross return to capital in table 4.1 along with the change which would have occurred from each of the four sources in isolation. In other words, the third column of table 4.1 shows the percentage change in the real gross return to capital which would have occurred from year to year solely from changes in our estimates of the size of Telstra’s capital stock, assuming both the level of productivity and real output and input prices remained constant. Similarly, the fourth column shows the year to
year percentage change in real gross return to capital attributable to productivity change had the size of Telstra’s capital stock remained the same and its real output and input prices remained constant. The fifth column of the table shows the percentage change in the real gross return to capital from year to year attributable solely to changes in real output prices assuming the size of the capital stock, productivity levels and real labour prices all remained constant. Finally, the last column of the table shows the percentage change in the real gross return to capital from year to year attributable solely to changes in real labour prices assuming the size of the capital stock, productivity levels and real output prices all remained constant.
Table 4.1: **Contributors to Telstra’s annual change in real gross return to capital, 1985 to 1994**

<table>
<thead>
<tr>
<th>Year ending</th>
<th>Change in real gross return to capital</th>
<th>Change in real return to capital solely due to:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Growth</td>
<td>Total capital productivity</td>
</tr>
<tr>
<td>30 June</td>
<td></td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>1985</td>
<td>-7.24</td>
<td>-2.34</td>
<td>-2.86</td>
</tr>
<tr>
<td>1986</td>
<td>27.72</td>
<td>0.03</td>
<td>37.03</td>
</tr>
<tr>
<td>1987</td>
<td>-2.53</td>
<td>1.48</td>
<td>8.36</td>
</tr>
<tr>
<td>1988</td>
<td>24.96</td>
<td>-1.04</td>
<td>16.62</td>
</tr>
<tr>
<td>1989</td>
<td>10.04</td>
<td>0.20</td>
<td>14.08</td>
</tr>
<tr>
<td>1990</td>
<td>-6.78</td>
<td>1.83</td>
<td>4.98</td>
</tr>
<tr>
<td>1991</td>
<td>8.12</td>
<td>1.21</td>
<td>15.02</td>
</tr>
<tr>
<td>1992</td>
<td>-15.12</td>
<td>0.23</td>
<td>15.98</td>
</tr>
<tr>
<td>1993</td>
<td>25.36</td>
<td>-2.75</td>
<td>56.69</td>
</tr>
<tr>
<td>Average</td>
<td>7.20</td>
<td>-0.48</td>
<td>19.83</td>
</tr>
</tbody>
</table>

Over the 11 year period the real gross return to capital increased by an average 7.2 per cent per annum. If there had been no productivity change and no change in real output and labour prices but the same growth in the size of the capital stock occurred then the real gross return to capital would have decreased by an average 0.5 per cent per annum. This means the actual increase in real gross returns to capital has outpaced the growth in the size of the capital stock on average.

If all the benefits from productivity growth had been retained by Telstra and there had been no growth in the capital stock and no change in real output and labour prices then the real gross return to capital would have increased on average by a massive 19.8 per cent per annum. Conversely, in the absence of growth in the capital stock, productivity changes and real labour price changes, then real gross returns would have been reduced annually by 8 per cent on average given the actual pattern of real output price changes. Finally, real labour price changes in the absence of any other changes reduced real gross returns to capital by an average of 1.7 per cent annually.

The cumulative impact of growth, productivity and real price changes on real gross returns to capital is shown in figure 4.1. Here we take the real gross return to capital in 1984 as the base and look at the cumulative effect of the actual annual changes in each of the three sources of change and also look at the progressive impact of the sources of change on the real return to capital. The dashed line near the bottom of the figure shows what would have happened to the real gross return to capital over the 11 years if there had been no productivity change and no changes in real labour and output prices – by 1994 the annual real return to capital for that year would have been 5 per cent lower.
The large dashed line at the top of the figure shows what would have happened to the real gross return to capital over the 11 years if there had been both the observed levels of growth and productivity change but no change in either real labour or average real output prices – by 1994 the annual real gross return to capital for that year would have been 430 per cent higher. The small dashed line near the top of the figure shows what would have happened to the real gross return with growth, productivity and real labour price changes but no change in the real output price. Finally, the solid line near the bottom of the figure shows the cumulative effect of all four contributors to changes in the real gross return to capital. This line coincides with the actual observed change in Telstra’s real gross return over the period.

The gap between the ‘growth’ and ‘growth plus TFP’ lines indicates the size of the potential contribution to Telstra’s real gross return to capital from productivity improvements from 1984 onwards. The gap between the top two lines shows the extent to which the benefits from Telstra’s high productivity growth has been passed on to its labour force in the form of higher real wages (although this overstates the benefits to labour as it ignores skill and compositional changes). For the first 8 years of the decade this gap was small but negative indicating that real wages fell behind cumulative inflation in that period. This was reversed in the last 3 years when the gap became positive and relatively wide. The large gap between the second top (small dashed) line and the solid line near the bottom of the figure indicates the size of the benefit Telstra has passed on to its consumers over the period in the form of lower real prices. Finally, the gap between the solid line
and the small dashed line at the bottom of the graph indicates the extent to which Telstra’s owners (in this case the government) have benefited from Telstra’s high productivity growth. With the exception of 1985, this gap was positive throughout the decade.

To illustrate how this information can be converted into dollar values, we now look at the contributors to changes in Telstra’s real gross return to capital between 1990 and 1994. Over this 5 year period the average annual change in Telstra’s real gross return to capital was 6.5 per cent. The change due to productivity improvement alone would have been on average 30 per cent per annum while the change due to growth alone would have been an average of –1.2 per cent per annum. Changes in the real price paid for labour alone decreased real returns by 6 per cent per annum on average while changes in the real price of Telstra’s outputs alone reduced real returns by an average of 11.6 per cent per annum.

In figure 4.2 we present the cumulative effect of these contributions to changes in the real gross return to capital. In 1994 the actual annual real gross return to capital was 24 per cent higher than it was in 1990. Growth in the real capital stock on its own, all else unchanged, would have again led to the 1994 return to capital being 5 per cent lower than it was in 1990. The combined effect of growth and productivity improvements would have led to the 1994 real gross return to capital being 163 per cent higher than it was in 1990. These effects combined with changes in the real price of Telstra’s labour would have led to real gross returns being 103 per cent higher in 1994 than in 1990. Adding the impact of real output price reductions accounts for the gap between this figure and the increase actually observed of 24 per cent – a large part of the Telstra ‘productivity dividend’ has been passed on to consumers in the form of lower real prices.

In 1990 Telstra’s real gross return to capital was around $4.4 billion (expressed in 1994 prices). Table 4.2 shows how this changed over the subsequent 4 years. By 1994 the gross return to capital was around $5.5 billion. In the absence of other changes, growth in the size of the capital stock would have taken this figure down to around $4.2 billion. Growth plus TFP improvement would have taken it to $11.7 billion in the absence of real price changes while growth, TFP improvement and real labour price changes would have taken it to $9 billion.

Figure 4.2: Changes in real return to capital and the distribution of Telstra’s cumulative productivity dividend, 1990 to 1994
### Table 4.2: Telstra’s real gross return to capital and cumulative productivity dividend, 1990 to 1994

<table>
<thead>
<tr>
<th>Year ending 30 June</th>
<th>Cumulative real return due to:</th>
<th>Productivity dividend</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Growth</td>
<td>Growth + TFP</td>
<td>(2)  plus real price labour</td>
</tr>
<tr>
<td></td>
<td>(1) $1994m</td>
<td>(2) $1994m</td>
<td>(3) $1994m</td>
</tr>
<tr>
<td>1990</td>
<td>4,439</td>
<td>4,439</td>
<td>4,439</td>
</tr>
<tr>
<td>1991</td>
<td>4,492</td>
<td>5,167</td>
<td>5,252</td>
</tr>
<tr>
<td>1992</td>
<td>4,503</td>
<td>6,007</td>
<td>5,115</td>
</tr>
<tr>
<td>1993</td>
<td>4,379</td>
<td>9,153</td>
<td>7,322</td>
</tr>
<tr>
<td>1994</td>
<td>4,222</td>
<td>11,680</td>
<td>9,014</td>
</tr>
</tbody>
</table>

The total ‘productivity dividend’ in 1994 for productivity change since 1990 was, thus, around $7.5 billion. The distribution of this cumulative productivity dividend was a benefit of around $3.5 billion passed on to consumers, a benefit of around $2.7 billion passed on to Telstra’s labour (although, as noted above, this overstates the benefit to labour as skill and compositional changes are ignored) and a benefit of around $1.3 billion passed on to Telstra’s owners in the form of an increased rate of return. This means around 47 per cent of the benefit from cumulative productivity improvements over this 5 year period was passed on to consumers in 1994. Another way of looking at this result is
that, in 1994, if Telstra had not passed a large proportion of the benefits of productivity improvement over the 5 years on to consumers, then all else being equal its pre–tax profit would have been $3.5 billion higher.

5 CONCLUSIONS

A new economic method for decomposing the contribution of productivity and price changes to changes in a firm’s real gross return to capital has been developed in this paper and applied to a publicly available database on Telstra.

The results show that around half of the benefits from Telstra’s productivity improvements over the decade from 1984 to 1994 were passed on to consumers in the form of real price reductions. This benefit to consumers amounted to $3.5 billion in 1994 prices. Around 30 per cent was passed on to labour (subject to some measurement limitations) while the remaining 20 per cent was passed on to Telstra’s owner (the government as it then was) in the form of higher returns.

As well as providing the first rigorous means of quantifying the distribution of benefits from productivity and real price changes, the methodology could also play an important role in the regulation of infrastructure utilities. By rigorously quantifying the distribution of gains it provides regulators with a better source of information on how to treat the various stakeholders – consumers, employees and owners – in future periods.

Like any empirical study, a number of assumptions have to be made to operationalise the analysis. One remaining area of weakness, particularly in a rapidly changing area like telecommunications, concerns the introduction of new products and technologies. The illustrative case study assumed that the type and quality of both outputs and inputs remains constant over time. Consequently, the case study underestimated the extent of consumer benefit since no allowance was made for the increased utility associated with an increase in the consumer’s choice set. Conversely, the extent of benefits flowing to labour was likely to be overestimated as no allowance was made for increases in average skill levels associated with technological change and downsizing. Both these topics should be the focus of future work.

APPENDIX: PROOF OF THEOREM 1

The proof exploits the ‘translog identity’ of Caves, Christensen and Diewert (1982; p. 1412), which in turn uses the ‘quadratic identity’ of Diewert (1976; p. 118).

Consider a profit function $\pi(p, k)$, for any period. If producers are competitively profit maximising under either technology, then using Hotelling’s Lemma,

$$y = \nabla_p \pi(p, k)$$
using vector notation, where $\nabla_p$ denotes the vector of first order derivatives with respect to each element of the price vector $p$. Also, following Diewert (1974; p.140) we have the following shadow pricing result:

(17) \[ r = \partial \pi(p, k) / \partial k. \]

Then, if we assume constant returns to scale

(18) \[ \pi(p, k) = p \cdot y = rk, \]

Using the notation $p \cdot y = \sum p_i y_i$. Now,

(19) \[ R^{t-1} = \frac{\pi(p^{-1}, k^{-1}, t)}{\pi(p^{-1}, k^{-1}, t-1)/k^{-1}} \]

where we have used the translog identity, and (18). Then using (16) to re-express this last line yields:

(20) \[ R^{t-1} = \frac{p^t \cdot y^t}{p^{t-1} \cdot y^{t-1}} \exp \left[ \sum_{i=1}^{S} \frac{1}{2} \left( \frac{p_i^t y_i^t}{k^t} \cdot \frac{p_i^{t-1} y_i^{t-1}}{k^{t-1}} \right) \ln \left( \frac{p_i^{t-1}}{p_i^t} \right) \right] k^{t-1} / k^t, \]

which can be easily simplified to prove the theorem.

We can note that the capital stock growth index can also be interpreted as a Törnqvist index

(21) \[ k^{t-1,t-1} = \frac{k^t}{k^{t-1}} = \exp \left[ \frac{1}{2} \left( s_k + s_k^{-1} \right) \ln \left( k^t / k^{t-1} \right) \right], \]

where the equality follows as the profit share of capital is one, ie $s_k = rk / (p \cdot y) = 1$ from (18).

REFERENCES


