USE OF TFP IN CPI-X REGULATION

A Report Prepared by NERA

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1. BACKGROUND

TransGrid has requested that NERA comment on the process for establishing expenditure forecasts based on TFP estimates and CPI indexation. In particular, TransGrid has asked NERA to advise whether it is appropriate to forecast future required levels of expenditure on the basis of the following equation:

$$(\text{Required expenditure})_t = (\text{Required expenditure})_{t-1} * (1 + \Delta CPI_t - \Delta TFP_t); \text{ where} \qquad (1)$$

$(\text{Required expenditure})_t$	= the level of expenditure in period t required to achieve a predetermined level of output;
$\Delta CPI_t = (CPI_t - CPI_{t-1}) / CPI_{t-1}$	= the percentage change in the consumer price index (CPI) of inputs from period t-1 to period t; and
ΔTFP_t	= the percentage change in total factor productivity from period t-1 to period t associated with performing the constant set of functions associated with efficient expenditure.

The background to this request is that the ACCC's January 2000 *NSW and ACT Transmission Network Revenue Caps* Decision (the ACCC Decision) set operating expenditure benchmarks over five years based on an initial estimate of required operating expenditure in 1999/00 rolled forward at CPI less 1.55% per annum. The ACCC indicated that this approach was consistent with a target TFP of 1.55% per annum which was just below the range of its own internal estimates of TFP.

> *"This translates to an average saving of just over 1.5 percent per annum which is slightly less than the range of efficiency gains indicated by a preliminary total factor productivity (TFP) analysis conducted by the Commission in-house."* (Page 100 of the ACCC Decision)

From this statement it appears reasonable to conclude that, by employing a CPI-X roll forward of operating expenditure over the regulatory period, the ACCC believed that it was imposing a TFP requirement on TransGrid of X (in this case 1.5%).

2. ANALYSIS

2.1. What is TFP?

In order to answer the questions put to us by TransGrid it is important to carefully define the meaning of TFP. The term TFP was first coined in the economic growth literature[1] where it referred to an increase in output that could not be explained by known increases in inputs to the production process. For example, a 1% change in TFP suggested that output could be increased by 1% without any increase in inputs (labour or capital). Alternatively, output could be maintained constant while reducing the number of inputs used by 1%.

More recently, Diewert and Lawrence in a paper for the Reserve Bank of New Zealand state:

> *A total factor productivity (TFP) index is generally defined as the ratio of an index of output growth divided by an index of input growth. Outputs refer to the total quantities of all outputs produced by the production sector and inputs are the total quantities of all inputs utilised by the same production sector over two accounting periods.*[2] p7

2.2. The correct relationship between required expenditure and TFP

With this definition of TFP it follows axiomatically that the change in required expenditure each year to continue to provide a given level of output is:

(Required expenditure)$_t$ =(Required expenditure)$_{t-1}$ *(1+ΔIP_t - ΔTFP_t); where (2)

(Required expenditure)$_t$= the level of expenditure in period t required to achieve a predetermined level of output;

$\Delta IP_t = (IP_t - IP_{t-1}) / IP_{t-1}$ = the percentage change in the average price of inputs used in producing that output from period t-1 to period t; and

ΔTFP_t = the percentage change in total factor productivity in relation to that output during in period t associated with performing the constant set of functions associated with efficient expenditure.

1 See Domar, E., "On the measurement of technological change", *Economic Journal*, 71, December 709-29.

2 Diewert E. and Lawrence D., *Measuring New Zealand's Productivity*, Report prepared for the Department of Labour, Reserve Bank of New Zealand and The Treasury, March 1999 pg 7

That is, in the absence of any change in TFP (ΔTFP=0) the required level of expenditure rises exactly in proportion to the average increase in input prices from one period to the next. This is because a change in TFP of zero means that the same number of inputs must be purchased at the new input prices in order to deliver the same level of output. However, if the change in TFP is positive then fewer inputs must be purchased to produce the same level of output. In this situation required expenditure rises less slowly than input prices. If the change in TFP is actually greater than the change in input prices then required expenditure falls.

Equation 2 above provides the correct relationship between TFP and required expenditure for a given level of output. To the extent that equation 1 (as employed by the ACCC) gives a different answer then equation 1 is incorrect.

2.3. When is the ACCC's approach correct?

TransGrid has asked us to advise on whether it is reasonable to set required expenditure on the basis of equation 1 as used by the ACCC (reproduced below):

$$(\text{Required expenditure})_t = (\text{Required expenditure})_{t-1} * (1+\Delta CPI_t - \Delta TFP_t); \text{ where} \quad (1)$$

2.3.1. Assuming constant output levels

By comparison with equation 2 it is possible to see that equation 1 will only give the correct estimate of required expenditure if $\Delta CPI_t = \Delta IP_t$. That is, if the percentage change in input prices (IP) the regulated business faces is equal to the percentage change in CPI over the relevant period. Specifically, if:

$$(IP_t - IP_{t-1}) / IP_{t-1} \text{(for the regulated business)} = (CPI_t - CPI_{t-1}) / CPI_{t-1} \text{ (for the economy)}$$

However, in general it will be the case that ΔCPI_t is less than ΔIP_t and that, consequently, equation 1 will understate the correct level of required expenditure.

This is because any increase in TFP generally in the economy tends to already be reflected in lower CPI growth and higher real returns to the factors of production (ie, higher real input prices). If a regulated business faces the same input price inflation as the average in the domestic economy (ie, if the regulated business used the same inputs on average as are used in the general economy) then this means that ΔCPI_t will underestimate the businesses ΔIP.

For example, if the average price of inputs across the entire economy rose by 5% in one year and the TFP for the entire economy was 2% then the cost of producing the average unit of final output will only rise by 3%. This is because the 2% economy wide TFP partly offsets the 5% factor price increase. This also means that owners of factors of production, on average, receive a 2% real increase in the price they can charge (in line with their increased productivity). Abstracting from statistical imperfections and the role of foreign trade in the compilation of the CPI, the change in the CPI should also reflect the change in average domestic input prices less the average domestic TFP. That is, the change in CPI should be approximately equal to:

$$\Delta CPI_t = \Delta IP_t - \Delta TFP_t \qquad (3)$$

This is consistent with available empirical estimates with real unit wage costs (as measured by the ABS's Wage Cost Index) growing at around 1% faster than CPI since the inception of the Wage Cost Index in 1997. (The Wage Cost Index was compiled due to recognised shortcomings in available indexes as measures of unit input price changes).

The fact that the CPI already incorporates the average economy wide TFP means that setting required revenues in line with equation 1 will result in a 'double counting' of TFP gains if the input price inflation faced by a regulated business is the same as the average input price inflation in the domestic economy.

It is possible that if the input price inflation faced by the regulated business is, by coincidence, lower than the average input price inflation in the general economy by exactly the economy wide TFP then equation 1 may still provide the correct estimate of required revenue. However, this would only be the case 'by accident' rather than design.

Moreover, it may be likely that the regulated business would face higher input price inflation than exists in the general economy. This will be the case if the regulated businesses tends to have to purchase inputs that themselves have lower TFP than the general economy. Most TFP in the general economy is delivered by relatively new industries or industries that substantially benefit from new technologies (such as faster computing power). As a result, the price of these inputs tends to fall relative to the price of other inputs.

For example, if TransGrid's suppliers (eg, metal manufacturers and construction companies) tend to have relatively low TFP gains themselves then TransGrid can expect the price of its inputs to rise faster than the average price of inputs in the domestic economy as a whole. This appears to be a reasonable assumption. In this circumstance the use of equation 1 to set required revenues actually imposes more than a double counting of TFP gains. That is, the regulated business must make efficiency gains equal to the estimated X factor **plus** efficiency gains in excess of the average gains in the general economy.

2.3.2. Non constant output levels

Equation 2 is the correct formula for forecasting required revenues if required output levels are constant. If required output levels are increasing over time then equation 2 will underestimate the correct required revenues associated with any given level of TFP growth. In order to correct this problem equation 2 must be amended to include a growth of output term as is done below:

$$(\text{Required expenditure})_t = [(\text{Required expenditure})_{t-1} * (1+\Delta IP_t - \Delta TFP_t)]*[1+g_t] \qquad (2)$$

Where g is a factor that represents the impact of changes in the scale of output on total costs. If the production function exhibits constant returns to scale in output (however output is defined) then g is simply the change in quantity of output. For example, if output was defined as 'number of kilometres of electricity lines' and there was constant returns to scale (ie, doubling the number of lines doubled the total number of inputs required) then 'g' would be equal to the proportionate change in electricity lines from period t-1 to period t.

2.4. Conclusion

Setting a required expenditure path for a regulated business on the basis of CPI less a business specific estimate of TFP will, in general, double count potential productivity gains. Such an approach implicitly requires the regulated business to make the same average level of productivity gains in the economy **plus** the business specific TFP estimate.[3] If regulated businesses face higher input inflation than the general economy, then regulated businesses are even more disadvantaged by such an approach. Furthermore, to the extent that regulated businesses obligations (output) are actually growing over time then rolling forward required revenues on the basis of 'CPI – TFP' further underestimates true required revenues.

[3] Assuming that the regulated business faces the same input price inflation as the economy in general.