Community Perceptions of Unmeasured Quality Improvement in Goods and Services

ID Black

South Australian Research and Development Institute, Adelaide, Australia

Mr ID Black
South Australian Research and Development Institute,
GPO Box 397,
Adelaide, 5001
SA
Australia
Tel: +618 8303 9608
Fax: +618 8303 9424
E-mail: black.ian@saugov.sa.gov.au

Abstract

Because of the costs involved in such exercises, current productivity measures do not necessarily fully take into account changes in the quality of goods and services over time. This paper outlines the derivation of measures that lead to quantification of the "community preference for its perceptions of improved unmeasured quality" in products. The measures are based on the proposition that individuals behave in such a manner as to maximise their quality of life. This is expressed by the individual's choices in her purchase of quantity, quality and type of goods and services. This choice reflects her particular trade-offs, given her level of spending. The government is responsive to the community's choices in terms of the services it produces. In aggregate, this is expressed in an economy by the choice of goods and services purchased. The measures that are derived are not grounded in production theory, but the "payment for output" measure can be related to theory assuming competitive markets and profit maximising, efficient firms.

This paper first shows the development of a "payment for output" of goods and services from an entity measure. From this the "community preference for output increases" measure was developed. Using the mining industry as a basis and the wholesaling industry as a check, a measure of changes in the "community preference for its perceptions of improved unmeasured quality" in other entities in an economy is derived. These two community preference measures for an entity are relative to what is on offer in the whole economy and are not absolute measures, in contrast to productivity (incorporating changes in measured quality) estimates. For Australia as a whole in the 1989-90 to 1998-99 period, the annual multifactor productivity (MFP) increase was 1.64 percent and the annual increase in community preference for its perceptions of improved unmeasured quality was 0.31 percent. The addition of the two measures therefore represents an increase of 19 percent on the MFP figure alone. A measure of the efficiency of an economy in responding to changing community preferences is also derived.

Key words:

Payment, productivity, quality, community, preference, efficiency

Introduction

Total factor productivity / multi factor productivity indexes do not appear to adequately take into account improvements in quality in some industries. For example, measured productivity in the banking sector in the US decreased by 3.7 percent per year over the 1987-97 period, despite the industry having the highest intensity of spending on information technology (IT) in the industries surveyed[1] (The Economist, 2000). While the problem seems to be greatest in industries based on services, where changes in the quality of output are not easily measured reliably (McKenzie 2002), it also exists in industries where the products are goods.

The main problem with the measurement of quality improvements using total factor productivity (TFP) / multi factor productivity (MFP) indexes seems to be the cost involved in adequate disaggregation of inputs and outputs. That is, it is a practical problem, not a methodological one[2]. Statistical agencies make considerable efforts to measure quality improvements. These include the matched model method, incorporating explicit and implicit quality adjustments, and the hedonic method (ideally, the latter seems to be the methodology of choice). Triplett (2002) and Silver and Heravi (2002) outline these methods. However, the resources that are devoted to such exercises are limited. Triplett (2001) states that cost is a great barrier to the more widespread adoption of hedonic indexes for information technology deflators. Cooper, Rayner and Greenway (1993) used the hedonic method to produce a constant quality price index for tractors in the United Kingdom over the 1947-1988 period. They used 28 characteristics of tractors in the regression. The considerable effort, and therefore cost, needed to construct such an index is obvious. While this could be an extreme example, in a complex economy there may be thousands of inputs and outputs of goods and services where the hedonic method ought to be applied to produce constant quality price indices. The problems of adjustment of productivity indexes for quality appear at least as great for service industries (McKenzie 2002) as for goods industries and hence the resources necessary to correct for quality change in these industries will also be considerable. In fact, the Australian Bureau of Statistics (ABS) does not provide statistics that quantify items of output in some service industries in the economy. Instead it measures output on the basis of movements in labour inputs for the "Property and Business Services" and "Personal and Other Services" private sectors, as well as the government/private mixed sectors of "Health and Community Services" and "Education". Therefore it is impractical to disaggregate growth into its labour, capital and multifactor productivity components (Industry Commission 1995, p. QB1). The implication is that it is too costly and/or too difficult to provide quantification of items of output in these sectors of the Australian economy. This reading of some of the literature leads to the first proposition on which this paper is based – see below.

TFP/MFP indexes are grounded in production theory, provided the technical change is disembodied (Chambers 1988 pp. 203-249). This grounding in production theory brings with it a second problem with TFP/MFP measures: theoretically they cannot measure productivity in those sectors of the economy covering the non-market sector. The assumption of optimising behaviour implicit in production theory "whereby technically efficient producers substitute around isoquants and production-possibility frontiers in response to changes in relative prices of inputs and outputs" (Alston, Norton and Pardey 1995, p. 131) is invalid. The Australian Bureau of Statistics (ABS) does not provide measures of input in the "Government Administration and Defence" sector of the Australian economy, relying instead on movements in labour inputs to quantify output.

In the longer term, all entities that produce goods and services in an economy have to meet changing community expectations or resources will be withdrawn from them. This is obvious for the market sector of the economy where suppliers need to meet quality and price expectations in

competition with other producers of the same or similar products. However, at least in a working democracy, it is assumed in this paper that a level of discipline can also be imposed on the non-market sector of the economy through governments responding to the demands of the electorate.

The measures outlined in this paper simply represent a manipulation of available national statistics to produce intuitively sensible outcomes. The paper is not grounded in production theory. It departs from production theory in order to suggest an alternative assessment of quality that is based on "community choice". Also, the measures developed are not productivity estimates, which are measures of the relationship between physical inputs and outputs. Hence the term "productivity" has been avoided in naming them

Four propositions are made:

1. Because of the costs involved in such exercises, current productivity measures do not necessarily fully take into account changes in the quality of goods and services over time.

   Hence actual changes in the quality of goods and services have both "measured" and "unmeasured" components.

2. The consumer price index (CPI) is very well measured in terms of making due allowance for changes in the quality of its defined bundle of goods from period to period.

   It is assumed that it can be used with confidence as a basis for measuring changes in the monetary value of goods and services between periods.

3. Firstly, individuals behave in such a manner as to maximise their quality of life. This is expressed by the individual's choices in her purchase of quantity, quality and type of goods and services. This choice reflects her particular trade-offs, given her level of spending. Secondly, the government is responsive to the community's wants in terms of the services it produces. In aggregate, this is expressed in an economy by the value of goods and services produced.

   The corollary over time is that an individual's perception of how her quality of life can be maximised changes from period to period. In aggregate, this is expressed in an economy by changes in the value of goods and services from period to period which, subject to its spending power, reflect the community's choices in terms of the quantity and the community perception of the relative quality of those goods and services. The "relative" qualifier is important. The community perception of the quality of a particular good or service is relative to its perception of the quality of all the other goods and services on offer in the economy. It is not an absolute assessment and therefore represents a departure from accepted methods of quality adjustment.

4. From period to period the *community perception* of the relative quality of any particular good or service is assumed to be *not* identical, unless there are good reasons for believing that it is identical.

Also, the community perception of changes in relative quality may not be the same as those of a statistical service or other person/group who make adjustments for changes in quality.

A value for output measure

As a reference for what follows, after Alston, Norton and Pardey (1995, p. 130), a measure of total factor productivity (TFP) can be defined as

(1) $$TFP = \frac{Q}{X}$$

where:

Q is an output aggregate, and

X is an input aggregate

By analogy with (1)

(2) $$AO = \frac{Q}{A}$$

where:

AO is a payment for output aggregate measure, and

A represents the payment for an entity's output.

The monetary value of goods and services from an entity (payment, A) is used as a descriptor similar to the input aggregate (X) in the TFP measure. It is assumed that the value of goods and services purchases all the necessary factors of production for entities, including a rate of return sufficient to attract the necessary level of capital in the commercial sector. Hence change in value is used as a measure of input growth. The term "payment" is used instead of revenue (P*Q) because non-market sectors of the economy may not receive revenue (P*Q). They are simply paid for the services they produce. Probably the purest example of this is the military. It also sidesteps the implication of P*Q in production theory: that P and Q are set in competitive markets. One other assumption is needed to make the following maths operational: the economy of a country is sufficiently flexible as to accurately reflect the changing choices of the community. "Community choice" is used instead of "demand" because of the latter's use and implications in production theory. Use of the "payment" and "community choice" descriptors implies that the AO measure does not carry with it the assumption of optimising behaviour implicit in production theory. Hence, non-market and mixed government/commercial service entities in an economy can be accommodated. In the market sector of the economy the measured output, $Q_{E,t}$, is quantity of goods and services produced by entity E in year t. However, as already stated, the measurement of output is not straightforward in the non-market sector and some service sectors of an economy and the Australian statistics reflect labour movements. Despite this problem the convention of use of quantity, $Q_{E,t}$, is retained as a global measure of output, covering both types of measures.

For changes over time

$$(3) \qquad q_{E,t} = \frac{\mathrm{d}\, Q_{E,t}}{\mathrm{d}\, t} \frac{1}{Q_{E,t}} = \mathrm{d} \ln Q_{E,t}$$

where:

$q_{E,t}$ is the proportionate rate of growth of quantity of output from entity *E* in year *t*.

Similar to (3)

$$(4) \qquad a_{E,t} = \frac{\mathrm{d}\, A_{E,t}}{\mathrm{d}\, t} \frac{1}{A_{E,t}} = \mathrm{d} \ln A_{E,t}$$

where:

$a_{E,t}$ is the proportionate rate of growth of payment for output from entity *E* in year *t*,

$A_{E,t}$ is the real value of total payment in entity *E* in year *t*, and

$$(5) \qquad A_{E,t} = NVA_{E,t} \frac{CPI_b}{CPI_t}$$

where:

$NVA_{E,t}$ is the nominal value of payment for output from entity *E* in year *t*, and

CPI_b, CPI_t are the consumer price indexes in the base year, *b*, and year *t* respectively.

Equation (5) is based on proposition 2 – the consumer price index is very well measured and can be used as a basis to link monetary value between periods.

The observed proportionate rate of growth of total factor productivity in time t, tfp_t, is equal to the rate of growth of measured output, q_t,, minus the rate of growth of measured inputs, x_t, (Alston, Norton and Pardey 1995, p. 130):

$$(6) \qquad tfp_t = q_t - x_t$$

By analogy with (6), a proportionate rate of growth of payment for output measure for entity E in time t, $ao_{E,t}$, is defined as

$$(7) \qquad ao_{E,t} = q_{E,t} - a_{E,t}$$

The relationship of the payment for output measure to production theory

As stated in the Introduction, the new measures outlined in this paper are not grounded in production theory. However it is possible to relate (7) to theory, but not derive it. Assume firms are profit maximisers in the private sector of the economy and that they are efficient producers. Under these assumptions marginal cost equals marginal revenue. As noted above, payment is the same as revenue for the private sector. For an efficient, profit maximising entity (7) can therefore be interpreted as

"changes in the proportionate rate of growth in payment for output from an entity equals changes in the rate of growth of output minus changes in the rate of growth of costs".

A community preference for output increases measure

Payment to entities is obviously driven by the community's choice of goods and services. Assume changes in relative payment in different entities are monotonically related to the community preference for the goods and services produced - at any given time payment conveys precisely the community's preferences relative to what is on offer in the whole economy. The "relative" descriptor is important because it leads to the concept of elasticity as a measure of change in community choice for goods and services. A measure of elasticity of the proportionate rate of growth of payment, *A*, in entity *E* in time *t* to produce a proportionate rate of growth of output of equal community preference compared to that in the economy, *N*, as a whole ($e_{A_E:A_N,t}$) is

(8) $$e_{A_E:A_N,t} = a_{E,t} \big/ a_{N,t}$$

Equation (8) is based on propositions 3 and 4: the elasticity measure reflects the changing choices of the community between periods, subject to what is on offer in the economy as a whole.

Assume that the proportionate rate of growth of output from different entities reflects community choice, and are shown by changing payments. Therefore, the rate of growth of output in the economy as a whole, $q_{N,t}$, modified by the elasticity of the rate of growth of payment in the entity compared to the economy as a whole, ($e_{A_E:A_N,t}$), provides a measure of community preference for the rate of growth of output from an entity, $q_{E,t}$. In mathematical terms: An output-elasticity-of-payment measure for entity *E* with respect to the economy *N* in time t, $oea_{E:N,t}$, is defined as

(9) $$oea_{E:N,t} = q_{N,t} e_{A_E:A_N,t}$$

By analogy with (6), the proportionate rate of growth in community preference for output increases in entity *E* in time *t*, $cpo_{E,t}$, is defined as

(10) $$cpo_{E,t} = oea_{E:N,t} - a_{E,t} = q_{N,t} \frac{a_{E,t}}{a_{N,t}} - a_{E,t}$$

Relative price changes for the output of an entity compared to that for the whole economy

This section represents an interesting diversion. It is not central to the paper.

Returning to the scalar, for the market sector of the economy:

(11) $$oea_{E:N,t} = \mathrm{d}\ln OEA_{E:N,t} = \mathrm{dln}\, Q_{N,t} \frac{\mathrm{dln}\, P_{E,t}}{\mathrm{dln}\, P_{N,t}} \frac{\mathrm{dln}\, Q_{E,t}}{\mathrm{dln}\, Q_{N,t}} = \frac{\mathrm{dln}\, P_{E,t}}{\mathrm{dln}\, P_{N,t}} \mathrm{dln}\, Q_{E,t}$$

Given that

(12) $p_{E:N,t} = \dfrac{\mathrm{d}\ln P_{E,t}}{\mathrm{d}\ln P_{N,t}}$, and reverting to proportionate change nomenclature:

$$oea_{E:N,t} = p_{E:N,t} + q_{E,t}$$

Rearranging:

(13) $$p_{E:N,t} = oea_{E:N,t} - q_{E,t} = \frac{a_{E,t}}{a_{N,t}} q_{N,t} - q_{E,t}$$

Where prices are accessible, (12) can, of course, be obtained directly. However, as inferred in the introduction, prices in some services sectors and in the non-market sectors are not mathematically accessible in the Australian set of economy-wide statistics (and presumably in statistics for many other countries). Assume that discipline is imposed on the non-market sector by the community choice mechanism and this mechanism is, in some intuitive sense, expressed through price. Subject to this assumption, equation (13) can then be used to obtain the relative price change.

Example 1: Growth in community preference for output increase, total factor productivity and payment for output increase in Australian farm production

The Australian Bureau of Agricultural and Resource Economics (ABARE) provide summary statistics for Australian agriculture. These allow a measure of the proportionate increase in total factor productivity for the farm industry. The series of measures used in this example are shown in Table 1 and are taken from an ABARE publication (ABARE 1999) and Australian Bureau of Statistics publications (ABS 1999, 2000).

A measure of the proportionate increase in quantity of farm industry output, q_{Ft} , follows directly from the production volume index; the proportionate increase in quantity of inputs, x_{Ft}, is found by applying the prices paid index to farm costs; the proportionate increase in payments to farming for increases in output, a_F, and in GDP, a_N, from applying the consumer price index to the value of production; and the chain volume measure for GDP follows directly. In order to allow for imperfect yearly adjustments in production entities, as well as the influence of weather in the farm industry, these measures were found using log-linear procedures over the time domain.

Results: q_F = 0.0331, x_F = 0.0131, a_F = 0.0123[3], a_N = 0.0290, q_N = 0.0354. Hence annual increases over the period in total factor productivity, *tfp* (= $q_F - x_F$), = 0.0200; payment for output, *ao* (= $q_F\, a_F$), = 0.0208; community preference for output increase, *cpo* (= $q_N a_F/a_N - a_F$), = 0.0027.

Example 2: Growth in community preference for output increases and payment for output in the gross value added of Australian industries

The Australian Bureau of Statistics (ABS) (1999, 2000) provides summary statistics of yearly gross value added in broad categories of Australian industry. The extra series of measures used in this example for the ABS defined Australian industries is shown in Table 2.

Table 3 shows the values for *q*, a^4, *ao* and *cpo* for the industries. The community preference for output increase measure (*cpo*) intuitively provides more sensible values than the payment for output (*ao*) measure. All values are positive in the services industries, as would be expected from the application of information technology (IT) to these industries over the past decade. The comparison of manufacturing *cpo* and *ao* shows that the community perceives a shift away from quantity-based production in favour of quality-based production in Australia.

The *cpo* figures for industries based on production of goods where there is little or no quality improvement (agriculture, forestry and fisheries; mining; electricity, gas and water), will come as a shock to those used to the relatively large productivity increases resulting from *tfp/mfp* measures applied to these industries. In an economy where there is increasing emphasis on quality rather than quantity, particularly in services, commodity based industries necessarily require relatively high productivity increases in order to justify increased investment in them.

Rates of change in the community preference for its perception of unmeasured quality

It is important to be clear about what is discussed in this section. (A) Consumer taste is changing over time, and (B) improvements in unmeasured quality are changing over time. These two inseparable components are together termed "the rate of change in the community preference for its perception of unmeasured quality".

Assume there are no unmeasured changes in quality of output in the mining industry. This is not unreasonable, given that the products of the mining industry cannot change by alchemy and measurement is precise, hence purchasers of mining outputs pay for any measured changes in the quality of raw and semi-processed output. It follows that community preference for output increases in the mining industry represents what the community is prepared to pay to an industry where there its perception is that there are no unmeasured quality improvements. Note that "measured" changes in quality cannot be calculated as they are incorporated in a *tfp/mfp* index (which reflects proposition 1). If changes in payments reflect community choice, the community preference for its perception of unmeasured quality change in products from an entity is therefore given by

(14) $$cul_E = cpo_E - cpo_M$$

where:

cul_E is the proportionate rate of change in community preference for its perception of unmeasured quality in the products from an entity, and

M refers to the mining industry.

The proportionate rates of change in unmeasured quality in reference to the mining industry are shown in Table 3. Changes in the community perception of unmeasured quality in the wholesaling industry would not be expected. The industry simply provides an intermediary service between

producers of goods and retailers. The cul_E figure for the industry shows this to be the case (0.0000, Table 3).

Output *plus* community preference for its perception of unmeasured quality

A change in total output plus quality measure for an entity is defined as the addition of the rates of change in total factor productivity plus the community preference for its perception of unmeasured quality:

(15) $$tol_E = tfp_E + cul_E$$

where:

tol_E is rate of change in total output plus quality

Where the data available do not support generation of a *tfp* measure, it is sometimes possible to calculate multifactor productivity, *mfp*, as an approximation[5]. Hence

(16) $$tol_E = mfp_E + cul_E$$

Table 4 shows the extra data necessary to generate *mfp* measures for the industries in the Australian market sector as defined by ABS[6]. The results are shown in Table 3. Multifactor productivity for the Australian economy as a whole (mfp_N) over the time domain was 0.0164. The community preference for its perception of unmeasured increases in quality in the national economy (cul_N) was 0.0031. The total output plus quality measure (tol_N) is therefore 0.0195, which represents a 19 percent increase on the mfp_N measure alone.

Efficiency in meeting community preferences

Table 3 shows that the spread between the best and worst performing industries was 6.42 percent, using the payment for output (*ao*) measure. The spread in the community preference for output increase (*cpo*) estimates was 1.50 percent. There is a marked convergence in the estimates.

Assume that a national economy continuously renews itself through the means of changing payments to its component parts. It is not rational that some components of the economy are highly productive and others are poorly performed, as the payment for output measure implies. It follows that at the limit - perfect and instantaneous responsiveness to community preferences - all industries would have the same community preference for output increases. Therefore the standard deviation of the mean of community preference for output increases in an economy, expressed as a percentage, provides an estimate of the efficiency of a national economy in responding to community preference.

(17) $$E_N = 100 - {100 s_{mpp,n}}/{\overline{X}} = 100 - 100 \left/ \overline{X} \sqrt{\frac{\sum_1^n \left(X - \overline{X}\right)^2}{n-1}} \right.$$

where:

E_N is the efficiency of a national economy in responding to community preference,

$s_{mpp,n}$ is the standard deviation of the community preference for output change of the *n* industries of an economy, and

X and $\overline{X}$ are, respectively, an industry and the mean of the industries community preference for output change.

For the complete set of industries of the Australian economy defined by ABS, except "Ownership of dwellings", the efficiency measure is 47 percent for the 1989-90 to 1998-99 period[7].

Concluding remarks

Due to the high cost of adequately accounting for changes in the quality of goods and services, *tfp/mfp* measures often do not fully capture improvements in quality. The problem is exacerbated by the fact that post-industrial societies have become increasingly dominated by service sectors over the past five decades (Aarnio 1999). In these sectors, accounting for changes in quality appears to be particularly difficult. As a result, serious discrepancies have arisen between published volume productivity measures and intuitive assessments of relative productivity improvement in some of the component industries of post-industrial economies. This paper outlines a method for addressing those discrepancies. It relies on the concept of changing payment to an entity reflecting community preference for its goods and services. Also, because the measures are not based on production theory, the non-market sectors of the economy and those service sectors where quantity of output is not directly measured can be included, with sensible outcomes.

Notes

[1] In relation to the IT problem, Siegel (1997) found that "computers are an important source of quality change and that computers are positively related to (manufacturing) productivity growth when adjustments are made for measurement errors".

[2] "A fundamental insight from the literature on productivity measurement is that …….a high level of disaggregation is required to avoid aggregation bias. Star (1974) showed that one is safe in using preaggregated inputs (and outputs) only if all inputs (or outputs) in the class are growing at the same rate or are perfect substitutes for one another" (Alston, Norton and Pardey 1995, pp 131-132). Wording in brackets inserted by the author. Craig and Pardey (1996) showed that the level of disaggregation used when compiling the index significantly affected the rate of TFP increase in US agriculture.

[3] The payment to agriculture, forestry and fishing is unstable, due to a large drop in value at the beginning of the series followed by years of consistent increase from the low point. Unfortunately, ABS chain volume measures do not go back past 1989-90.

[4] Strictly speaking, use of industry gross product as a measure of industry value is invalid because intermediate outputs and inputs are stripped out. However, use of industry gross products will suffice for this indicative, illustrative purpose.

[5] Multifactor productivity suffers from a high-level of aggregation, much more than *tfp* and is therefore likely to be less accurate. The accuracy of the *tfp* measure itself is dependent upon the level of dis-aggregation in inputs and outputs (Alston, Norton and Pardey, 1996, p. 131).

[6] Following the methodology used by the Industry Commission (1995, pp QB1-QB8), the *mfp* figures are derived from data in ABS (1999, 2000) as the difference between the rate of growth in industry gross product and the sum of the total factor income weighted rates of growth in indexes of labour (total hours worked) and capital (capital services flowing from capital stock).

[7] "Electricity, gas and water" was the only industry of the Australian economy where reduced payment occurred over the time domain, which automatically results in a negative *mpp*. This industry is affected by a significant level of market inefficiency (Forsyth, 1998). When it is excluded from the computation, efficiency is 66 percent.

References

Alston, JM, Norton GW and Pardey PG (1996) *Science Under Scarcity – Principles and Practice for Agricultural Research Evaluation and Priority Setting.* Ithaca and London: Cornell University Press.

Aarnio O (1999) Can we trust the service sector to generate decent rates of growth and employment? *Personnel Review,* **28** (5/6), 382-405.

Australian Bureau of Agricultural and Resource Economics (ABARE) (1999) *Australian Commodity Statistics*. Canberra, ACT, Australia.

Australian Bureau of Statistics (ABS) (1999, 2000) *Australian System of National Accounts*. 5204.0

Chambers RG (1988) *Applied Production Analysis: A Dual Approach*. Cambridge University Press. Cambridge, UK.

Cooper D, Rayner AJ and Greenway D (1993) Constant-quality price indices for agricultural inputs: tractors and fertilizers revisited. *Journal of Agricultural Economics,* **44**(1), 67-81.

Craig BJ and Pardey PG (1996) Productivity measurement in the presence of quality change. *American Journal of Agricultural Economics*, **78**, 1349-1354.

Economist, The (2000) Virtual guesswork. **356** (Sept. 23), "A survey of the new economy", p 15.

Forsyth P (1998) Economic policy issues of reform in the utilities and services industries. In *Microeconomic Reform and Productivity Growth, Workshop Proceedings*, pp 283-289. Productivity Commission and Australian National University. Canberra: Ausinfo.

Industry Commission (1995) *Research and Development*. Report No 44. Canberra: Australian Government Publishing Service.

McKenzie (2002) Quality adjustment in service industry producer price indexes. *2002 Voorburg Group Conference Paper.* Paper available from the Author, Australian Bureau of Statistics, Producer Price Index Section, Canberra, Australia. Paper downloaded from an Internet site.

Siegel D (1997) The impact of computers on manufacturing productivity growth: a multiple indicators, multiple causes approach. *The Review of Economics and Statistics* **79** (1) 68-78.

Silver M and Heravi S (2002) Quality adjustment for PPP: principles and an empirical study. Draft paper prepared for a *Conference on the International Comparisons Program.* World Bank, Washington DC, March 11-12 2002. Paper available from the Authors, Cardiff University, Cardiff, UK.

Star S (1974) Accounting for the growth of output. *American Economic Review*, **64**, 123-135.

Triplett JE (2001) IT, hedonic price indexes and productivity. Paper prepared for IAOS Satellite Conference, Tokyo, August 30-31, 2001. Paper available from the author, Brookings Institution, Washington, DC, USA. Paper downloaded from an Internet site.

Triplett JE (2002) Chapter II: Quality adjustments in conventional price index methodologies. Chapter III: Hedonic price indexes and hedonic quality adjustments. In *OECD Manual on Quality-Adjusted Price Indices for Information Technology* (forthcoming). Chapters revised January 29, 2002; available from the author, Brookings Institution, Washington, DC, USA. Paper downloaded from an Internet site.

Table 1: Measures of the Australian farm industry and national economy

Year	Farm Production Volume Index	Farm Production Value $M	Farm Costs $M	Farm Prices Paid Index	Consumer Price Index	Current Price GDP $M	Chain Volume GDP $M
1989-90	77.2	23848	20008	90.1	83.2	383173	441109
1990-91	80.3	21185	20167	90.8	87.6	397180	439783
1991-92	78.6	20966	19392	90.7	89.3	406427	441458
1992-93	83.7	22109	19340	89.5	90.2	427404	457735
1993-94	87.0	23585	20187	91.1	91.8	449785	476556
1994-95	75.7	23726	21591	94.9	94.7	474546	498113
1995-96	88.6	27542	22879	99.4	98.7	508113	520669
1996-97	98.7	28040	23808	99.3	100.0	533632	540379
1997-98	100.0	28021	23930	100.0	100.0	565881	565881
1998-99	104.8	28253	24397	100.0	101.3	593311	591546

Table 2: Gross value added measures for Australian industries ($M)

Year	Agric., forestry and fishing		Mining		Manufacturing		Communication services		Health and community services	
	Chain volume	*Current prices*	*Chain volume*	*Current prices*	*Chain volume*	*Current prices*	*Chain volume*	*Current prices*	*Chain volume*	*Current prices*
1989-90	14097	16179	16548	16809	66349	52122	8520	9003	25408	19901
1990-91	15054	12183	17598	19392	64949	50730	8989	9913	26707	22295
1991-92	14532	11574	18459	18979	63022	51288	9638	10974	27252	23385
1992-93	15775	13435	18570	20035	64369	54496	10764	11290	27811	24331
1993-94	16326	15041	18898	19465	67240	58471	11758	11678	28491	25337
1994-95	13049	13456	20199	20540	68668	61809	13149	12697	29168	26603
1995-96	16536	17030	22678	23028	70099	64730	14325	14066	30341	28590
1996-97	17804	17267	23422	23506	71795	66933	15966	15279	31286	30431
1997-98	17719	17719	24651	24651	72068	72068	17281	17281	32630	32630
1998-99	19044	18191	23873	23001	73800	74272	18945	17247	33092	34292
Year	**Gov. administration and defence**		**Finance and insurance**		**Education**		**Electricity, gas and water**		**Construction**	
	Chain volume	*Current prices*	*Chain volume*	*Current prices*	*Chain volume*	*Current prices*	*Chain volume*	*Current prices*	*Chain volume*	*Current prices*
1989-90	18895	14814	26618	19689	21457	16459	11886	12188	14053	23238
1990-91	19206	15785	26955	23307	21627	17725	12138	12573	24923	22387
1991-92	20038	16744	25892	24738	21698	18732	12280	13222	22597	21116
1992-93	20524	17571	26462	27094	23574	20320	12506	13579	23858	21049
1993-94	21379	18760	26857	28677	24613	21358	12946	13465	25858	22623
1994-95	22270	19719	28463	28536	25244	22144	13300	13313	27003	25144
1995-96	22656	20848	30306	30341	25292	22692	12970	12980	27707	27214
1996-97	23087	22527	32688	32142	26222	24382	12930	13233	29230	29295
1997-98	23429	23429	35151	35151	25881	25881	13312	13312	32741	32741
1998-99	22906	24056	37696	39277	26541	26719	13496	13164	34334	35820
Year	**Wholesale trade**		**Retail trade**		**Accommodation, cafes, restaurants**		**Transport and storage**		**Property and business services**	
	Chain volume	*Current prices*	*Chain volume*	*Current prices*	*Chain volume*	*Current prices*	*Chain volume*	*Current prices*	*Chain volume*	*Current prices*
1989-90	22949	22184	23493	21092	9961	7180	23006	21701	38811	36112
1990-91	20966	23611	23048	21365	9840	7831	23165	22207	39268	36929
1991-92	20687	23431	23785	21912	9902	7938	23709	22963	38515	39636
1992-93	20853	24019	24136	23170	9799	8144	23855	23485	41905	39508
1993-94	22463	25707	24902	24536	10460	8550	25142	24620	43045	40168
1994-95	25160	26479	26098	25780	11327	9785	26679	26856	45828	46118
1995-96	26611	27434	27921	28084	11552	10536	28724	29241	47660	49357
1996-97	27379	28025	28855	28971	11930	11177	29666	30023	49797	53153
1997-98	29034	29034	30260	30260	12256	12256	30484	30484	54741	54741
1998-99	31226	31757	31140	33358	13314	12814	31372	32969	59547	61031
Year	**Cultural and recreational serv's**		**Personal and other services**		**Ownership of dwellings**					
	Chain volume	*Current prices*	*Chain volume*	*Current prices*	*Chain volume*	*Current prices*				
1989-90	8322	5958	10592	7138	39294	33172				
1990-91	8424	5981	10595	7674	40482	35940				
1991-92	8647	6390	10479	8528	41598	37055				
1992-93	8771	6949	10438	9046	42913	38024				
1993-94	8966	7454	10418	9102	44425	39435				
1994-95	9506	8114	11074	10139	46106	41663				
1995-96	9534	8290	11650	11073	47740	44115				
1996-97	9720	8678	11956	11871	49614	47948				
1997-98	10147	10147	12505	12505	51233	51233				
1998-99	10544	10888	12928	13457	52961	52398				

Table 3: Australian industry gross value added productivity and community preference related measures, 1989-90 to 1998-99

Industry	Output	Payment	Input	Multifactor productivity	Payment for output	Relative Price change	Community preference for output increases	Community preference for unmeasured quality improvements	Total output plus quality change
				(mfp)	*(ao)*	$(p_{E:N})$	*(cpo)*	*(cul)*	*(tol)*
	q	a	x	$q-x$	$q-a$	$(a_E/a_N)q_N-q_E$	$(a_E/a_N)q_N-a_E$	cpo_E-cpo_M	mfp_E+cul_E
National (N)	0.0354	0.0290	0.0190	0.0164	0.0064	0	0.0064	0.0031	0.0195
Agriculture, forestry & fishing	0.0290	0.0163	-0.0009	0.0299	0.0127	-0.0091	0.0036	0.0003	0.0302
Mining (M)	0.0455	0.0149	0.0328	0.0127	0.0306	-0.0273	0.0033	0	0.0127
Manufacturing	0.0158	0.0240	-0.0063	0.0221	-0.0082	0.0135	0.0053	0.0020	0.0241
Communication services	0.0925	0.0519	0.0451	0.0474	0.0406	-0.0291	0.0115	0.0082	0.0556
Health & community services	0.0288	0.0353			-0.0065	0.0143	0.0078	0.0045	
Government admin. & defence	0.0253	0.0339			-0.0086	0.0161	0.0075	0.0042	
Finance & insurance	0.0401	0.0434	0.0213	0.0188	-0.0033	0.0129	0.0096	0.0063	0.0251
Education	0.0264	0.0310			-0.0046	0.0114	0.0068	0.0036	
Electricity, gas, water	0.0132	-0.016	-0.0056	0.0188	0.0292	-0.0327	-0.0035	-0.0068	0.0120
Construction	0.0432	0.0333	0.0202	0.0230	0.0099	-0.0026	0.0073	0.0040	0.0270
Wholesale trade	0.0442	0.0149	0.0083	0.0359	0.0293	-0.0260	0.0033	0.0000	0.0359
Retail trade	0.0357	0.0303	0.0265	0.0092	0.0054	0.0013	0.0067	0.0034	0.0126
Accomm., cafes, restaurants	0.0343	0.0448	0.0403	-0.0060	-0.0105	0.0204	0.0099	0.0066	0.0006
Transport, storage	0.0391	0.0272	0.0201	0.0190	0.0119	-0.0059	0.0060	0.0027	0.0217
Property, business services	0.0479	0.0374			0.0105	-0.0022	0.0083	0.0050	
Cultural, recreational services	0.0262	0.0466	0.0547	-0.0285	-0.0204	0.0307	0.0103	0.0070	-0.0215
Personal, other services	0.0243	0.0479			-0.0236	0.0342	0.0106	0.0073	

Table 4: Australian industry labour and capital services indexes

Year	National			Agriculture, forestry and fishing			Mining			Manufacturing		
	Labour	*Capital services*	*Labour weighting*	*Labour*	*Capital services*	*Labour weighting*	*Labour*	*Capital services*	*Labour weighting*	*Labour*	*Capital services*	*Labour weighting*
1989-90	93.1	82.0	0.54	99.0	95.3	0.68	117.0	67.9	0.29	115.5	79.4	0.60
1990-91	91.7	83.9	0.55	99.4	102.7	0.70	108.8	70.8	0.26	109.5	79.2	0.62
1991-92	89.4	85.4	0.54	94.2	102.2	0.70	101.8	73.0	0.25	100.0	80.2	0.60
1992-93	90.1	87.0	0.53	93.5	102.4	0.69	98.8	76.5	0.24	97.8	82.0	0.59
1993-94	92.2	88.9	0.53	93.4	103.0	0.69	106.1	79.3	0.25	99.8	83.8	0.56
1994-95	96.1	91.4	0.54	92.2	105.8	0.71	103.2	83.0	0.25	103.6	87.3	0.57
1995-96	98.3	93.9	0.54	94.1	100.8	0.69	102.5	86.6	0.25	99.9	90.8	0.58
1996-97	98.9	96.8	0.55	96.7	99.6	0.70	102.0	92.7	0.26	98.9	94.8	0.56
1997-98	100.0	100.0	0.54	100.0	100.0	0.70	100.0	100.0	0.27	100.0	100.0	0.54
1998-99	101.9	103.3	0.54	94.1	100.8	0.70	99.2	105.3	0.28	98.2	103.2	0.52
Year	**Electricity, Gas and Water**			**Construction**			**Wholesale trade**			**Retail trade**		
	labour	*Capital services*	*Labour weighting*	*Labour*	*Capital services*	*Labour weighting*	*Labour*	*Capital services*	*Labour weighting*	*Labour*	*Capital services*	*Labour weighting*
1989-90	162.5	88.9	0.38	99.1	80.4	0.63	101.8	80.2	0.73	94.3	58.6	0.72
1990-91	152.8	89.0	0.37	91.2	83.1	0.65	101.3	81.3	0.72	92.5	62.2	0.74
1991-92	156.0	89.4	0.36	81.2	84.2	0.63	96.9	81.7	0.71	91.6	67.1	0.73
1992-93	143.0	89.6	0.33	86.6	85.0	0.64	97.4	82.7	0.71	92.6	70.6	0.74
1993-94	138.4	90.1	0.31	90.6	88.5	0.63	103.6	86.8	0.71	92.3	76.6	0.73
1994-95	133.7	92.2	0.30	97.2	92.4	0.63	99.8	91.7	0.72	99.7	82.5	0.73
1995-96	123.6	94.7	0.30	97.6	96.0	0.60	101.9	91.9	0.73	100.6	87.0	0.75
1996-97	101.6	97.3	0.26	96.5	97.0	0.60	98.3	94.2	0.77	100.0	91.6	0.81
1997-98	100.0	100.0	0.25	100.0	100.0	0.58	100.0	100.0	0.78	100.0	100.0	0.80
1998-99	106.9	104.8	0.25	105.5	103.6	0.60	101.8	104.7	0.78	103.1	112.3	0.81
Year	**Accommodation, cafes and restaurants**			**Transport and storage**			**Communication**			**Finance and insurance**		
	Labour	*Capital services*	*Labour weighting*	*Labour*	*Capital services*	*Labour weighting*	*Labour*	*Capital services*	*Labour weighting*	*Labour*	*Capital services*	*Labour weighting*
1989-90	77.9	62.8	0.62	94.2	78.9	0.55	93.5	58.5	0.57	113.6	59.0	0.68
1990-91	81.4	66.4	0.62	94.2	81.1	0.55	95.1	62.2	0.54	111.8	65.3	0.58
1991-92	85.7	71.8	0.67	92.4	84.1	0.56	88.6	65.0	0.50	104.5	69.4	0.56
1992-93	82.8	72.8	0.69	89.2	86.5	0.54	79.3	68.9	0.51	98.1	72.7	0.50
1993-94	87.1	75.6	0.70	92.1	89.5	0.53	88.7	71.7	0.50	98.8	75.3	0.50
1994-95	93.1	81.3	0.69	96.0	92.7	0.54	100.4	76.7	0.49	99.0	77.8	0.54
1995-96	96.0	88.1	0.66	99.7	92.7	0.51	108.5	83.3	0.50	102.1	81.8	0.56
1996-97	99.3	93.8	0.69	99.9	97.9	0.55	112.6	91.5	0.46	101.6	89.0	0.57
1997-98	100.0	100.0	0.68	100.0	100.0	0.55	100.0	100.0	0.41	100.0	100.0	0.55
1998-99	101.4	109.6	0.68	103.0	103.6	0.54	103.3	108.4	0.42	104.1	107.5	0.55
Year	**Cultural and recreational services**											
	Labour	*Capital services*	*Labour weighting*									
1989-90	80.9	56.8	0.48									
1990-91	75.6	57.6	0.51									
1991-92	81.8	57.1	0.54									
1992-93	76.7	58.8	0.49									
1993-94	84.6	64.1	0.48									
1994-95	95.5	69.1	0.52									
1995-96	94.5	75.4	0.56									
1996-97	96.8	89.9	0.58									
1997-98	100.0	100.0	0.55									
1998-99	102.6	108.2	0.55									