Productivity statistics: Sources and methods

(10th edition)

New Zealand Government

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Purpose

Productivity statistics: Sources and methods outlines the data sources, definitions, and methodologies used to compile the annual labour, capital, and multifactor productivity (MFP) indexes.

Summary

Productivity is a measure of how efficiently inputs (labour and capital) are being used in the economy to produce outputs. It is commonly defined as a ratio of a volume measure of output to a volume measure of input use.

Labour productivity growth is a key determinant of growth in gross domestic product (GDP) per capita, the benchmark by which countries are ranked on a material standard-of-living basis. Growth in GDP itself can come from either the contributions of labour input, capital input, or MFP. In this sense, productivity growth becomes a driver of growth in the economy.

The productivity growth indexes cover a subset of the economy, referred to as the measured sector, and are available from the base year of 1978 (year ended March) for the former measured sector and 1996 for the measured sector. The former measured sector and measured sector consist of industry divisions that meet these two criteria:

1. Constant-price output measures are derived independently of inputs in all principal working industries for all years.
2. Both capital and labour inputs are used in all principal working industries.

The measured sector is defined as ANZSIC06 published industries AA1 to AA3, BB1, CC1 to CC9, DD1, EE1, FF1, GH1, GH2, II1, JJ1, KK1, LL1, MN1, MN2, RS1, and RS2.

Appendix A lists the published industries included in the measured sector. Productivity series for the measured sector are published with a one-year lag, while industry productivity series are published with a two-year lag. Industry productivity estimates are available for the education and training (PP1) and health care and social assistance (QQ1) industries. They are not included in the measured sector, which retains comparability with the Australian Bureau of Statistics' productivity series, and maintains focus on the market sector of the economy.[1]

We have adopted an index-number approach to calculate the productivity series, based on guidelines published by the Organisation for Economic Co-operation and Development (OECD) in the *Productivity Manual* (OECD, 2001b). Apart from the benefit of aligning with an international consensus on good practice, following the OECD guidelines should, over time, allow us to better compare productivity statistics between New Zealand and other countries.

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[1] See Statistics New Zealand (2013a) for more methodological detail for these industries.

3 The labour series

3.1 Introduction

This chapter details the methods used in constructing: (a) a labour volume series (LVS) at industry level, and (b) a labour input index for the measured sector.

The LVS measures the quantity of labour input over time. Hours paid is the unit of labour volume in the LVS. The series is based on hours paid per week for a given quarter. For data on counts and hours for employees and working proprietors across industries, the LVS uses the:

- Quarterly Employment Survey (QES)
- Business Demography Database (BDD)
- Household Labour Force Survey (HLFS)
- Census of Population and Dwellings (census)
- Linked Employer-Employee Data (LEED)
- Department of Labour Quarterly Employment Survey (DoL QES) and Half Yearly Employment Information Survey (DoL HYEIS).[2]

These data are combined with data on worker's compensation to construct a labour input index for use in compiling productivity statistics.

The LVS is based on estimates of paid hours for all employed people engaged in producing goods and services in New Zealand. There are four components.

Component 1 includes employees in industries covered by the QES. From 1987 to 2000, annual BDD counts of employees are interpolated using quarterly movements in employee count from the QES. This series is then multiplied by quarterly estimates of average weekly hours (including overtime) from the QES to achieve a quarterly series for paid hours. From 2000 onwards, the methodology is similar, except that annual LEED counts of employees replace the BDD counts.

Components 2 and 3 are estimated in the same manner, using a combination of household survey data, establishment survey data, census data, and LEED. Component 2 covers working proprietors, and component 3 covers employees out of scope of the QES. For both of these components, the hours data are benchmarked using totals from the census. Until 2000, job counts are also benchmarked from the census, but from 2000 on, LEED totals provide the benchmarks.

From 1988 onwards, movements between hours benchmarks are interpolated using quarterly estimates of change from the HLFS, applying the same methodology used in the interpolation of component 1. Over this period, movements between job count benchmarks are also interpolated using quarterly HLFS estimates of change.

Component 4 covers non-civilian employees in the armed forces. For the entire 1988 to 2012 series, quarterly employee counts for this component are sourced from the Ministry of Defence. An average 40 working hours a week is assumed and multiplied by the employment count to get a quarterly series of paid hours.

The four components are then summed to derive industry totals, and March annual averages of the series are taken. This basic methodology is complicated by a number of steps that make datasets consistent over time. More detail on the four components is given in section 3.4.3.

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[2] The Department of Labour is now part of the Ministry of Business, Innovation and Employment

The labour input index for productivity measurement in the measured sector is formed using a Tornqvist index formula that weights the annual industry averages of paid hours by their relative shares of compensation of employees, the latter sourced from the national accounts.

3.2 Desirable features of a labour volume series

Key requirements:

- consistent and compatible with the output series (ie the gross domestic product (GDP) series), in terms of industry detail and coverage, and institutional breakdown
- accurate annual estimates (long-term trends are of primary importance, with secondary importance attached to quarterly patterns)
- a time series sufficiently long to allow the analysis of business cycles
- a continuous measure, rather than one based on a ‘point in time’.

3.3 Options for measuring labour input

The following options for measuring labour input are listed in ascending order of conceptual ‘correctness’.

Employment count

The most straightforward measure of labour input is a count of the labour force. This is usually the easiest measure to obtain, but does have some drawbacks. One issue with this option is that workers are given the same weight regardless of whether they work full or part time. A change in productivity is implied if there is a change in output accompanied by a change in the mix of full-time and part-time employment but the employment count is held constant. This occurs because the volume of output changes but ‘measured’ labour volume has not.

Full-time equivalent

A measure of the full-time equivalent (FTE) labour force is preferred to a straight count measure as it takes into account the mix of full-time and part-time employment. This measure can be constructed when an indicator of full-time status is available. It makes an assumption about the relative input of full-time to part-time workers. The most common assumption is that a part-time worker has a weight of one-half that of a full-time worker. An increase in productivity is implied if there is an increase in output accompanied by a change in the relative input between full-time and part-time workers but the FTE count, based on a fixed relativity, is held constant. Again, this is because the volume of output changes but ‘measured’ labour volume has not.

Hours paid

An improvement on the FTE volume measure is a measure of hours paid. This does not require an assumption about the relative input of full-time to part-time workers – but it is still deficient. Often workers are paid for a set number of hours, but it is common for workers to change the number of hours from week to week. An increase in productivity is implied if there is increased output as a result of more hours worked but hours paid is unchanged.

Notice that the drawbacks of each of the above methods can be generalised as not fully accounting for changes in hours worked.

Hours of work/actual hours

Hours of work or hours worked is a more accurate measure of labour volume than hours paid. However, it treats hours worked by all individuals as equal, regardless of their 'quality'. An increase in productivity is implied if there is increased output as a result of changes in the distribution of hours over skill categories, but hours worked is constant and the average productivity of workers in each skill category is unchanged.

'Composition-adjusted' hours worked

The most representative measure of labour volume is composition-adjusted (often referred to as 'quality-adjusted') hours worked because differences among workers are explicitly recognised. To account for differences in skill composition, more weight should be given to units of relatively higher skill in aggregating units of labour input. In doing this, changes in labour composition that affect output will be reflected in changes in labour contribution, not as a change in productivity. An increase in the average quality of labour implies that a composition-adjusted measure will rise faster than an unadjusted one.

3.4 The labour volume series

3.4.1 Data sources

Data from establishments (or firms), household-based surveys, and administrative taxation sources are combined to create a series that covers the economy. This is the preferred approach mentioned in the *Productivity manual* (OECD, 2001b). The manual states that "national accounts data on employment that makes use of the comparative advantages of different statistical sources should generally be preferred over employment data from any single source".

Quarterly Employment Survey (QES)

The QES is a sample survey of New Zealand enterprises with paid employees. It is designed to estimate average hourly and weekly earnings, average weekly hours paid, and the number of filled jobs for the pay week ending on or immediately before the 20th of the middle month of the quarter. QES data are available from the March 1989 quarter onwards.

Business Demography Database (BDD)

BDD data provide a snapshot of the Business Frame in February, and contain information (such as employee job count) for all units on the frame. The BDD does not provide quality estimates of the number of working proprietors. The prime objective of the Business Frame is to provide an up-to-date and accurately classified register or list of the survey population for Statistics NZ's economic and financial survey programme. The BDD allows analysis by variables that include region, industry, institutional sector, business type, degree of overseas ownership, and employment levels. BDD data are available from 1987 to 2003, but are used only until 2000 in the LVS.

Household Labour Force Survey (HLFS)

The HLFS is a quarterly sample survey that produces estimates for the civilian non-institutionalised usually resident New Zealand population aged 15 years and over. Statistics are produced for the employed, unemployed, and those not in the labour force. Employment estimates include counts of employed people and hours of work. HLFS data are available from the March 1986 quarter onwards.

Census of Population and Dwellings

The Census of Population and Dwellings is a five-yearly census of the population of New Zealand and its dwellings. Individuals in the household are included in census estimates of the labour force if they are 15 years or older. The census produces estimates of employed people and hours of work. It is the primary source of information on the size, composition, distribution, economic activities, and state of well-being of the population. The data used for the LVS correspond to published estimates. For the purposes of the LVS, census data are available for the March quarters of 1976, 1981, 1986, 1991, 1996, 2001, and 2006.

Census and labour hours non-response

The census data include employees and working proprietors who don't record any labour hours. The effect of this non-response is that labour hours from census data are understated. That is, labour hours should be higher. The current methodology has been revised to adjust for non-response, increasing the labour hours. The adjustment involves separately applying the average hours of employee and working-proprietor respondents at the industry classification level, to the employee and working-proprietor non-respondents.

Employees and working proprietors are separate, distinct groups and have different characteristics. For example, employees typically work (on average) fewer labour hours than working proprietors. Note that unusually high labour hours recorded by respondents influence average hours upwards. These high hours are generally ascribed to working proprietors and affect industries with a relatively higher proportion of working proprietors than employees.

Linked Employer-Employee Data (LEED)

LEED uses longitudinal information from existing administrative taxation sources, and the Business Frame, to provide a range of information on the dynamics of the New Zealand labour market. LEED provides information on all taxpayers, and is therefore very close to a census of the working population. Due to differences in tax forms, there are differences between the LEED information available for wage and salary earners and that available for working proprietors. LEED information is used solely for job counts in the LVS, and is available from the June 1999 quarter onwards.

Administrative data from the Ministry of Defence

Quarterly counts of non-civilian employees in the armed forces are available from the Ministry of Defence. For the LVS, this administrative data are available from 1978 onwards.

Department of Labour Quarterly Employment Information Survey (DoL QES) and Half Yearly Employment Information Survey (DoL HYEIS)

For the LVS, the DoL employment data are available from 1978 to 1988. The DoL HYEIS was a full-coverage semi-annual survey until 1980, when it was renamed the DoL QES, and provided quarterly sample data – the February quarter was full coverage. Minor changes to the coverage of the survey were also made in 1980, and it became a postal questionnaire.

Firm-based data

Firm-based data was selected as the primary source for the LVS. Industry data from establishment surveys are more robust, have a better output link, and greater potential for generating a longer time series of reasonable quality.

3.4.2 Hours paid – the measure of labour input in the labour volume series

Totals for hours are calculated on an 'hours paid' basis rather than 'hours of work' basis. Hours paid is the number of ordinary and overtime hours for which an employee is paid. It excludes unpaid overtime but may include some hours that are not actually worked, such as paid leave and statutory holidays.

While hours of work is the preferred measure of labour input, only hours paid is available from the QES. The selection of hours paid over hours of work has meant trading off the theoretical preference of hours of work with robust industry data from the QES, BDD, and LEED. Two main reasons are behind choosing hours paid as the measure of labour input.

Greater confidence in industry estimates of hours paid

Robust industry data and good alignment with output and capital data are important for producing industry measures of productivity.

Actual hours worked, derived from household survey data, would have been selected as the measure of labour input if the sole objective was a measured-sector (or economy-wide level) series without any industry splits. At the measured-sector level, the annual change in actual hours worked (estimated from the HLFS) is as statistically robust as hours paid (estimated from the QES). However, there are some caveats:

- At the industry level, the 'hours paid' measure is more robust than the 'hours worked' measure. We have more confidence in aligning industry labour inputs with corresponding industry outputs using hours paid data.
- Given that the methodology we use to calculate the labour volume index is based on aggregated industry-level data, it is desirable to have good alignment of industry input and outputs.

Using establishment surveys ensures consistency with the other component series of productivity. The QES and the BDD largely survey the same enterprises that are covered by the data sources feeding into the output and capital series.

The annual change in hours paid at the aggregate level is not significantly different from the annual change in actual hours worked. For productivity purposes, the main interest is in the annual growth of the volume series. It is assumed that the annual growth in hours paid is a good proxy for the growth in actual hours worked.

HLFS industry data can be volatile. We don't know how much of any quarterly movement in estimated industry totals of actual hours worked is affected by real fluctuations in work – as a result of holidays or external factors. Quality of responses and coding can create volatility, but this impact on change estimates has yet to be fully investigated.

Further work required to model industry totals for actual hours worked

Current options for modelling industry totals of actual hours worked are based on HLFS data and are not suitable, given concerns about the robustness of HLFS industry totals and insufficient understanding of factors affecting quarterly industry movements. More work is required to investigate possible auxiliary data sources that can be used for modelling actual hours worked.

3.4.3 Components in the series

From 1988 to 2000, establishment survey data (from the QES and BDD) is the primary data source for the LVS. Data for coverage gaps (working proprietors and employees in industries not covered by the QES and BDD) come from household survey data (census and the HLFS). As a result, the LVS combines people-count data from the HLFS and census, with job-count data from the QES and BDD. There is a conceptual difference in that the HLFS counts people, whereas the latter two sources count jobs. The HLFS collects limited information on multiple-job holding, and industry information relates to a respondent's main job only. This is an issue regardless of how the series is compiled, as there is no workable alternative to using household survey data to fill gaps in the QES coverage.

From 2000 onwards, all job-count and people-count benchmarks are sourced from LEED. BDD is not used from this time, and census data are used only to provide hours benchmarks. In the future, it is anticipated that LEED will continue to provide the job- and people-count benchmarks.

To ensure consistency with the industry capital and output series, the source data for the LVS has been aligned with the industry definitions (referred to as ANZIND or ANZSIC working industries) used for measuring New Zealand's gross domestic product (GDP). The industry alignment is performed on data (post-1987) from the QES and BDD at the kind-of-activity unit (KAU) level rather than at the enterprise or geographical location level. This is in line with the level used in the calculation of output (GDP). LEED, which is available at the geographic unit (GEO) level, has been aggregated up to the KAU level to maintain consistency with the BDD and QES.

Different methodologies are used to calculate four components in an ‘economy-wide’ LVS.

Component 1 – Employee jobs in industries covered by the QES (sourced from establishment or firm-based data, and administrative taxation data)

This component of the quarterly hours paid series is constructed by first estimating an employee job-count series.

From 1978 to 1980, job counts are obtained from full-coverage semi-annual data from the DoL HYEIS. Linear interpolation is used to convert the biannual data to quarterly. For 1980 to 1988, the full-coverage February quarter acts as a benchmark, with the May, August, and November quarters being interpolated using growth rates at the ANZSIC working-industry-by-sector level.

From 1989 to 2000, quarterly movements in the QES[3] job count are used to interpolate between annual employee job-count totals from the BDD, at the ANZSIC working-industry-by-sector level. ANZSIC working industries (or ANZIND) are defined by six-digit ANZSIC codes.

From 2000 onwards, LEED provides the annual employee job-count totals, at the ANZSIC working-industry level. LEED monthly point-in-time data (from the 15th of each month) on the counts of jobs, and people in jobs, are used. Job counts are combined with quarterly job-level hours-paid data from the QES to calculate the total hours paid in each industry.

There are a few exceptions to this standard methodology – where other data sources are judged to produce more suitable labour volume estimates.

The quarterly hours paid series is then compiled as the product of the interpolated job-count series and the average weekly hours paid per job calculated from the QES. (The average weekly hours paid per job from the QES is calculated by dividing total hours paid per week, as recorded in the survey, by the survey employee job count.) Quarterly totals of hours paid are not further benchmarked, as hours data are not collected for the BDD or LEED.

Component 2 – Working proprietors (sourced from household survey data, and administrative taxation data)

Refer to component 3.

Component 3 – Employees in industries excluded from QES (sourced from household survey data, and administrative taxation data)

Throughout the LVS, usual hours worked (from the census) provide a benchmark to estimate hours paid for components 2 and 3. This measure is the number of hours the respondent usually works in employment during a particular reference period, even if they did not in fact do so during the survey reference period because of temporary absences (eg due to sickness or holidays). The QES measure of hours paid is different in concept to usual hours of work measured by the HLFS and census. It is assumed, at least for the relevant industries, that these are close enough to allow them to be treated as measuring the same thing.

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[3] QES estimates of change are calculated at the ANZIND level.

From 1978 to 1986, for industries within the scope of the DoL employment surveys, census benchmarks for working-proprietor counts are interpolated using movements in the DoL employment survey data. This data is limited to working proprietors who employ two or more staff, implicitly assuming that this group is representative of all working proprietors. Working-proprietor hours are interpolated using movements in employee hours from the DoL surveys.

For agricultural sub-industries outside the scope of the DoL survey, census data for 1976, 1981, and 1986 are used to create an annual working-proprietor average-hours series. This series is created by using linear interpolation between census benchmarks. This series is then combined with Agriculture Census employment data to get an annual series of agriculture hours worked.

For other industries where robust data are not available from the DoL surveys or Agriculture Census, linear interpolation between census benchmarks is used to create a quarterly series of labour input.

From 1986 to 2000, the quarterly series for employment, and hours paid for the above two components, are derived by interpolating between five-digit ANZSIC totals from the census, using quarterly estimates of change from the HLFS at the published one-digit ANZSIC level. The resulting five-digit ANZSIC-level series are then aligned to ANZIND for the relevant industries. Usual hours worked (from the HLFS) is used as a proxy for hours paid.

From 2000 onwards, the series for employment is sourced from LEED for both components 2 and 3. Consistent with the earlier 1986–2000 period, hours paid are derived by interpolating between five-digit ANZSIC totals from the census, using quarterly estimates of change from the HLFS at the published one-digit ANZSIC level. Monthly point-in-time LEED data on secondary jobs are also used, combined with HLFS data on hours worked in secondary jobs. These data are not disaggregated by worker type or industry. A small proportion is added to the employment count to account for unpaid family work. These data are sourced from the HLFS.

For working proprietors, quarterly proportions from the HLFS and QES are used to add seasonality to the LEED counts, while keeping the annual average counts unchanged.

Component 4 – Non-civilian employees in the armed forces (sourced from administrative data)

Quarterly employment counts come from the Ministry of Defence. The Ministry does not provide hours paid data. In estimating total hours paid for non-civilian employees in the armed forces, 40 hours is assumed to be the average weekly total.

Table 1
Summary of how the economy-wide labour volume series is constructed[1]
1988–1989[2]

Industry	Data source for employee count	Data source for employee hours	Data source for working-proprietor count	Data source for working-proprietor hours
DoL QES industries[3]	DoL QES	DoL QES	Census/DoL QES	Census/DoL QES
Agriculture	Census/Agriculture Census	Census	Census/Agriculture Census	Census
Services to agriculture; hunting and tramping	Census	Census	Census	Census
Commercial fishing	Census	Census	Census	Census
Residential property operators	Census	Census	DoL QES	Census/DoL QES
Private households employing staff	Census	Census	DoL QES	DoL QES
Non-civilian defence staff	Administrative data	40 hours/week	…	…
Foreign government representation	Excluded	…	…	…
International sea transport	Excluded	…	…	…

Note: For footnotes and symbols, see end of table.

Table 1 continues next page

Table 1 continued

1989–2000

Industry	Data source for employee count	Data source for employee hours	Data source for working-proprietor count	Data source for working-proprietor hours
QES industries	BDD(4)/QES jobs	QES paid hours	Census/HLFS count	Census/HLFS usual hours
Agriculture	Census/HLFS count	Census/HLFS usual hours	Census/HLFS count	Census/HLFS usual hours
Services to agriculture	Census/HLFS count	Census/HLFS usual hours	Census/HLFS count	Census/HLFS usual hours
Commercial fishing	Census/HLFS count	Census/HLFS usual hours	Census/HLFS count	Census/HLFS usual hours
Residential property operators	Census/HLFS count	Census/HLFS usual hours	Census/HLFS count	Census/HLFS usual hours
Private households employing staff	Census/HLFS count	Census/HLFS usual hours	Census/HLFS count	Census/HLFS usual hours
Non-civilian defence staff	Administrative data	40 hours/week	…	…
Foreign government representation	Excluded	…	…	…
International sea transport	Excluded	…	…	…

Note: For footnotes and symbols, see end of table.

Table 1 continues next page

Table 1 continued

2000 onwards[5]

Industry	Data source for employee count	Data source for employee hours	Data source for working-proprietor count	Data source for working-proprietor hours
QES industries	LEED	QES paid hours	LEED[6]	Census/HLFS usual hours
Agriculture	LEED	Census/HLFS usual hours	LEED[6]	Census/HLFS usual hours
Services to agriculture	LEED	Census/HLFS usual hours	LEED[6]	Census/HLFS usual hours
Commercial fishing	LEED	Census/HLFS usual hours	LEED[6]	Census/HLFS usual hours
Residential property operators	LEED	Census/HLFS usual hours	LEED[6]	Census/HLFS usual hours
Private households employing staff	LEED	Census/HLFS usual hours	LEED[6]	Census/HLFS usual hours
Non-civilian defence staff	Administrative data	40 hours/week	…	…
Foreign government representation	Excluded	…	…	…
International sea transport	Excluded	…	…	…

1. Exclusions from the series include international sea transport (people working in this industry are working abroad) and foreign government representation (embassies are deemed to be island states and economies of their particular home country).

2. Data sourced from the census and Agriculture Census are linked to Census/HLFS data in 1986. All other DoL QES-based employee data are linked to BDD/QES in 1989.

3. The DoL QES started in 1980. Before this, DoL HYEIS data were used.

4. Annual BDD employee-count benchmarks are incorporated into the series from 1987 for most industries, and from 1988 for the remainder.

5. Where LEED data are unavailable due to timeliness, labour counts are rated forward using movements in the QES and HLFS.

6. LEED counts for working proprietors are based on annual data, supplemented by data from HLFS and QES.

Symbol: … not applicable

3.4.4 Other issues

HLFS sample redesigns

The HLFS sample is redesigned periodically (approximately every five years) based on data from the population census. When the sample is redesigned the sample stratification may be changed, all primary sampling units (PSUs) are re-selected, and weights are adjusted. Note that this differs from a sample rebase, where weights are adjusted in order to benchmark the total working-age population to the census working-age population.

HLFS sample redesigns occurred in 1993–94, 1998–99, and 2004–06. For the first two redesigns, the new sample was phased in over four quarters, with two rotation groups from the new sample rotated in and two rotation groups from the old sample rotated out in each of the four quarters. In the most recent redesign, the new sample was phased in over eight quarters. The objective for introducing the sample over four or eight quarters is to smooth the transition between samples. This is why any variation in the series due to a redesign is not obvious when viewing a time series of HLFS data.

During the phasing in of the new sample, movements reported in the HLFS will be due not only to changes in the labour market but also to any differences between the new and old sample. Any analysis of HLFS data during these redesign periods should consider the sample redesign. In general, the sample redesign does not affect the general labour market trends.

However, in 1993–94 several changes made to the design of the HLFS sample may have increased the measured growth in employment during this period,[4] including the stratification basis changing from urban/rural area to regional council area.

Other changes were as follows:

- The number of strata reduced from 194 more variable-sized strata to 122 more even-sized strata.
- Proportionately fewer rural PSUs were selected.
- Proportionately more PSUs were selected from strata with relatively high concentrations of Māori. Targeting Māori in the new HLFS design improved the accuracy of Māori statistics.
- The number of PSUs reduced from 2,400 to 1,752. The average number of households selected in each PSU increased from 6.5 to 9.0.

QES and casual employment

The collected data relate to paid employees of all ages but casual labour is not well covered. This is particularly relevant during periods where environmental factors affect the composition of the labour force. For example, one such environmental change occurred when the Employment Contracts Act 1991 came into force. One objective of the Act was to increase flexibility in the labour market; it is quite likely that along with this increased flexibility came an increase in the number of casual workers.

Data about unpaid labour are not collected by the QES. In the majority of businesses, data are extracted from the payroll system. Individuals with more than one paid job can be counted at each workplace if they are not in an industry excluded from the QES, or in non-economically significant enterprises. Estimated counts of working proprietors with employees are produced, but the quality is not good, and data on hours are not collected for this group.

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[4] Some of these changes were introduced due to the availability of new information or data that were useful for sample design – for instance, regional councils were created in 1989.

Creating a continuous LVS

Various data sources have been used to compile a long-term continuous series. The key linking period for datasets is 2000 as LEED data are introduced as the sole data source for counts of employees, and as the benchmark for working-proprietor counts.

The linking is done at the ANZSIC working-industry level, meaning that published industry and measured-sector aggregates will also be linked to create a continuous series.

The rental, hiring, and real estate services (LL1); professional, scientific, and technical services (MN1); administrative and support services (MN2); and other services (RS2) industries are included in the expanded measured sector from 1996 onwards. No attempt is made to create a continuous LVS at this point, so there is a break in the series.

Timeliness of LEED

The LEED series is the preferred data source for employment and working-proprietor counts. However, due to the way data are collected, the series is not as timely as other survey-based data sources. Because of this, the series is rated forward to calculate the latest period's labour counts when necessary. This is done by using movements in QES for employees in industries within its scope, and using HLFS data for all other industries' employees and working proprietors.

This QES and HLFS data are tested for robustness, and adjustments are made where necessary. There is generally a 14-month lag following the quarterly reference period for LEED employment data, and a 20-month delay in LEED annual working-proprietor data becoming available. This means that the latest quarter of employee data is not timely enough, and neither is the latest year of most LEED working-proprietor data. LEED is also subject to revision, due to late tax forms being processed. This primarily affects the working-proprietor data. To account for this, the working-proprietor series is rated up, using previous years' undercount proportions data until the LEED data are no longer provisional.

3.4.5 Quality assurance of the industry labour volume series

As a quality assurance measure, several coherency adjustments are made to the employee count and hours series that feed into the measured-sector LVS. The main data sources in constructing the LVS are sourced independently of the estimates of compensation of employees (CoE) from the national accounts. CoE estimates are primarily derived from the Annual Enterprise Survey (AES), while LVS estimates are compiled using a number of sources, as discussed above. Current-price CoE estimates are deflated using the QES average hourly earnings measure to provide an implicit LVS. This provides a benchmark for comparing against the LVS at an industry level. Adjustments are made to the industry data, based on alternative labour data sources in the years where the LVS shows a significantly different movement to the deflated CoE series.

3.5 The labour input index

For productivity purposes, the main interest is in the annual growth rate of labour input for the measured sector.

To derive this rate, industry annual-average hours paid per week are first calculated for the March year for each industry. These annual values of industry labour volume are the simple average of the four quarterly values. A chain-linked Tornqvist index is then used to calculate the measured-sector labour input index. The quantity relatives in the index are two-period ratios of annual industry labour volumes. Industry two-period mean shares of measured-sector nominal labour income form the exponential weights.

Assuming a positive correlation between industry labour incomes and skill levels, this industry weighting regime goes some way towards 'quality adjusting' the labour volume index. Quality adjusting in this manner means that the series captures, to some degree, changes in the 'quality' (ie skill level) of labour used in producing output. This implies that an increase in the aggregate level of output due to an increase in the skill level of the labour force will only partially show up as an increase in labour productivity. If the labour measure did not have this degree of implicit quality adjustment, the increase in output would be fully reflected as an increase in labour productivity.

The formulas for the Tornqvist index and its weights are given in the equations below:

Equation 3.1

$$\frac{L_t}{L_{(t-1)}} = \prod_i \left(\frac{L_{it}}{L_{i(t-1)}} \right)^{Wl_{it}}$$

Equation 3.2

$$Wl_{it} = \frac{1}{2} \left(\frac{Yl_{it}}{\sum_i Yl_{it}} + \frac{Yl_{i(t-1)}}{\sum_i Yl_{i(t-1)}} \right)$$

Where L_t = measured sector volume of labour in period t

L_{it} = volume of labour in industry i, period t

Yl_{it} = current price labour income in industry i, period t.

A Tornqvist index is used to construct the measured-sector labour input index. This is consistent with the formulations of the measured sector capital services series and the composite input series used in calculating multifactor productivity.

3.5.1 Scope of the labour input index – the 'measured sector'

The labour input index covers the subset of the economy that is referred to as the 'measured sector'. This includes ANZSIC06 published industries AA1 to AA3, BB1, CC1 to CC9, DD1, EE1, FF1, GH1, GH2, II1, JJ1, KK1, LL1, MN1, MN2, RS1,and RS2. Industries include:

- agriculture
- forestry and fishing, and services to agriculture, forestry, and fishing
- mining
- food, beverage, and tobacco manufacturing
- textile, leather, clothing, and footwear manufacturing
- wood and paper products manufacturing
- printing
- petroleum, chemical, polymer, and rubber products manufacturing
- non-metallic mineral products manufacturing
- metal products manufacturing
- transport equipment, machinery, and equipment manufacturing
- furniture and other manufacturing
- electricity, gas, water, and waste services
- construction
- wholesale trade

- retail trade
- accommodation and food services
- transport, postal, and warehousing
- information media and telecommunications
- financial and insurance services
- rental, hiring, and real estate services
- professional, scientific, and technical services
- administrative and support services
- arts and recreation services
- other services.

The measured sector excludes industries that are problematic for productivity measurement. Excluded industries are those for which estimates of value added at constant prices are derived largely using input methods, such as number of employees. This mainly comprises government non-market industries whose services are provided free or at nominal charges, such as government administration and defence.

The LVS is constructed at the ANZSIC working-industry level for all industries (except the exclusions noted in table 1). It can be aggregated to the published industry, measured-sector, or total economy-wide level.

For estimated employment in the measured sector (on average):

- component 1 contributes about 72 percent
- components 2 and 3 (combined) contribute about 28 percent.

In terms of hours paid in the measured sector (on average):[5]

- component 1 contributes about 69 percent
- components 2 and 3 (combined) contribute about 31 percent.

3.5.2 Estimating industry labour income

To calculate the measured sector labour input index, it is necessary to derive estimates of industry labour income in current prices.

The annual March-year national accounts include estimates of industry gross operating surplus, compensation of employees, and net indirect taxes on production. However, gross operating surplus includes the net mixed income received by working proprietors and those who are self-employed. This net mixed income must be separated into its two components – the income flows that result from the use of labour and capital.

The previously calculated employee and working-proprietor hours paid series, along with the national accounts compensation-of-employees data, are used to allocate the industry net mixed income to the primary factors. The labour income of working proprietors is imputed as:

Equation 3.3

$$Ylwp_{it} = COE_{it}\left(\frac{WPhp_{it}}{TEhp_{it}}\right)$$

[5] Component 4 is part of the government administration and defence industry and is therefore excluded from the measured sector. Component 4 contributes less than 1 percent to total-economy hours paid.

Where $Ylwp_{it}$ = labour income of working proprietors in industry i, period t

COE_{it} = compensation of paid employees in industry i, period t

$WPhp_{it}$ = working proprietor hours paid in industry i, period t

$TEhp_{it}$ = total hours for paid employees in industry i, period t.

The labour income of working proprietors for industry i, as defined in equation 3.3, has a ceiling; it cannot be greater than the net mixed income of that industry. In such cases, the net mixed income apportioned to capital will be equal to zero.

A share of net taxes on production is apportioned to labour income as well. This is based on the relative share of labour income to the sum of labour and capital income.

Total net taxes on production attributable to labour are given by:

Equation 3.4

$$NTl_{it} = \left(\frac{COE_{it} + Ylwp_{it}}{COE_{it} + GOS_{it}} \right) NT_{it}$$

Where NTl_{it} = net taxes on production attributed to labour income in industry i, period t

NT_{it} = net taxes on production in industry i, period t.

GOS_{it} = gross operating surplus in industry i, period t.

So that current price industry labour income is given by:

Equation 3.5

$$Yl_{it} = COE_{it} + Ylwp_{it} + NTl_{it}$$

Where Yl_{it} = labour income in industry i, period t.

3.6 Composition-adjusted labour input

As noted, the theoretically ideal approach for measuring labour is through composition adjustment. A composition-adjusted labour input measure not only captures changes in the quantity of labour being utilised, but also the skill level of labour. The approach first calculates an index of the skill level of workers, based on movements in the distribution of proxies for skill, education, and estimated work experience, and then applies the movements of this series to the unweighted LVS most recently published. The result of this is a labour input series that accounts for changes in both the quality and quantity of labour.

The HLFS is the main data source for composition-adjustment, providing a breakdown of the employed by the variables of interest. The New Zealand Income Survey (NZIS) is an annual supplement to the HLFS. NZIS provides average incomes for each category of labour, which provides information on the relative incomes. These income shares are used in an approach similar to that for compiling the labour input index, as specified in the Tornqvist index specification in section 3.5. See Statistics New Zealand (2008) for more information on the composition-adjusted labour input series.

4 The capital series

4.1 Introduction

This section details the capital services series. This input series, along with the labour input series and constant-price value-added data, is used in forming productivity estimates.

4.2 Capital services construction

Constructing estimates of capital productivity and multifactor productivity (MFP) using an index number technique requires an index representing the flow of capital services. Capital services are generated by using capital assets over a specified period of time (year ended March in this case).

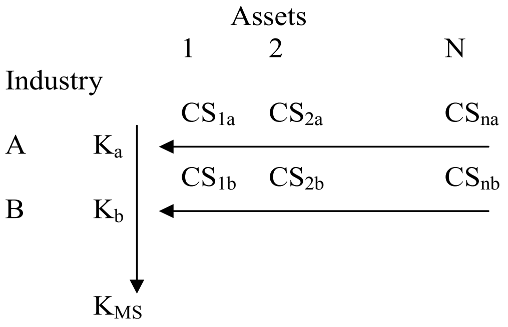
Capital assets include 24 of the 26 produced assets, which are estimated in the national accounts using a perpetual inventory method (PIM).[6] The PIM accumulates these assets' investment flows and applies retirement, efficiency, and discount parameters to derive estimates of productive capital stock (PKS), net capital stock (NKS), and consumption of fixed capital (CFK).

In addition to these assets, capital services estimates encompass land (for all industries except fishing), and inventories in selected industries. Livestock (in agriculture) and timber (in forestry) are included in the inventories estimates.

See appendix B for a full list of the assets within the scope of the Statistics NZ capital services series.

The construction of the capital services index for the measured sector has two distinct steps. For each industry within the measured sector, a capital services index is calculated by aggregating the services provided by the capital assets. This is the process of 'horizontal' aggregation (see figure 1). Secondly, these industry indexes are aggregated to the measured-sector level, which is 'vertical' aggregation.

Figure 1
The two stages of deriving measured sector capital services



In figure 1, CS_{xy} represents the capital services generated by asset x in industry y. The industry capital services index is denoted by K_y and K_{MS} represents the measured-sector capital services index.

6 Central government roading and local government roading are excluded. Refer to section 4.7 for further detail.

The capital services indexes are calculated at the aggregate (two-character) industry level, as published in the national accounts. Within the measured sector 25 published industries are formed from 103 working industries. Appendix A has a full list of published industries.

Estimates of capital services cover the private and government sectors. This coverage is consistent with the labour and output series.

4.3 Capital asset types within the scope of the PIM

Productivity studies require a measure of the PKS. An asset's productive capital stock is its gross capital stock adjusted for the decline in its efficiency. PKS at constant prices represents standardised efficiency units and can be interpreted as a measure of the potential capital services that the asset can contribute to the production process.[7]

For each asset type, the Statistics NZ PIM specifies a mean expected useful life, a retirement function based on a distribution about this life, and a pattern of (hyperbolic) efficiency decline. These parameters and gross fixed capital formation (GFKF) in constant prices are used to estimate an asset type's PKS in constant prices.

Considering one asset type of a single vintage, a hyperbolic age-efficiency function is specified as:

Equation 4.1

$$E_t = \frac{M - A_t}{M - bA_t} \qquad (0 \le A_t \le M)$$

Where E_t = the efficiency of the asset at time t, relative to its efficiency when new

M = the asset life, as per an assumed retirement distribution

A_t = the age of the asset of the given vintage, at time t

b = the efficiency reduction parameter.

To aggregate the efficiency units of assets with different lives (M), it is necessary to construct the weighted average of the age efficiency terms. The weights are the relative frequencies of asset lives, as determined by the Winfrey probability function.

Equation 4.2

$$R(A_t) = \sum_{M=A}^{M\max} P(M) \frac{M - A_t}{M - bA_t} \qquad (0 \le A_t \le M)$$

Where $R(A_t)$ = relative efficiency of assets of age A

$P(M)$ = relative frequency of assets with life M

$M \max$ = maximum useful life of the asset, as determined by the Winfrey function.

The real productive capital stock of an asset type within a given industry is then calculated as the sum of the relative efficiency of each vintage, weighted by its GFKF:

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[7] The productive capital 'stock' measures a flow of potential capital services in one period, which can be generated by the assets in existence. For this reason, *Measuring capital* (OECD, 2001a) does not use the term 'productive capital stock'.

Equation 4.3

$$PKS_t = \sum_{A=0}^{M\max} R(A).GFKF_{(t-A)}$$

Where PKS_t = productive capital stock of the asset type in period t, in constant prices

$GFKF$ = gross fixed capital formation in constant prices.

The critical input to the PIM is current-price GFKF. GFKF data at a detailed asset level are estimated by working industry, sector of ownership (private, local, or central government), and market group (market or non-market enterprise) as part of the annual national accounts supply-use balancing process. The supply-side estimates are sourced from data on imports and domestic production – AES sales figures and quarterly surveys. Demand-side estimates are obtained from AES GFKF data, direct enquiry, the financial accounts of large corporates, and government-sector financial accounts.

For the years in which the demand and supply estimates have yet to be reconciled through supply-use balancing, economy-wide GFKF data by asset type and sector are obtained from quarterly GDP estimates. Where specific information is not yet available, industry and market group allocations are made according to the proportions from the latest balanced year.

Data for all years enter the PIM by 26 asset types, by sector, by market group, and by working industry. From this point, constant-price GFKF estimates are derived using price index deflation. Age-price and age-efficiency functions are then used to form estimates of PKS, NKS, and CFK.

The AES covers approximately 90 percent of New Zealand's 'economically significant' enterprises. An enterprise is deemed to be economically significant if it meets at least one of the following criteria:

- has annual GST expenses or sales of more than $30,000
- has a rolling mean employment count of more than two over any 12-month period
- is in a GST-exempt industry (except residential property leasing and rental)
- is part of a group of enterprises
- is a new GST registration that is compulsory, special, or forced
- is GST registered and involved in agriculture or forestry.

Industries excluded from the AES include residential property operators not elsewhere classified, and foreign government representation, neither of which are in the Statistics NZ definition of the measured sector. Religious organisations, and private households employing staff are also excluded from AES.

The elemental level at which PIM outputs are produced is the working-industry-by-asset-type level. For a single asset type, estimates of these outputs at the published-industry level are the sums of the corresponding working-industry level values. This is so for both current and constant prices.

The asset price indexes employed in the PIM for deflation (and reflation) are specified by asset type and by sector (private and government), but are invariant to the industry of use.[8] However, the implicit price deflators that the PIM produces (at the working-industry-

[8] Asset price indexes are used in deflating current price GFKF and the subsequent reflation of constant price NKS, PKS, and CFK estimates. The majority of these price indexes are provided by Statistics NZ's quarterly capital goods price index.

by-asset-type level) are industry as well as asset specific. The industry deflator is influenced by the relative contributions of the sector's capital stocks to the industry's overall capital stock. To be consistent with the elemental level of analysis, our calculation of capital services employs these implicit price deflators as the asset price indexes.

A comprehensive description of Statistics NZ's PIM is provided in the manual *Measuring capital stock in the New Zealand economy* (Statistics NZ, 2013b).

4.4 Capital asset types outside the PIM scope

4.4.1 Land

Estimates of productive land stock are produced for the entire measured sector. Estimates of agricultural land use, by hectares, come from Statistics NZ agricultural production censuses and surveys. For years where agricultural production censuses and surveys are not held, land-volume data from Quotable Value Ltd are used to interpolate. The volume estimate for forestry land use, by hectares, comes from the Ministry of Agriculture and Forestry's National Exotic Forestry Description reports. Estimates of residential, commercial, industrial, mining, and other non-agricultural land volumes come from Quotable Value Ltd annually.

Residential, commercial, industrial, mining, and other non-agricultural land are included in the capital input series from 1996 onwards.[9]

Current-price estimates of the stock of land are calculated for all industries by multiplying their respective volumes (hectares) by a price per hectare. Average per hectare prices are estimated by using valuation and volume data from Quotable Value Ltd. The resulting current-price series include the value of land improvement expenditure, thereby creating a double count with the PIM asset type 'land improvements'. To address this, current-price productive capital stock estimates of land improvements, sourced from the PIM, are deducted from the current-price land values. These current-price values, net of land improvements, are then divided by land volumes to establish implicit price deflators.

Volume estimates of land for productivity analysis are derived by quantity revaluation using 1995/96 prices. These volumes are both the land's productive capital stock and net capital stock, as land is regarded as a non-depreciable asset.

4.4.2 Inventories

Inventories are included within the scope of the capital assets. Price and volume estimates of inventories are obtained from the national accounts for selected industries in the measured sector. They are included from 1978 for the agriculture and forestry industries, and from 1987 for the manufacturing; wholesale trade; retail trade; and accommodation, cafés, and restaurants industries. The dates reflect the availability of source data. Livestock and timber stocks, used within the agriculture and forestry industries, respectively, are now sourced from the national accounts as a part of the inventories series from 1980 onwards. Before 1980, movements are linked to the national accounts-sourced series.

4.5 The industry capital services index

The capital services index for an industry is a chain-linked Tornqvist index of the capital services provided by the asset types employed in that industry. A Tornqvist index is used,

[9] Estimates of the productive land stock for the education and training, and health care and social assistance industries are compiled in the same fashion.

to maintain consistency with the construction of the input index for MFP estimates, and the labour volume index.

Because movements in the volume of capital services provided by an asset are unobservable, they are proxied by movements in the asset's productive capital stock (ie the potential volume of capital-service flows based on the asset's physical stock and age-efficiency function). This is effectively an assumption of inter-temporal constant capacity utilisation. Assuming constant capacity utilisation is a simplification that ignores that rates vary over business cycles.

The Tornqvist index is constructed as the geometric mean of assets' two-period productive-capital stock ratios (representing capital services ratios) weighted exponentially by each asset's mean two-period share of the industry's value of capital costs. An asset's cost of capital is its user cost (rental price) multiplied by its flow of capital services.[10]

Equation 4.4

$$KC_{ijt} = u_{ijt} PKS_{ijt}$$

Where KC_{ijt} = cost of capital services for asset j in industry i, period t

u_{ijt} = user cost of asset j in industry i, period t

PKS_{ijt} = productive capital stock of asset type j in industry i, period t.

Industry capital cost is the sum of each asset's cost of capital services:

Equation 4.5

$$KC_{it} = \sum_j u_{ijt} PKS_{ijt}$$

Where KC_{it} = cost of capital services in industry i, period t.

So that the capital services index is represented by equation 4.6 and its associated weights by equation 4.7:

Equation 4.6

$$k_{it} = \frac{C_{it}}{C_{i(t-1)}} = \prod_j \left(\frac{PKS_{ijt}}{PKS_{ij(t-1)}} \right)^{Wijt}$$

Equation 4.7

$$Wijt = \frac{1}{2}\left(\frac{KC_{ijt}}{KC_{it}} + \frac{KC_{ij(t-1)}}{KC_{i(t-1)}} \right)$$

Where k_{it} = capital services index for industry i in period t

C_{it} = volume of capital services produced by industry i in period t.

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[10] Capital service flows are assumed to be proportional to the level of the productive capital stock.

The user cost is the cost of using a capital good for a specified period (in this case, one year). It is analogous to the wage rate in the LVS. In the context of ‘thin’ or non-existent rental markets, the user cost is approximated by the implicit rental that owners of capital pay to themselves.

We adopt a user cost that is determined by four factors:

- the asset price, as new, relative to its base-period price
- a real rate of return
- the asset’s rate of economic depreciation
- the effective rate of non-income tax on production.

This user cost is given by equation 4.8:

Equation 4.8

$$u_{ijt} = p_{ijt}(i + d_{ijt}) + p_{ijt}x_{it}$$

Where p_{ijt} = the price index of new capital asset j in industry i, period t

i = the real rate of return (set at 4 percent)

d_{ijt} = the rate of economic depreciation of asset j in industry i, period t

x_{it} = the average non-income tax rate on production for industry i, period t.

The asset price term, p_{ijt}, is the implicit price index that results from dividing an asset’s net capital stock in current prices by its constant-price equivalent. Equation 4.4 shows that the cost of capital services for a single asset is equal to its user cost multiplied by the volume of capital services, represented by PKS. In practice, PKS (the capital-services volume) is measured in constant dollars, hence the user cost (the capital-services price) is calculated as a price relative, so the resulting product is measured in dollar units. The user cost in the above formulation is effectively ‘unit free’. Using the asset price term p_{ijt} results in the cost of capital services being expressed in the prices of period t.

The rate of economic depreciation, which combines the devaluing effects of efficiency loss and ageing on an asset, is the ratio of the consumption of fixed capital to its productive capital stock:

Equation 4.9

$$d_{ijt} = \frac{CFK_{ijt}}{PKS_{ijt}}$$

Where CFK_{ijt} = consumption of fixed capital of asset j in industry i, period t

PKS_{ijt} = productive capital stock of asset j in industry i, at end of period t.

Both CFK_{ijt} and PKS_{ijt} values are in constant prices. The rate of economic depreciation (equation 4.9) is expressed with PKS_{ijt} as the denominator in order to derive the correct cost of capital services (refer to equation 4.4 in which PKS_{ijt} appears as the volume measure).

Non-income business taxes are taxes on production that are assignable to capital inputs. The parameter x_{it} is the ratio of these taxes at the industry level to the industry’s constant-price productive capital stock.

Equation 4.10

$$x_{it} = \frac{NTk_{it}}{PKS_{it}}$$

Where NTk_{it} = net taxes on production attributed to capital in industry i, period t

PKS_{it} = productive-capital stock in industry i, at end of period t

Both NTK_{it} and PKS_{it} values are in current prices. The allocation of taxes and subsidies on production to capital is elaborated on in section 4.6.

The remaining term in the user cost equation 4.8 is the real rate of return required by firms to effectively cover their financing costs. International work at the OECD, in which exogenous real rates of return were used for capital services measurement at the total-economy level, showed that in the 18 countries examined, long-run averages of real interest rates moved between 3 and 5 percent per year, depending on the country (OECD, 2009). Work done at Statistics NZ during the development of the PIM of capital stock found that for 1980–2000, the mean long-run real interest rate (represented by long-term interest rates on New Zealand Government stock, deflated by the consumers price index) was 4 percent. This rate is used in the PIM to discount the composite age-price function to derive the composite age-efficiency function. To ensure internal consistency, the same 4 percent real rate is used in calculating the user cost of capital.[11]

The user cost of capital, and in particular the interest rate, could be derived in a number of ways. A good summary of these different approaches is provided in *Measuring capital: OECD manual* (2009). One alternative adopted by many statistical agencies is to derive the rate of return endogenously. Under this approach, capital income is equated with the value of capital services (see equation 4.5) to give:

Equation 4.11

$$Yk_{it} = \sum_j u_{ijt} PKS_{ijt}$$

Where Yk_{it} = current price capital income in industry i, period t.

Using the user cost equation 4.8 and solving for the real rate of return gives:

Equation 4.12[12]

$$i_{it} = \frac{Yk_{it} - \sum_j PKS_{ijt}\left(p_{ijt} d_{ijt} + p_{ijt} . x_{it}\right)}{\sum_j p_{ijt} PKS_{ijt}}$$

While the endogenous approach has some theoretical appeal, and is by definition self-balancing, there are a number of drawbacks to this approach:

- Where asset coverage is incomplete, the rate of return will be biased upwards.

[11] See MacGibbon (2010) for more detail on Statistics NZ's approach to measuring the user cost of capital.

[12] Note that equation 4.12 results in a **real** rate of return. Including a capital gains term on the right-hand side of the equation would result in a **nominal** rate of return.

- An endogenous approach assumes perfect foresight on the part of economic agents (as it is an ex-post rate).
- The approach assumes the absence of economic rents.
- There is increased likelihood of negative user costs where there is either low capital income or significant capital gains.

After assessing alternative methods for calculating the user costs, to be used in weighting movements in volumes of assets within the industry capital services indexes, the exogenous real rate (4 percent) was selected as the most appropriate for New Zealand circumstances.

In a few cases the user cost can be negative or zero, which leads to computational problems. In both these cases, a user cost of 0.00001 is used, to ensure a non-zero and non-negative user cost of capital. In practice, this is a rare event and the impact of removing this treatment, which is based on pragmatism, has been quantified as negligible.

4.6 Estimating industry capital income

Capital income is assumed to be the sum of gross operating surplus (after the labour income of working proprietors is deducted – as defined in equation 3.3) and net taxes on production that are attributable to capital.

Gross operating surplus and net taxes on production are sourced from the current-price industry production accounts published in the national accounts. These production accounts are available for years in which the industries are balanced through an input-output analysis.[13]

Adjusted gross operating surplus (ie gross operating surplus less the labour income of working proprietors)[14] is given by:

Equation 4.13

$$AGOS_{it} = GOS_{it} - Ylwp_{it}$$

Where $AGOS_{it}$ = adjusted gross operating surplus in industry i, period t

GOS_{it} = gross operating surplus in industry i, period t

$Ylwp_{it}$ = labour income of working proprietors in industry i, period t.

Industry capital income is therefore calculated as the sum of adjusted gross operating surplus plus a share of net taxes on production, which is added so the capital and labour incomes sum to industry gross value added. This is based on the relative share of capital income to the sum of labour and capital income. Industry capital income is estimated as: [15]

[13] Industry capital income, industry capital service weights, and factor income shares are rated forward for non-balanced years.

[14] Labour income of working proprietors is sourced from the entrepreneurial income published in the institutional sector accounts.

[15] For the education and training, and health care and social assistance industries, capital cost (as defined by equation 4.5) is used as the factor weight for capital rather than capital income. This is because, as non-market dominated industries, gross operating surplus is negligible thus leading to a potential bias in using income shares. See section 6 of Statistics New Zealand (2013a).

Equation 4.14

$$Yk_{it} = AGOS_{it} + NTk_{it}$$

Where NTk_{it} = net taxes on production attributed to capital income in industry i, period t.

And:

Equation 4.15

$$NTk_{it} = \left(\frac{AGOS_{it}}{COE_{it} + GOS_{it}} \right) NT_{it}$$

Where NT_{it} = net taxes on production in industry i, period t

COE_{it} = compensation of paid employees in industry i, period t.

Note: NTk_{it} is used as the numerator in calculating the average rate of non-income tax on production (see equation 4.12).

4.7 Roading assets are excluded from industry capital services indexes

Of the 33 assets that are potentially within the scope of capital as defined for the productivity measures (refer appendix B), only 31 contribute to the measured-sector capital services index. The two excluded assets are central government roading and local government roading. These are ‘owned’ by ANZSIC published industries local government administration (OO1) and central government administration, defence, and public safety (OO2), which are outside the measured sector.

No industry within the measured sector bears the cost of using these assets. They are essentially public goods in the sense that they are non-excludable and non-rival in consumption. The roading network, like other public goods, does not represent a capital asset with an allocable user cost. Rather, the network enhances the use of other transport equipment assets and it is absorbed into the calculated MFP residual.

4.8 The measured-sector capital services index

The capital services index for the measured sector is formed by a Tornqvist aggregation of the constituent industries’ capital services indexes. The aggregation weights are the mean two-period industry shares of measured sector current-price capital income.

Equation 4.16 summarises this aggregation:

Equation 4.16

$$K_t = \prod_i \left(k_{it} \right)^{Wk_{it}}$$

Where K_t = the measured sector capital services index, period t.

This is equivalent to:

Equation 4.17

$$\frac{C_t}{C_{(t-1)}} = \prod_i \left(\frac{C_{it}}{C_{i(t-1)}} \right)^{Wk_{it}}$$

Where C_t = the volume of capital services in the measured sector, period t.

And:

Equation 4.18

$$Wk_{it} = \frac{1}{2} \left(\frac{Yk_{it}}{\sum_i Yk_{it}} + \frac{Yk_{i(t-1)}}{\sum_i Yk_{i(t-1)}} \right)$$

Equations 4.16 and 4.17 provide an index representing proportionate movements in measured-sector capital services. Assigning a value of 1000 to the base year volume of capital services, and using these movements, produces the capital services index.

5 Productivity estimates

5.1 Introduction

The purpose of this section is to outline the methods for obtaining:

- indexes of labour and capital productivity
- an index of multifactor productivity (MFP)
- a decomposition of output growth into growth in labour volume, growth in capital services, and MFP growth
- a decomposition of labour productivity growth into capital deepening, and growth in MFP.

5.2 The output index

For the productivity measures, output is defined as value added at constant prices. Annual value added for the measured sector is derived by following the same procedures used to derive constant-price GDP (a chained Laspeyres volume index of the constant-price value added of the industries that comprise the measured sector). The resulting chained volume series are re-expressed as an index with an expression base of 1000.

5.3 Labour productivity and capital productivity

Given indexes of labour volume and value added, it is possible to calculate labour productivity for the measured sector as:

Equation 5.1

$$LP_t = \frac{V_t}{L_t}$$

Where LP_t = an index of labour productivity in period t

V_t = an index of output (value added) in period t

L_t = an index of labour volume input in period t.

Similarly, a capital productivity index is found by dividing the output index by the capital services index (K_t):

Equation 5.2

$$KP_t = \frac{V_t}{K_t}$$

Where KP_t = an index of capital productivity in period t

K_t = an index of capital services input in period t.

These single factor (or partial) indexes reflect the combined influence of both primary factors. For example, labour productivity can be enhanced through greater levels of capital accumulation. For this reason, any attempt to track technological progress or efficiency gains must explicitly control for changes in the levels of both capital and labour. The measurement of MFP growth attempts to address this issue.

5.4 Multifactor productivity

Estimating MFP requires an index representing total inputs. This input index is calculated using the volume indexes of labour and capital.

Capital and labour are assumed to contribute to output according to the conventional Solow production function:

Equation 5.3

$$Q_t = A_t f(K_t, L_t)$$

Where Q_t = real output, period t

A_t = the observed MFP residual, period t

$f(K_t, L_t)$ = a production function capturing inputs of labour and capital volumes.

The residual term represents all factors that contribute to output, other than the volume of inputs. An increase in its value is commonly referred to as technical change or efficiency growth. However, it is more accurately interpreted as some combination of technological progress, efficiency gain, deviation from constant returns to scale, unobserved change in capacity utilisation, or departure from economy-wide long-run equilibrium. The residual also captures the impact of unobserved inputs on production. Indeed, Abramovitz (1956) refers to MFP as a “measure of our ignorance”.

The production function of equation 5.3 assumes Hicks’ neutral technical progress. This means that efficiency gains are external to the two primary factors of production, as represented by the residual term being disembodied from the interior of the production function equation. A Hicks neutral specification implies that changes in the residual term do not affect the relative marginal productivities of the primary factors.

From the OECD (2001b), Statistics NZ has adopted “the index number approach in a production theoretic framework. The growth accounting technique examines how much of an observed rate of change of an industry’s [or economy’s] output can be explained by the rate of change of combined inputs. Thus the growth accounting approach evaluates the MFP growth residually”.

Consider equation 5.4:

Equation 5.4

$$A_t = \frac{V_t}{I_t}$$

Where A_t = MFP in period t

I_t = a composite input index value in period t.

This is an index-number approach interpretation of MFP in which the residual is calculated as the ratio of the output index to the input index. Equation 5.4 is equivalent to:

Equation 5.5

$$V_t = A_t I_t ,$$

which is similar to the above production function. The selection of input index is therefore determined by the assumed underlying production function. In line with the recommendation in the OECD manual and following Australian Bureau of Statistics practice, we have adopted a Tornqvist input index.

Constructing the input series with a Tornqvist index is consistent with the existence of a transcendental logarithmic (translog) production function. The translog production function is a flexible aggregator that does not impose the restriction of constant elasticity of substitution between the inputs. The Tornqvist index is a symmetrical index – it attributes equal importance to the factor input weights of the current and immediately previous periods. It is also described as a superlative index because it is exact to a flexible-form production function.

A Tornqvist index is used to aggregate the primary factors to a composite input index. It is calculated as the geometric mean of the two-period input ratios, weighted by the respective two-period output elasticities. The output elasticities are unobservable and it is necessary to invoke two assumptions to proceed.

The first assumption is of constant returns-to-scale technology – this imposes the restriction that, in any one period, the output elasticities sum to unity.

The second assumption is the existence of perfectly competitive markets – competitive input markets imply that the real payments to capital and labour are equal to their respective marginal products.

With these assumptions, it can be shown that output elasticities are equal to their respective factor-income shares.[16] Hence, in the Tornqvist index, the factor weights are mean two-period shares of total-factor income. The input index is given in equation 5.6, while equations 5.7 and 5.8 specify the factor weights:

Equation 5.6

$$\frac{I_t}{I_{(t-1)}} = \left(\frac{K_t}{K_{(t-1)}}\right)^{Wk_t} \left(\frac{L_t}{L_{(t-1)}}\right)^{Wl_t}$$

Where I_t = a composite input index value for the measured sector, period t.

Equation 5.7

$$Wl_t = \frac{1}{2}\left(\frac{Yl_t}{Yl_t + Yk_t} + \frac{Yl_{(t-1)}}{Yl_{(t-1)} + Yk_{(t-1)}}\right)$$

Equation 5.8

$$Wk_t = \frac{1}{2}\left(\frac{Yk_t}{Yl_t + Yk_t} + \frac{Yk_{(t-1)}}{Yl_{(t-1)} + Yk_{(t-1)}}\right)$$

Where Wl_t = mean two-period proportion of labour income to total-factor income

WK_t = mean two-period proportion of capital income to total-factor income

Yl_t = measured-sector labour income, period t

Yk_t = measured-sector capital income, period t.

[11] The two assumptions ensure that the value of output is equal to the sum of the input values (ie to the sum of the factor-income shares). This condition is needed to derive the return to capital endogenously. Refer to equation 4.15, which solves for the rate of return, i_{it}, given the level of capital income Yk_{it}.

RULC is calculated as:

$$RULC = \frac{ULC}{GDP\ deflator}$$

$$= \frac{\dfrac{employee\ labour\ costs \times \left(\dfrac{total\ hours}{employee\ hours}\right)}{GDP_{kp}}}{\dfrac{GDP_{cp}}{GDP_{kp}}}$$

$$= \frac{employee\ labour\ costs \times \left(\dfrac{total\ hours}{employee\ hours}\right)}{GDP_{kp}} \times \frac{GDP_{kp}}{GDP_{cp}}$$

$$= \frac{employee\ labour\ costs \times \left(\dfrac{total\ hours}{employee\ hours}\right)}{GDP_{cp}}$$

where GDP_{cp}refers to current price GDP.

6.5 Data sources

6.5.1 Composition of labour cost

The choice of an appropriate variable for labour cost is dependent on what is practical and conceptually consistent. Available options include average earnings from the QES or LEED, and average CoE. CoE has been selected as the most appropriate choice as it is consistent with the national accounts framework under which output or value added GDP is produced. Internationally, it is generally recognised as a good proxy to the conceptual ideal of total labour cost, due to similarity of coverage.

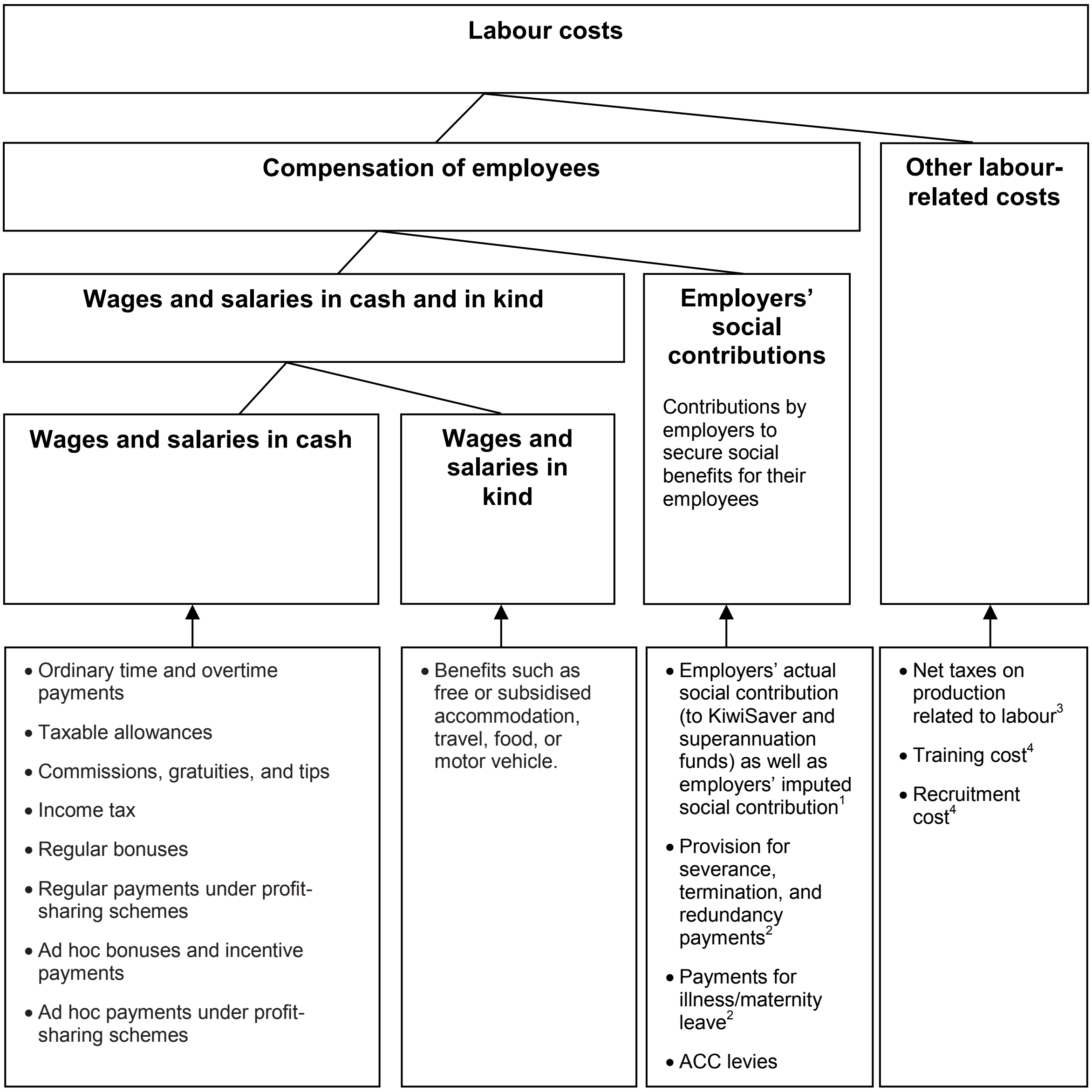
CoE consists of wages and salaries, as well as cash and in-kind payments, and employers' social contributions. CoE is defined in the System of National Accounts 1993 (SNA93) as "the total remuneration, in cash or in kind, payable by an enterprise to an employee in return for work done by the latter during the accounting period" (p164).

Labour costs are calculated as CoE plus payroll taxes minus employment subsidies. Training and recruitment costs are excluded because they are not specifically collected in the AES. This means that the cost of labour is slightly lower than total cost to employment. The impact is that the level of ULC will be lower. CoE also excludes the labour costs related to self-employed people.

In the absence of better data, an assumption is made that the self-employed earn, on average, the same as employees. This assumption is in line with international recommendations and should not affect the overall interpretability of total economy ULC. However, in industries where the proportion of self-employed is high, the results should be interpreted with some degree of caution.

Figure 2 presents a schematic view of the ideal coverage of the labour cost component of ULC.

Figure 2
Composition of labour cost



1. Some employers provide social benefits themselves directly to their employees out of their own resources without involving an insurance enterprise etc for the purpose.

2. In practice, it can be difficult to separate these payments from other salary and wage payments, in which case they are grouped with the latter.

3. Includes fringe benefit tax, employer superannuation contribution tax, less payroll subsidies, tax credit on superannuation, and tax credit for research and development.

4. Training and recruitment costs are excluded because they are not specifically collected in the AES.

Source: System of National Accounts 1993

6.5.2 Total and employee hours

The recommended method is to use hours paid, as this more closely reflects the cost incurred in the employment of labour. The LVS used in Statistics NZ's productivity series is based on hours paid and is available for this purpose.

The LVS is based on hours paid per week for a given quarter. The LVS uses QES, BDD, HLFS, census, and LEED for data on counts and hours for employees and the self-employed across industries. Employees and the self-employed are separate, distinct groups and have different characteristics. For example, employees typically work (on average) fewer labour hours than the self-employed. Unusually high labour hours tend to be ascribed to the self-employed. The ULC calculation 'rates up' employed hours to allow for CoE for self-employed labour. The rating up tends to affect industries with relatively higher proportions of the self-employed compared with employees, eg:

- agriculture
- construction
- rental, hiring, and real estate services
- professional, scientific, and technical services
- other services.

6.5.3 Gross domestic product

GDP is a frequently used measure of economic activity. It describes, in a single figure and with no double counting, all output or production carried out by all enterprises, government and non-profit institutions, and households in New Zealand during any given time. SNA93 defines the scope of output and production measured in the national accounts. Activities that are difficult to track down, such as illegal activities and unpaid work, are excluded from the scope of the national accounts.

Constant and current price GDP data, based on the production approach, were used in constructing ULC. The production approach calculates what each separate producer adds to the value of final output (value added) by deducting intermediate consumption from gross output. Value added is summed for all the producers. In practice, the components of value added are also independently estimated. This is the appropriate measure for ULC as it has a production by industry dimension.

Ideally, for ULC, GDP should be measured at basic prices. Excluding industries from the total economy while measuring output at basic prices is challenging. However, the aggregates required can be readily compiled using chain-volume value added, which uses producer prices.[17]

6.6 Industry coverage

Industry coverage is based on ANZSIC06 described in table 2.

The measured sector is based on the industries covered by Statistics NZ's productivity series. It excludes the following industries:

- ownership of owner-occupied dwellings
- local government administration

[17] The producer's price is the amount received by the producer from the purchaser for a unit of goods or a service produced, minus any VAT, or similar deductible tax, invoiced to the purchaser. It excludes any transport charges invoiced separately by the producer. The basic price is obtained from the producer price by deducting any other taxes while adding any subsidies.

- central government administration, defence, and public safety
- education and training
- health care and social assistance.

Unit labour costs cannot be readily compiled for industries with significant non-market components. Real ULC (employee labour costs over current price GDP) are often preferred as they account for both inflation and productivity. However, when current price GDP is based on the sum of input costs (as is the case for non-market providers), this leads to a ratio exhibiting minimal change. This is a statistical artefact rather than a precise representation of the labour market. Nominal ULCs (employee labour costs over constant price GDP) will be biased in level terms as the sum of input costs approach to current price GDP is required for the base year value of constant price GDP.

6.7 Rating forward CoE using LEED

To derive estimates for main aggregates in post-balanced years, industry-level CoE data are rated forward using the growth in LEED total gross earnings. The rated-forward CoE value is then balanced with the provisional estimate for total economy CoE. This enables ULC statistics to be timelier. Nominal ULC for the main aggregate (measured sector and measured sector excluding agriculture) are available with a one-year lag. Goods-producing and service-sector ULC are available with a two-year lag. This is because the industry-level labour volumes are not available. Real ULC estimates are available until the last balanced year of the national accounts.

Appendix A: ANZSIC06 divisions and published industries

Table 2
Industry coverage under ANZSIC06

ANZSIC06 industry
Measured sector(4))(5)
Primary sector
AAZ – Agriculture, forestry, and fishing(1)
BB1 – Mining
Goods-producing sector
CCZ – Manufacturing(1)
DD1 – Electricity, gas, water, and waste services
EE1 – Construction
Service sector(2)
FF1 – Wholesale trade
GH1 – Retail trade
GH2 – Accommodation and food services
II1 – Transport, postal, and warehousing
JJ1 – Information media and telecommunications
KK1 – Financial and insurance services
LL1 – Rental, hiring, and real estate services(3)
MN1 – Professional, scientific, and technical services(3)
MN2 – Administrative and support services(3)
RS1 – Arts and recreation services
RS2 – Other services(3)
Industries excluded from the measured sector
LL2 – Owner-occupied property operation
OO1 – Local government administration
OO2 – Central government administration, defence, and public safety
PP1 – Education and training(6)
QQ1 – Health care and social assistance(6)

1. Series for two agricultural sub-industries and nine manufacturing sub-industries are also available.

2. Service sector differs from national accounts service sector.

3. Not included in the former measured sector. Industry series available from 1996.

4. Former measured sector includes ANZSIC06 industries AA1–KK1 and RS1. Series available from 1978.

5. Measured sector includes ANZSIC06 industries AA1–MN2, RS1, and RS2. Series available from 1996.

6. Not included in the measured sector. Industry series available from 1996.

Source: Statistics New Zealand

Appendix B: Capital series – Statistics NZ asset classes and types

Table 3
Capital series – Statistics NZ asset classes and types

Asset class	Asset type
Intangible assets	Mineral exploration Other exploration Software
Land improvement	Land improvements Transfer costs on land
Non-residential building	Non-residential buildings Transfer costs on non-residential buildings
Other construction	Power construction Rail construction Transfer costs on construction Other construction not elsewhere classified
Plant, machinery, and equipment	Computers Electronic equipment Electrical equipment Furniture General purpose equipment Heavy machinery
Residential building	Residential buildings Transfer costs on residential buildings
Transport equipment	Aircraft Buses Rail Road vehicles (excluding buses) Ships
Land	Agricultural and forestry land Residential land Commercial land Industrial land Mining land Other non-agricultural land
Inventories	Inventories (includes livestock and timber)

Glossary

ANZSIC96 – Australian and New Zealand Standard Industrial Classification 1996.

ANZSIC06 – Australian and New Zealand Standard Industrial Classification 2006.

Average annual growth rate – reflects the average change in a variable across a period of time. Rates are calculated as geometric means, which take account of the compounding of growth rates over time. Arithmetic averages give higher growth rates and would lead to a different index figure for the latest year when applied to the base year.

Capacity utilisation – the relationship between actual and potential use of an input. Capacity utilisation is high when actual output is close to potential output because the most use is being made of labour and capital. In the productivity measures we produce, it is assumed that capital and labour are utilised at a constant rate over time.

Capital-to-labour ratio – the capital input index divided by the labour input index.

Capital deepening – positive growth in the capital-to-labour ratio. See also 'contribution of capital deepening'.

Capital income – the part of the cost of producing gross domestic product that consists of gross payments to capital. It represents the value added by capital in production, and is equivalent to the gross operating surplus, less the labour income of working proprietors, plus the capital proportion of taxes less subsidies on production.

Capital productivity – measured as a ratio of output to capital input. The ratio is derived by dividing the index of the chain volume measure of GDP by an index of capital services.

Capital services – the amount of 'service' each asset provides during a period. For each asset, the services provided in a period are directly proportional to the asset's productive capital value in that time. As an asset ages and its efficiency declines, so does the productive capital value and the service the asset provides. Capital services is the appropriate measure of capital input in production analysis.

Capital shallowing – a decline in the capital-to-labour ratio.

Chain volume measures – annually-reweighted chain Laspeyres volume indexes referenced to the current-price values in a chosen reference year (ie the year when the quarterly chain volume measures sum to the current-price annual values). Chain Laspeyres volume measures are compiled by linking together (compounding) movements in volumes, calculated using the average prices of the previous financial year, and applying the compounded movements to the current-price estimates of the reference year.

Compensation of employees – the total remuneration, in cash or in kind, payable by an enterprise to an employee in return for work done by the employee during the accounting period. It has two sub-components: wages and salaries, and employers' social contributions. Compensation of employees is not payable for unpaid work undertaken voluntarily, including the work done by members of a household within an unincorporated enterprise owned by the same household. Compensation of employees excludes any taxes payable by the employer on the wage and salary bill (eg payroll tax, fringe benefits tax).

Contribution of capital deepening – the growth in the capital-to-labour ratio, weighted by capital's share of total income. Given that capital's share of total income is always less than 100 percent, the contribution of capital deepening is always less than the growth in capital deepening. It is used for growth accounting for labour productivity.

Contribution of capital input – the growth in the capital input index, weighted by capital's share of total income. Given that capital's share of total income is always less than 100 percent, the contribution of capital input is always less than the growth in capital input. It is used for growth accounting for output.

Contribution of labour input – the growth in the labour input index, weighted by labour's share of total income. Given that labour's share of total income is always less than 100 percent, the contribution of labour input is always less than the growth in labour input. It is used for growth accounting for output.

Gross domestic product (GDP) – the total market value of goods and services produced in New Zealand within a given period, after deducting the cost of goods and services used up in the process of production, but before deducting allowances for the consumption of fixed capital. Thus, GDP is 'at market prices'. It is equivalent to gross national expenditure plus exports of goods and services less imports of goods and services.

Gross mixed income – the surplus due to owners of unincorporated businesses. It is often referred to as profit, although only a subset of total costs are subtracted from the output of unincorporated businesses to calculate it. Gross mixed income is split and allocated to capital and labour as factors of production.

Growth accounting – decomposes the growth rate of an industry's output into the part due to the increase in factors of production (labour and capital), and the part that cannot be accounted for by changes in labour and capital utilisation. This residual growth in output that cannot be accounted for is known as multifactor productivity (ie the extent to which an industry is getting more output from the same amount of inputs).

Growth cycle – the span of years between the peak of one cycle and the peak of a following cycle. Peaks are determined using statistical techniques, and are chosen to represent high points in capacity utilisation of the economy. Productivity is best analysed over growth cycles, as annual movements can be volatile and don't usually represent true changes to the underlying production function.

Index – an index series is a simple way of expressing, with reference to a base time period, the change in some variable from a given point in time to another point in time.

Inventories – a class of produced non-financial assets consisting of: stocks of outputs that are still held by the units that produced them before being further processed, sold, delivered to other units, or used in any other ways; and stocks of products acquired from other units that are intended to be used for intermediate consumption or for resale without further processing.

Labour income – the part of the cost of producing GDP that consists of gross payments to labour. It represents the value added by labour in production, and is equivalent to compensation of employees, plus the labour income of working proprietors, plus the labour proportion of taxes, minus subsidies on production.

Labour input index – an index of the weighted number of hours paid in the measured sector. It is created by weighting together the industry-level labour volume series using labour income weights.

Labour productivity – is measured as a ratio of output to labour input. Labour productivity estimates are indexes of real GDP per hour paid. Labour productivity reflects the contribution of labour to changes in product per labour unit, but is also influenced by the contribution of capital and other factors affecting production.

Labour volume series (LVS) – an estimate of the total number of hours paid in paid employment per week for the whole economy or a given industry over time.

Measured sector – the industry coverage of productivity statistics is defined as the 'measured sector'. It consists of industries for which estimates of inputs and outputs are independently derived in volume terms. Industries for which real value added in the national accounts is largely measured using input methods, such as number of employees, are excluded. These are mainly government non-market industries that provide services (eg administration, health, and education) free or at nominal charges.

Multifactor productivity (MFP) – estimates are indexes of real GDP per combined unit of labour and capital. They are derived by dividing chain-volume estimates of market sector GDP by a combined measure of hours paid and capital services. An increase in MFP is referred to as technical change or efficiency growth. However, it is more accurately interpreted as a combination of technological progress, efficiency gain, deviation from constant returns to scale, unobserved change in capacity utilisation, or departure from economy-wide long-run equilibrium. MFP is essentially a residual, and so also captures the impact of unobserved inputs on production.

Output – chain-volume value added. Annual value added for the measured sector is derived following the same procedures used to derive constant-price GDP (ie as a chained Laspeyres volume index of the constant-price value added of the industries making up the measured sector). The resulting chained volume series are re-expressed as an index with an expression base of 1000 in the March 1978 year.

Productive capital stock – a measure of productive capacity that forms the basis for the measure of capital services. Productive capital stock estimates are derived as the written-down value of each asset as its efficiency declines, due to age. This stock is measured in units of 'standardised efficiency'.

Rental prices – also referred to as the user cost of capital. It is the unit cost for the use of an asset for one period. That is, the price for employing or obtaining one unit of capital services. The rental price of an asset is determined by its price index when new, its rate of economic depreciation, the average tax rate on production within the industry, and an exogenous real rate of return (set at 4 percent).

Total income – the part of the cost of producing GDP that consists of gross payments to factors of production (labour and capital). It represents the value added by these factors in the process of production and is equivalent to current-price GDP.

Unit labour costs (ULC) – the ratio of labour costs to output. It is also the ratio of labour costs per unit of output to labour productivity (output per hour). There are two types: the first is nominal ULC, as labour costs are expressed in nominal terms; and the second is real ULC, which removes the effect of general cost increases.

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