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Estimating Average Annual Hours Worked

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Estimating Average Annual Hours Worked

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Methodology Division

Methodology Advisory Committee

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The ABS welcomes comments on the research presented in this paper.
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ESTIMATING AVERAGE ANNUAL HOURS WORKED

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ABSTRACT

Estimates of annual hours worked by employed Australians are used in an index of hours worked. The index is a labour input for productivity estimates in the Australian System of National Accounts. While adequate for use in an index designed to measure change, the level estimates of annual hours worked contain an upward bias because the method used does not adjust for the effects of public holidays and other events which tend to reduce hours actually worked. This paper describes an ABS project to improve the quality of the Australian average annual hours worked estimates. We outline a new approach for calculating estimates of average annual hours worked for Australia based on methodology used by Statistics Canada. Unlike the Statistics Canada method, the method presented in this paper uses an intervention analysis to estimate the effects of holiday events on the hours worked data from the monthly ABS Labour Force Survey.

Between 2002 and 2005, the estimates of average annual hours worked calculated using this new method are on average 4.6%, or 83.9 hours, lower than estimates calculated using the current method.

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1. INTRODUCTION

Each year the Australian Bureau of Statistics (ABS) produces an index of hours worked as a labour input for the productivity estimates in the Australian System of National Accounts. The index captures underlying trends in hours worked over the year and is derived from estimates of hours actually worked by employed people using the ABS Labour Force Survey (LFS). While the estimates of hours actually worked capture underlying trends they are not of sufficient quality to be published separately by the ABS.

There is an upward bias in the level estimates because they do not include the effects of public holidays and other events which tend to reduce hours actually worked. The ABS states that the estimates of average actual hours worked are only appropriate for use as an index. However, the estimates are provided to the Organisation for Economic Co-operation and Development (OECD) for their Employment Outlook publication. The international comparisons suggest that Australians are working longer than workers in other comparable countries.

This paper describes an ABS project to improve the quality, accuracy and reliability of the Australian average annual hours worked estimates. In the next section we provide a summary of the average hours worked in selected OECD countries. Section 3 describes the concepts used in the estimation of average annual hours worked. We present the advantages and disadvantages of different data sources and identify the most appropriate data source for the estimation of actual average hours worked. We summarise the current methodology used by the ABS and present an alternative approach, that is one based on the Statistics Canada method.

Section 4 describes the time-series analysis used to improve estimates of holiday corrections applied to the hours worked series. In Section 5, we outline how we combine the results from Section 4 with the Statistics Canada method to develop an appropriate method for deriving Australian estimates of average annual hours worked. Finally in Section 6 we conclude and describe possible future directions for improving the annual hours worked estimates.

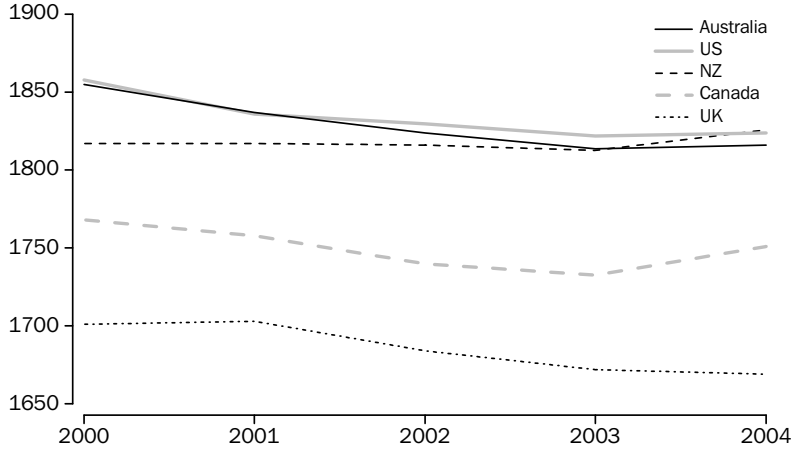
2. AVERAGE ANNUAL HOURS WORKED IN SELECTED OECD COUNTRIES

Each year the ABS makes the estimates of average annual hours worked by employed Australians available to the OECD for publication. In 2002 a table in the Employment Outlook publication presented results that indicated that employed people in Australia worked longer hours than workers in other comparable countries.

Average annual hours worked by employed Australians have been lower than in the United States since 2001 (OECD Employment Outlook 2005). In 2002, the original US estimates of average hours were lower than Australia's and although these estimates have since been revised they are regularly misquoted. Occasionally it is suggested that Australian workers work longer hours than workers in any other OECD country.

Figure 2.1 presents the average annual hours worked in Australia, Canada, the United States, the United Kingdom and New Zealand for the period 2000 to 2004. All estimates in this figure have been taken from OECD Employment Outlook Statistical Annex (2005) Table F.

2.1 Selected employment indicators from OECD Employment Outlook 2005 – Average annual hours worked



There are large differences in data sources and methods used by each of these countries and because of this, the OECD clearly states that these estimates are only suitable for intra-country comparisons over time and are not suitable for inter-country comparisons. Despite this caution, the Australian media quickly picked up on the fact that the estimates for Australia were higher than the estimates for the United Kingdom and Canada.

Differences between the Australian labour force and the labour forces of these comparable countries suggest that the estimate of average annual hours worked is unrealistically high for Australia. For example, in 2004, 24.2% of employed Australians

usually worked less than 30 hours per week compared with only 13.2% in the United States.[1] However, the US estimates of average annual hours worked are only slightly higher than the Australian estimates. This would suggest that the 76% of employed Australians who usually work at least 30 hours per week work must be working very long hours relative to workers in the United States. Given the large differences in methodology, definitions and survey coverage between Australia and the United States it is very difficult to quantify the differences in average hours worked estimates.

1 This estimate for the United States is taken from the OECD Employment Outlook Statistical Annex (2005), Table E.

3. CONCEPTS, DATA AND METHODS

In this section we outline the framework and concepts used in the estimation of average annual hours worked. We then review a number of ABS surveys which collect information on hours worked and look at what data is being used in other countries. Finally we look at the methods used by the ABS and Statistics Canada to estimate average annual hours worked.

3.1 Framework

Measuring hours worked is a complex issue. What should be included and excluded from the definition of hours worked? What is the best source of data for obtaining information on hours worked? Should we look at the number of hours worked per person or per job?

With questions like these in mind, we need a framework for the measurement of hours worked before we can start creating a reliable and representative indicator of hours worked in Australia.

A framework for the measurement and production of statistics on hours worked has been described in the "[Draft] Resolution concerning statistics related to working time" (2006) which may be adopted by the Eighteenth International Conference of Labour Statisticians in 2008. We have used this draft resolution, and the discussions of the Paris Group [2] on the draft resolution, as a basis for this average annual hours worked project and as a source to define some of the terms in this paper (given below). This framework allows us to answer the questions posed above, as well as many others.

3.2 Concepts

In this section we define the main concepts used in this paper to review and create measures of average annual hours worked.

Employed people are people in paid employment and people who are self-employed during a specified reference period. [3]

Hours actually worked are the number of hours worked by an employed person during the reference period. We want to understand the behaviour of workers and measure the number of hours actually worked. *Hours actually worked* can then be used in social and labour force analysis and be consistent with productivity measures and the System of National Accounts. Because of this, and to align with the OECD

2 The Paris Group is a city group which was set up in 1997 for the informal discussion, by representatives of national statistical agencies, on labour market conditions and compensation.

3 For more details of the definition of employment and the differences in the definitions between various ABS surveys, see ABS (2006c).

directions we will focus on *hours actually worked*, rather than alternative measures such as *hours usually worked*.

The ABS follows the definition of actual hours worked adopted by the Tenth International Conference of Labour Statisticians in 1962 in reference to wage and salaried employees for all types of employment. *Hours actually worked* refers to a specified reference period and should include:

- hours actually worked during normal periods of work,
- time spent in addition to hours worked during normal periods of work (including overtime),
- time spent at the place of work on activities such as the preparation of the workplace, repairs and maintenance, preparation and cleaning of tools, and the preparation of receipts, time sheets and reports,
- time spent at the place of work waiting or standing by, and
- time corresponding to short rest periods;

and should exclude:

- hours paid for but not worked such as paid annual leave, public holidays or paid sick leave,
- meal breaks, and
- time spent on travel to and from work.

Total hours worked are the number, or volume, of hours actually worked by all employed people during a given reference period.

Average hours worked are the average number of hours actually worked by all employed people during the specified reference period.

Average annual hours worked are the average number of hours actually worked by all employed people for the year. [4]

Random events [5] are events which do not systematically affect hours worked and occur to some extent in each week of the year. Such events may include normal sick days, carers days, some annual leave and overtime. There may be some seasonality in these random events. For example there may be an increase in the incidence of sick leave during winter but no one week is affected more than another.

4 In this paper we focus on calendar years. The methods described in this paper could also be applied to other periods, such as financial years, quarters or individual months. Similarly, although we consider average annual hours worked by employed people, estimates could be derived for jobs, or the Australian population.

5 The terms "random events" and "non-random events" are taken from Maynard (2004).

Non-random events are events which systematically affect hours worked throughout the year. Such events are times when employed people are more likely to be absent from work. Examples of non-random events are school holidays, the Christmas period, Easter and other public holidays. Weeks with non-random events are not representative of neighbouring weeks.

3.3 ABS data sources

The ABS collects information on hours worked in a number of different surveys. Two of these surveys are household surveys:

- Labour Force Survey,
- Time Use Survey

and three are establishment surveys:

- Survey of Employee Earnings and Hours,
- Major Labour Costs Survey,
- Labour Price Index Survey.

In this section we evaluate the usefulness of these data collections for estimating average annual hours worked.

Labour Force Survey (LFS)

The LFS is a monthly survey of approximately 27 000 households. Information for over 60 000 people is collected each month during a two week enumeration period. The interviews usually begin on the Monday which falls between the 6th and 12th of the month. Information is collected on work patterns during the week preceding the interview, providing us with information on work patterns during two reference weeks of each month.

The LFS has collected information on hours actually worked in the reference week since 1978. In April 2001 the ABS made some changes to the set of questions on hours worked. The questions on hours worked which have been used in the LFS since April 2001 can be found in Appendix B. The main changes include:

- memory prompts about days the respondent worked,
- a question on usual hours worked,
- additional questions on hours worked for the main job and for all jobs held by multiple jobholders. Prior to this change information was only collected for the main job.

The major advantage of using the LFS to estimate annual hours worked is that the careful survey design allows us to collect reliable information on actual working

behaviour in the reference week including information on hours actually worked and labour force status – the main variables of interest in estimating annual hours actually worked. The survey also has a large sample size, has been run on a monthly basis since November 1978 and hence provides us with a long time series of hours actually worked.

Another advantage is that the LFS includes people who are self-employed and people employed in industries such as agriculture and fisheries. These groups are not included in the scope of the ABS establishment surveys.

The major disadvantage of using the LFS is that although we have two reference weeks in every month of the year, the LFS does not cover every week of the year. This means that some non-random events are never observed in the LFS. For example, working patterns over the Christmas period are never observed. Table 3.1 shows a list of national public holidays which are expected to have a significant effect on hours worked. These effects will be explored further in Section 4. Table 3.1 also indicates whether the public holiday is regularly observed in the LFS or not. Although our preliminary work has focused on national public holidays, in the future we plan to extend our focus to include state public holidays.

3.1 National public holidays

Month/day	*Event*	*Observed in LFS*	*Week 1 or 2*
January 1	New Year's Day	Regularly observed	1
January 26*	Australia Day	Not since 1990	
March/April	Good Friday	Regularly observed	1 and 2
March/April	Easter Monday	Regularly observed	1 and 2
April 25	Anzac Day	Not observed	
June	Queen's Birthday (ex. WA)	Regularly observed	2
December 25	Christmas Day	Not observed	
December 26	Boxing Day	Not observed	

* Although this holiday has not been observed since 1990, we have kept this in the analysis so that if needed, we can produce estimates of total annual hours worked back to 1979.

Another issue with using the LFS is the use of proxy reporting by one responsible adult in the household for all other household members aged 15 years or over. Proxy reporting may lead to rounding and the reporting of usual hours rather than actual hours worked. However, in Canada, the United States, the United Kingdom, and Finland there have been studies which compare the reporting of actual hours worked through proxy reporting in a household LFS to the non-proxy reporting of actual hours worked in Time Use Survey time diaries (see below). Each of these studies found the two different reporting techniques lead to very similar estimates of hours

actually worked at the aggregate level. [6] We have not addressed this potential measurement error in this paper but this could be an area of further study.

Time Use Survey (TUS)

At first glance the TUS seems to be an ideal source of data for estimating average annual hours worked. The survey collects hours actually worked through the use of a detailed time diary which can be used to establish hours worked on each day of the week during the four two week reference periods and there is no proxy reporting.

The TUS has been run twice on a national scale – in 1992 and 1997. A third survey is scheduled for 2006. While the TUS provides some unique information on working hours behaviour in the reference periods, the infrequency of the collection means that it is not an appropriate alternative to the monthly LFS as the basis of our average annual hours worked estimates.

The TUS may have some potential for validation of estimates of average annual hours worked derived from the LFS. Unfortunately, the reference periods for the TUS does not provide us with a great deal of additional information on events which are not regularly observed in the LFS. For example, the four two week reference periods of the 1997 TUS began on the: 27 January, 21 April, 23 June and 27 October.

Establishment surveys

Using an establishment survey as the basis of annual hours worked estimates would ensure high consistency with production statistics. However, none of the ABS establishment surveys collect information on actual hours worked.

Another drawback with the establishment surveys is the non-coverage of self-employed people who account for around 18% of all employed people [7] and people employed in industries such as agriculture. This means that establishment surveys are not appropriate for estimating average annual hours actually worked.

However, detailed breakdowns by industry from the establishment surveys will be more consistent with production statistics than industry breakdowns using household surveys such as the LFS. Establishment surveys could be used in conjunction with household surveys to develop coherent industry level hours actually worked estimates. [8]

Establishment surveys can provide additional intelligence about the estimates of average annual hours worked derived from the Labour Force Survey. For example,

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6 For Canada, see Maynard et al. (2004:6); for the United Kingdom, see Williams (2004:76); for Finland, see Keinänen (2004:4); for the United States, see Frazis and Stewart (2004:6).

7 Estimated from the Labour Force Survey, April 01 – Oct 05.

8 Although current work has focused on the aggregate level to generalise the methodology, we are aware of the importance of accurate industry level estimates and have identified this area as an area for future work.

the Labour Price Index Survey collects information on standard weekly ordinary time and overtime hours paid. In each June quarter the survey also collects information on entitlements to annual leave. Estimates of entitlements to public holiday leave are also used in the Labour Price Index.

International data sources

Table 3.2 presents a summary of the data sources used in Canada, New Zealand, the United Kingdom and the United States. Apart from Canada, each of these countries uses an establishment survey as the basis for annual hours actually worked, even though establishment surveys do not collect information on actual hours worked. The main reason for this is the high reliability and stability of the industry data in establishment surveys.

3.2 Data sources used for productivity based hours worked estimates in selected countries (as presented to the 2004 Paris Group meeting in Lisbon)

Country	*Data source*	*Comments on choice of data source*
Canada Statistics Canada Maynard (2004)	Household LFS for hours actually worked Establishment survey and administrative data used to provide additional information to determine number of jobs in industries.	The Canadian LFS (similar in relative size and design to the Australian LFS) is a reliable source of information on hours actually worked by Canadian workers.
United Kingdom Office of National Statistics (ONS) Bird, Black and Hopwood (2004)	For their Labour Cost Index (LCI) the ONS uses an establishment survey.	The ONS has a continuous LFS which provides a representative week every quarter (13 weeks). The ONS uses an establishment survey to ensure consistency between numerator and denominator in the LCI.
New Zealand Statistics New Zealand (2004)	Quarterly Establishment Survey (QES)	Proposed method estimates hours actually worked from ordinary hours paid in the QES using a ratio of actual to usual hours from the LFS. An establishment survey was chosen because of the relative stability of the industry data and the long time series (relative to the LFS).
United States Bureau of Labour Statistics (BLS)	Establishment survey (Current Employment Survey)	Hours paid, obtained from the CES, are converted to hours worked using a ratio of paid work to the sum of the value of paid leave and paid work, obtained from Employment Cost Index data.

Which data source should we use?

After considering the relative advantages and disadvantages of the LFS, the Time Use Survey and the various establishment surveys, we have decided to continue using the LFS as the basis for average annual hours worked estimates. The main reason for not using the ABS establishment surveys is that they do not adequately capture the concept we are trying to measure. In contrast, the LFS collects information:

- on hours actually worked
- on multiple jobs
- on people who are self-employed, work in agriculture, fisheries, etc.
- in each month of the year
- from a large sample
- over a long period of time.

The LFS industry data could be supplemented by establishment survey data if high consistency with production statistics is required.

3.4 Current methods

In this section we explore the methods currently used by the ABS and Statistics Canada to estimate annual hours worked. Statistics Canada conducts a very similar household LFS to Australia and is one of the few countries to use their LFS as the basis of annual hours worked estimates.

Australian estimates for OECD Employment Outlook

The current method of estimating average annual hours worked, as published in the OECD Employment Outlook, is based on hours actually worked in the LFS reference periods for February, May, August and November. These four mid-quarter months are used for two reasons. The first and most important reason is that these months are relatively unaffected by non-random holidays and so they tend to capture underlying trends in hours worked. Secondly, the LFS only collects information on industry and occupation in these four mid-quarter months.

Total hours worked in the four mid-quarter months are averaged to estimate the total hours worked by all employed people in an average week. This weekly average is then divided by seven to estimate the number of hours worked per day and then multiplied by 365.25 to estimate the total hours worked during the year. Finally total annual hours worked are divided by the average number of employed people in the mid-quarter months. Box 1 shows a worked example of this method.

BOX 1

ESTIMATING AVERAGE ANNUAL HOURS WORKED FOR 2004

Number of employed people and total hours worked in thousands – 2004

Month	*Employed ('000)*	*Total hours ('000)*
Feb 2004	9 540.0	336 390.7
May 2004	9 640.7	333 950.5
Aug 2004	9 578.0	332 642.9
Nov 2004	9 786.5	338 216.1
Average	9 636.3	335 300.1

Average hours worked per day = 335,300.1 ÷ 7 = 47,900.0

Total hours worked per year = 4,7900.0 × 365.25 = 17,495,477.6

Average annual hours worked per person = 17,495,477.6 ÷ 9,636.3 = 1,815.6

This simple method overestimates average annual hours actually worked by employed people over the year. This method makes no adjustment for hours lost from national public holidays, school holidays and other non-random events. The method also excludes seasonal changes in hours worked, such as the relatively high hours worked in early December and relatively low hours worked in January.

Statistics Canada method

Statistics Canada uses all 12 LFS reference weeks from each month of the year to estimate annual hours worked. Jean-Pierre Maynard (2004) notes that there are five main stages to Statistics Canada's method of estimating average annual hours worked.[9] The method begins with estimates of average hours worked per job in each reference week.[10]

1. If a non-random event occurred during the reference week, hours lost are added back into average hours worked to obtain a "standardised LFS week".
2. Linear interpolation between the 'standardised LFS weeks' is used to obtain an estimate of hours worked for the remaining 40 weeks of the year. The

9 For more information on the Statistics Canada method, the paper presented by Jean-Pierre Maynard (2004) to the Paris Group meeting in Lisbon clearly sets out the methodology.

10 Statistics Canada focuses on average annual hours worked per job, which aligns with the Canadian System of National Accounts. We use average annual hours per employed person as it aligns with the OECD and with the current index used in the Australian System of National Accounts. This is an area we may consider for future work.

'standardised LFS weeks' are mid-month weeks and reference weeks for the December of the preceding year and the January of the following year are needed to estimate the first and last weeks of the year.

3. The hours lost from non-random events are then subtracted out of each of the individual weeks.

    a. Reference weeks: The hours lost from any observed non-random events (added at step 1) are removed. This results in the original observed average hours worked in the reference week.

    b. Estimated weeks (from step 2): The effects of non-random events which occur during estimated weeks are not observed. Because of this, the effects of unobserved non-random events are estimated using the effects of similar observed non-random events. The estimated effects of unobserved non-random events are subtracted from the estimates of hours worked calculated in step 2.

4. To accurately estimate partial weeks at the beginning and end of a month, or a year, a special survey provides estimates of hours worked on each day of the week. These are used to weight the partial weeks.

5. Monthly total hours worked are calculated by adding average hours per job in each full and partial week of the month and multiplying by the estimated number of jobs in the reference week. Monthly total hours for each of the 12 months are added to obtain annual total hours worked. Finally total annual hours worked are divided by the average annual number of jobs. This results in an estimate of average annual hours worked per job.

Conceptually, the method used by Statistics Canada provides a more appropriate way of estimating average annual hours worked than the method used to calculate the OECD published Australian estimates. The Statistics Canada method makes adjustments for hours lost from public holidays, school holidays and other non-random events. The method also uses LFS reference weeks from all 12 months of the year, which captures the effects of seasonal highs and lows on annual hours worked.

As a first step to improving the Australian estimates of average annual hours worked, we have decided to apply the Statistics Canada method to Australian data.

4. HOLIDAY CORRECTION

Whether we are calculating an index of hours worked as a labour input for productivity estimates in the System of National Accounts, or considering the use of a Statistics Canada style method of estimating average annual hours worked, the effects of non-random events on hours worked is an issue that needs to be carefully considered.

If our LFS reference period happens to contain a public holiday, or another non-random event, it will not be representative of work patterns during other weeks in that month, or in that quarter. When we are using hours worked in productivity estimates we need to remove the effects of non-random events to provide us with a more accurate view of the underlying movements in hours worked. Accurately estimating the effects of both observed and unobserved non-random events is also an important part of the Statistics Canada method of estimating average annual hours worked.

In this section we review the methodology used to estimate the effects of observed non-random events on the LFS hours actually worked estimates. Applying these holiday corrections to a LFS reference period with a significant observed non-random event will effectively increase hours worked during that reference period. [11]

It must be noted that the holiday corrected estimates of hours actually worked cannot be used as an indicator of the level of hours actually worked. They may only be used as an index to indicate underlying movements in hours actually worked. In Section 5 we will use the holiday corrected estimates of hours worked as an intermediate step in estimating average annual hours worked.

4.1 Intervention analysis

Seasonal adjustment is a process which estimates and removes systematic calendar related effects, $\hat{S}_t$, from the original series, O_t, to give the seasonally adjusted estimates, $\widehat{SA}_t = O_t / \hat{S}_t$. As part of the seasonal adjustment process, known effects need to be estimated and removed prior to seasonal adjustment. These effects are called prior corrections.

11 All our holiday corrections increase the hours worked during a reference period because they correct for significant events which reduce working hours below a 'normal' week for that time of year. We have not observed any non-random events which increase the working hours above a 'normal' week. For example, we have not observed a single event (rather than a seasonal one) of high overtime levels affecting a large number of people.

Intervention analysis is a technique used to identify the impact to a regular time series system from certain known events. This technique is widely used in economic time series analysis, for example, Box and Tiao (1975), Tsay (1988), and Findley *et al.* (1998) used this technique to identify outliers and calendar related effects for seasonal adjustment purposes. This process involves the design of an appropriate regressor to estimate a particular effect. For example,

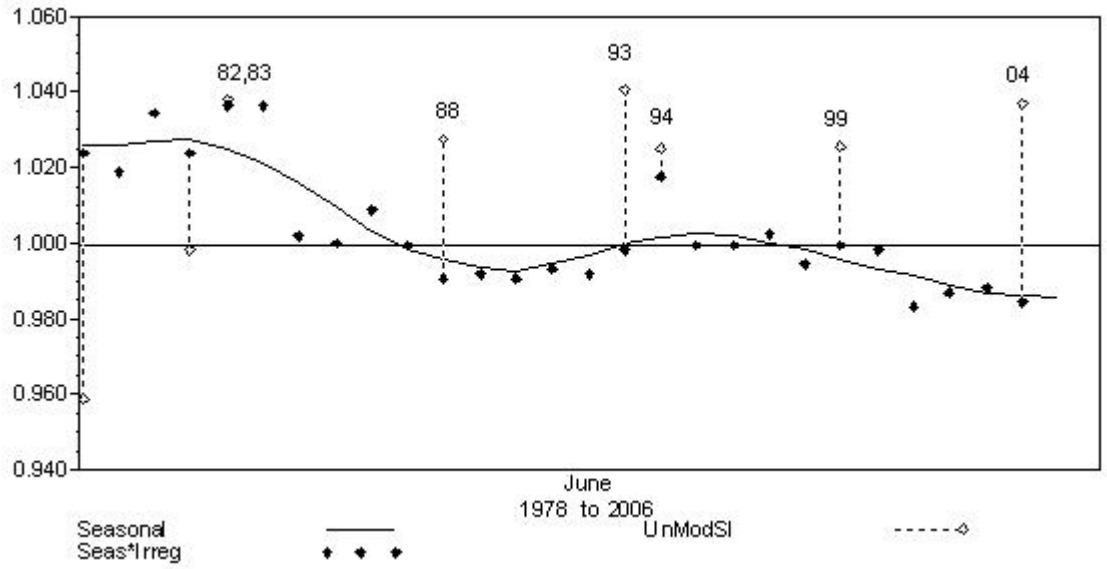
$$O_t = \sum_i \beta_i x_{it} + r_t$$

where β_i are regression parameters estimated from the original estimates, x_{it} is a regressor designed to assess for a specific effect, and r_t describes the dynamics of the regular time series without the impact of holiday events. Appropriate regressors can be designed to remove specific known impacts from the original estimates and improve the seasonally adjusted estimates. For example, effects such as public holidays, the starting date of the survey, use of supplementary surveys, and impacts of questionnaire redesign can be considered as measurement interventions to the 'normal regular' hours worked time series, which does not contain effects due to the overlap of known holidays with the LFS reference period.

The aim of the holiday correction is to estimate and remove the holiday impacts prior to seasonal factor estimation. This means that the seasonally adjusted holiday corrected series does not contain the impact induced from holidays as a part of calendar (seasonal) adjustment. The extent of the impact of a particular holiday will depend on how different people are affected by that holiday. For example, there may be different reactions to specific holidays in different states, in metropolitan/ ex-metropolitan areas and in different industries. For some holidays the effect may not be consistent from year to year due to factors such as the different dates of public holidays in different states.

A visual identification of the effect of holidays on hours worked is the seasonal by irregular chart (SI chart). SI charts are used to assess the seasonal by irregular components (SIs), used in the estimation of the seasonal factors, for a particular month or quarter. SIs are calculated by removing the trend estimate from the original series (for details see ABS, 2004). SI charts show the seasonal component as an unbroken line and the modified seasonal by irregular component as a set of filled points. The unmodified seasonal by irregular factors are included as the hollow points and are connected to the modified seasonal by irregular factors by a broken line. An example of the SI chart for hours worked in June is shown in figure 4.1. The high values in 1982, 1983, 1988, 1993, 1994, 1999 and 2004 relate to months in which the Queen's Birthday public holiday did not overlap the Labour Force reference period. This shows a significant impact due to this public holiday on hours worked.

4.1 Seasonal by irregular chart for hours worked in June



4.2 Which holidays have a significant impact on hours worked?

The approach adopted below is to estimate the holiday correction factors simultaneously as part of the seasonal adjustment process. This is the approach adopted in Regression–ARIMA intervention analysis.

To adjust for the impact of holidays on the hours actually worked estimates a range of appropriate regressors were developed and assessed individually. Each of the regressors was examined in detail and determined to adjust for a specific holiday affecting the hours actually worked series. Estimated correction factors were found to be statistically significant for the following holiday impacts: Easter, start date of the LFS in January, Queen's Birthday, Australia Day and school holidays in particular months.

In practice, all holidays impacting the hours worked series cannot be considered individually. For example, if an employed person does not work any hours on the New Year's day public holiday they will not work any less hours on this day if it is also a school holiday. The regressors identified in table 4.2 must be considered together to determine their combined significance. All regressors identified in table 4.2 were still significant.

4.2 Significant holiday regressors on hours worked estimates

Holiday	*Regressor*	*Parameter estimate (percentage impact)*	*t-statistic*
Easter overlap with LFS reference period	Easter Monday	–11.9%	–33.2
	Easter Monday, Good Friday	–18.8%	–48.1
	Good Friday	–6.5%	–15.5
January start date of LFS	New Year's Day	–7.1%	–13.2
	Summer holiday	–1.6%	–11.9
Queen's Birthday	June	–4.2%	–12.1
Australia Day	February	–6.3%	–14.2
School holidays	October	–8.2%	–10.6
	September	–8.8%	–7.4
	May	–6.6%	–5.2
	July	–4.0%	–4.3

Note: If the absolute value of the t-statistic is higher than a critical value of approximately 2.0 then this effect is significant (at the 95% level) relative to the variation expected of such estimates.

We compared the irregular component after seasonal adjustment for the monthly time series before and after holiday corrections. We found that the volatility of the irregulars of each month is reduced with the implementation of the new holiday corrections. The holiday corrected method has the most impact in January, April, June and October.

For more information, please refer to the feature article in the September 2005 edition of the Australian Economic Indicators publication, ABS (2005).

In summary, a Reg–ARIMA intervention methodology was applied to estimate the effects of observed non-random events on the hours worked estimates. The effects of non-random events occurring in an LFS reference period can now be removed from the hours worked estimates. The resulting holiday corrected LFS reference periods are similar to the 'standardised LFS weeks' used by Statistics Canada to estimate average annual hours worked. In the next section, the holiday corrections described above will be a major feature of the new method for estimating average annual hours worked based on the Statistics Canada methodology.

5. AN EXPERIMENTAL METHOD FOR ESTIMATING AVERAGE ANNUAL HOURS WORKED

The estimates of average annual hours worked published by the OECD overstate the average number of hours worked by employed Australians. In this section we adapt and apply the methodology used by Statistics Canada to estimate average annual hours worked for employed Australians. The method is summarised in Box 2. One of the advantages of this method is that we can take account of the effects of both random and non-random events on annual hours worked. A detailed explanation of each step (or compiler's notes) can be found in Appendix A.

The method we describe in this section is based on work-in-progress. Feedback on the preliminary method and the resulting estimates is encouraged.

BOX 2

APPLYING THE STATISTICS CANADA METHOD TO AUSTRALIAN DATA

1. Calculate average hours worked by all employed people in each reference period of the year, plus the December of the previous year, and the January of the following year.
2. Remove the effects of observed non-random events using the holiday corrections described in Section 4.
3. Use the holiday corrected reference period as the estimate of average hours worked in the first reference week of the month.
4. Interpolate linearly between the first reference weeks to obtain an estimate of average hours worked in each week of the year.
5. Estimate the effects of observed non-random events on an individual week based on the holiday correction estimates and proportional weighting.
6. Estimate the effects of unobserved non-random events based on the effects of observed non-random events.
7. Apply the effects of observed and unobserved non-random events to each week.
8. Estimate the proportion of total hours worked on each day of the week to weight partial weeks of the year.
9. Add all full and partial weeks together to estimate average annual hours worked.

Step 1: Average hours worked from the LFS

We begin our estimation of average annual hours worked by calculating average hours actually worked per employed person for each LFS reference period.

This is calculated as:

Average hours worked per employed person =

$$\frac{\text{Total number of hours actually worked by employed people}}{\text{Total number of employed people}}$$

As we will explain in step 4, in addition to the 12 two week reference periods from each month of the year, we also need the reference periods from the December of the previous year and the January of the following year.

Step 2: Holiday corrected reference weeks

In this step, we apply the holiday corrected estimates described in Section 4 to remove the effects of observed national public holidays and state school holidays from each of the 14 reference periods. Effectively, this step increases hours worked during the reference period. This provides us with average hours worked in a set of holiday corrected LFS reference periods.

If a reference week contains a non-random event, such as a public holiday, it will be different to the hours worked in neighbouring weeks. In this step we temporarily remove the effects of non-random events to reduce their impact on the imputed hours worked estimates.

Step 3: Assign reference periods to calendar weeks

Although the LFS has a two week reference period, the two weeks are combined together to produce one representative reference period. One of the reasons for this is that the sample is not evenly split across the two enumeration weeks. In the first week of enumeration, around 50% of households in metropolitan areas and around 80% of households outside of metropolitan areas are interviewed.

A second reason is the significant level of correlation between hours worked between the first week of one month and the hours worked in the first weeks of the neighbouring months. Each household remains in the LFS for eight months with one-eighth of the sample replaced each month. A household which is enumerated in the first week of the survey in one month is more likely to be enumerated in the first week of other months.

As the sample composition of the two reference weeks are different we cannot use the information on hours worked in the two reference weeks separately. Since hours worked in the reference period were holiday corrected in step 2 and a higher

proportion of people are enumerated in respect to the first reference week, we have decided to allocate the information on average hours worked in the two week reference period to the first reference week.

Step 4: Linear interpolation

Once we have assigned our 12 holiday corrected reference periods to a calendar week we impute average hours worked for the other 40 weeks of the year. This is done by interpolating linearly between each holiday corrected reference week. To estimate hours worked in the weeks at the beginning of January and the end of December of our target year we require holiday corrected reference weeks for the December of the previous year and the January of the following year.

At the end of this step we have an intermediate estimate of average hours worked in each week of the year, without the effects of non-random events.

Step 5: Re-estimate holiday corrections for observed non-random events

In this step, we estimate the effects of non-random events which are regularly observed in the LFS, such as Easter, the June Queen's Birthday holiday and some school holidays. We base our estimation on the holiday correction parameter estimates described in Section 4.

The parameter estimates in Section 4 are based on the effects of the holiday on the combined two week reference period. Because of this, the effect of an event which only occurs in one of the two reference weeks (for example the June Queen's Birthday holiday is only observed in the second reference week) will underestimate the effect of the event on the actual week. Events which occur in the first reference week will also appear to have a larger effect than events which are observed in the second reference week, simply because more people are enumerated in the first week.

We use a proportional weighting scheme on the holiday correction parameter estimates of Section 4 to take account of this.

Step 6: Estimate holiday corrections for unobserved non-random events

In step 6 we estimate the effects of non-random events which are not regularly observed in the LFS, such as Australia Day, Anzac Day, the Christmas period and unobserved school holidays. The effects of unobserved non-random events are based on the effects of observed non-random events which were estimated in step 5. The very simplified process of estimating the effects of unobserved non-random events is shown in Table 5.1.

5.1 Basis for estimation of unobserved public holiday effects

Type of event	*Estimation based on the holiday corrections of*
Basic public holiday	Queen's Birthday and New Year's Day
Large effect public holiday (e.g. Christmas)	Easter
School holidays	Average of observed school holiday corrections

Step 7: Adjusting for non-random events

Once the magnitude of each non-random event has been estimated in steps 5 and 6, step 7 is a relatively simple matter of adjusting the average number of hours worked in a week to take into account the effect of each non-random event. Effectively, this reduces the average number of hours worked in any week if a non-random event occurs during that week.

At the end of this step we have an estimate of average hours worked in all 52 weeks of the year.

Step 8: Estimate partial weeks

In this step we adjust for the fact that not all years begin on a Monday, or end on a Sunday. To do this we estimate the proportion of hours worked on each day of the week. While the LFS does not collect hours worked per day it does collect information on whether a person worked in their main job on each day of the week. From this we can estimate, for each day of the week, the proportion of employed people who work on that day and use this to calculate the total hours worked per day of the week.

Step 9: Average annual hours worked

The final step of estimating average annual hours worked is to add together all full weeks and the two partial weeks of the target year. This provides us with our estimate of the average annual hours worked in that year.

6. CONCLUSION AND FUTURE DIRECTIONS

The main aim of this paper has been to present a more accurate and reliable method for estimating average annual hours worked for Australia at the aggregate level. We believe that this method for estimating average annual hours worked, based on the Statistics Canada methodology, is a conceptual improvement over the method currently used to produce the estimates which are published by the OECD. The preliminary results from this Statistics Canada style method and the estimates published in the 2005 OECD Employment Outlook are shown in table 6.1 for each year between 2002 and 2005. The preliminary estimates are an average of 83.9 hours, or 4.6%, lower than the estimates published by the OECD.

6.1 Estimated average annual hours worked 2002–05

Year	*OECD Employment Outlook 2005*	*Preliminary estimates*	*Percentage change*
2002	1,824	1,737	–4.8%
2003	1,814	1,734	–4.4%
2004	1,816	1,733	–4.6%
2005	1,810	1,724	–4.8%

We have made a number of assumptions about the impact of holidays on hours actually worked. In Appendix F we have started to quantify this impact. Linear Interpolation reduces, on average, the OECD estimate by around 2% and other 2.6% reduction is due to our holiday adjustments and a small increase of around 0.3% is due to the adjustment for the start and end days of the year. Further analysis is being carried out to look at the impact of specific holiday assumptions.

Improving estimates of average annual hours worked at the aggregate level is not the end of the story. Developing a conceptually sound method at the aggregate level is seen as just the first stage. We hope to extend and refine the method in a number of areas, including:

- the estimation of state public holiday effects. Although individual state public holidays did not have a significant effect on aggregate hours worked, the sum of all individual state holidays across a year is likely to have an effect. State public holidays will also provide more observations for us to base our estimation of unobserved public holidays.
- estimates of average annual hours worked disaggregated by industry and benchmarked to the total. This is an area of high interest in productivity areas. We will investigate the use of supplementing the LFS with establishment surveys to create accurate estimates.

- estimates of annual hours worked per job.
- there has also been some interest in estimates of average annual hours worked disaggregated by:
    - gender
    - state
    - full-time and part-time employed.
- adjusting for the number of weekdays per year. When we calculated preliminary quarterly estimates we found that the number of weekdays per quarter explained the majority of the differences between years and quarters. Further work is being undertaken to adjust for the weekday effect in the estimates. Preliminary estimates can be found in Appendix G.
- when is it appropriate to use the original or adjusted level estimates of average annual hours worked? The original level estimates of average annual hours worked can be used to indicate actual hours worked at one point in time, or they can be use to indicate changes in actual hours worked across time. A standardisation such as the adjustment for weekdays described in the point above which takes account of leap years and differing numbers of weekdays in the year is essential before we conduct any analysis of changes in average annual hours worked across time. However, if we are interested in actual average hours worked during a period, the original series may be a more appropriate series. The issues of when and how to standardise average annual hours worked will be considered further in our future work.

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APPENDIXES

A. DETAILED INSTRUCTIONS FOR CALCULATING AVERAGE ANNUAL HOURS WORKED

This appendix provides detailed instructions to calculate average annual hours actually worked.

Step 1: Average hours worked from the LFS

This is the simplest of steps in the Statistics Canada based methodology.

This is calculated as: [12]

Average hours worked per employed person =

$$\frac{\text{Total number of hours actually worked by employed people}}{\text{Total number of employed people}}$$

To estimate average annual hours worked we require 14 reference periods. In addition to the 12 reference periods from each month of the target year, we need the reference periods from the December of the previous year and the January of the following year. These two extra reference periods are used in the interpolation of the first and last weeks of the year. This process will be explained further in step 4.

Table A.1 presents the workings for the holiday corrected hours worked in 2004. We have taken the last reference period from December 2003 and the first reference period for 2005.

Column 5 shows average hours worked by employed people for each of the 14 months required to calculate average annual hours worked for 2004. Columns 6 and 7 will be explained in more detail in step 2.

12 Hours worked and the number of employed are population weighted.

A.1 Calculation of holiday corrected hours worked Dec 2003 – Jan 2005

Reference period		Total hours worked	Total employed	Average hours worked		
Begins (1)	Ends (2)	('000) (3)	('000) (4)	Original (5)	Corrected (6)	Holiday correction applied (7)
1 Dec	14 Dec	346,867	9,683	35.82	35.82	None
5 Jan	18 Jan	272,607	9,458	28.82	29.74	2×Jan start date effect
2 Feb	15 Feb	336,391	9,540	35.26	35.26	None
1 Mar	14 Mar	331,090	9,627	34.39	34.39	None
5 Apr	18 Apr	275,413	9,622	28.62	34.01	Good Friday & Easter Monday
3 May	16 May	333,951	9,641	34.64	34.64	None
31 May	13 Jun	334,124	9,655	34.61	34.75	0.1×Queen's Birthday
5 Jul	18 Jul	316,670	9,670	32.75	33.69	0.7×July school holiday
2 Aug	15 Aug	332,643	9,578	34.73	34.73	None
30 Aug	12 Sep	338,612	9,803	34.54	34.58	0.01×September school holiday
27 Sep	10 Oct	323,489	9,799	33.01	33.86	0.3×October school holiday
1 Nov	14 Nov	338,216	9,787	34.56	34.56	None
29 Nov	12 Dec	355,515	9,947	35.74	35.74	None
3 Jan	16 Jan	252,699	9,765	25.88	29.37	New Year's Day and 4×Jan start date effect

Step 2: Holiday corrected reference weeks

LFS relates to two reference weeks each month and in this step we use this information to impute hours actually worked so that we have an estimate of hours actually worked for all 52 weeks of the year. In this step we begin a process to impute hours worked in all 52 weeks of the year.

If a reference period contains a non-random event such as a public holiday, hours actually worked in that week will be very different to hours worked in neighbouring weeks. We need to temporarily remove the effects of non-random events to reduce their impact on the imputed hours worked estimates.

The holiday corrected estimates described in Section 4 are used to remove the effects of observed national public holidays and state school holidays from each of the 14 reference periods.[13] Effectively, this step increases hours worked during the reference period. This provides us with average hours worked in a set of holiday corrected LFS reference periods.

Column 6 of table A.1 shows the average hours worked in each reference period of 2004 after the holiday corrections shown in column 7 have been applied.

The following table shows how each of the holiday corrections were applied.

13 In future work we will investigate the effects of state public holidays on average annual hours worked.

A.2 Derivation of holiday correction estimates

Reference period					
Begins (1)	*Ends (2)*	*Parameter estimate (3)*	*Parameter adjustment (4)*	*Total correction (3 × 4)*	*Description of parameter adjustment*
5 Jan	18 Jan	–1.6%	2.0	–3.2%	Parameter adjustment is zero if the first reference week begins on the 7th Jan, 1 for the 6th Jan and so on. (See step 6 for further details)
5 Apr	18 Apr	–18.8%		–18.8%	Includes both Good Friday and Easter Monday
31 May	13 Jun	–4.2%	0.1	0.042%	Reference period does not include the Queen's Birthday. However, WA, who celebrate the Queen's Birthday in October, are included in the parameter estimate. Their holiday is observed in the October reference period. We have added the WA component (10% of the population) of the Queen's Birthday in June for simplicity and consistency with other years.
5 Jul	18 Jul	–4.0	0.7	–2.8%	School holidays Week 1 – NSW, Vic, Qld, WA(2 days), NT, ACT Week 2 – NSW, Qld (1 day), SA, WA, NT, ACT Parameter adjustment – calculation of overlap of reference period and state population sizes
30 Aug	12 Sep	–8.8%	0.01	–0.088%	School holidays – Tasmania
27 Sep	10 Oct	–8.2	0.3	2.46%	School holidays Week 1 – NSW, Vic, Qld, SA, NT, ACT Week 2 – NSW, SA, WA, NT, ACT Parameter Adjustment – calculation of overlap of reference period and state population sizes
3 Jan	16 Jan	–7.1%			New Year's Day
		–1.6%	4.0	–13.5%	Parameter adjustment is zero if the first reference week begins on the 7th Jan, 1 for the 6th Jan and so on. (See step 6 for further details)

Step 3: Assign reference periods to calendar weeks

Although the LFS has a two week reference period, the two weeks are combined together to produce one representative reference period. One of the reasons for this is that the sample is not split evenly across the two enumeration weeks. In the first week of enumeration, around 50% of households in metropolitan areas and around 80% of households outside of metropolitan areas are interviewed.

There is also a significant level of correlation between hours worked in the first week of one month and the hours worked in the first weeks of the neighbouring months. Each household remains in the LFS for 8 months with 1/8th of the sample replaced each month. A household which is enumerated in the first week of the survey in one month is more likely to be enumerated in the first week of other months.

As the sample composition of the two reference weeks are different we cannot use the information on hours worked in the two reference weeks separately. Since hours worked in the reference period were holiday corrected in step 2 and a higher proportion of people are enumerated in respect to the first reference week, we have decided to allocate the information on average hours worked in the two week reference period to the first reference week.

For 2004, these weeks refer to the weeks beginning on the Mondays in column 1 of table A.1.

Step 4: Linear interpolation

The fourth step is to estimate average hours worked in each week of the year. This is done by interpolating linearly between each holiday corrected reference week.[14] To estimate hours worked in the weeks at the beginning of January and the end of December of our target year we require holiday corrected reference weeks for the December of the previous year and the January of the following year.

During our analysis of hours worked in the first and second weeks of each December we found that hours worked tended to be higher in the second week of December than in the first. Since the holiday corrected reference weeks are very high in December and very low in January, linear interpolation will underestimate the number of hours worked in the unobserved weeks between the December and January reference weeks. To avoid this we use the average hours worked in the December holiday corrected reference week for both the first and second reference weeks. We then interpolate linearly between the second reference week in December and the first reference week in January.

14 In the linear interpolation we must take into account whether there are four or five weeks between consecutive first reference weeks.

Step 5: Re-estimate holiday corrections for observed non-random events

Steps 5, 6 and 7 involve the estimation and inclusion of the effects of non-random events on the average hours worked in each week of the year.

In step 5 we estimate the effects of observed non-random events such as Easter, the June Queen's Birthday holiday and some school holidays. We base our estimation on the holiday correction parameter estimates described in Section 4. However, the parameter estimates in Section 4 are based on the effects of the holiday on a composite week. Because of this, the effect of an event which only occurs in one of the two reference weeks (for example the June Queen's Birthday holiday is only observed in the second reference week) will underestimate the effect of the event on the actual week. In addition, events which occur in the first reference week will appear to have a larger effect than events which are observed in the second reference week simply because more people are enumerated in the first week.

To reflect differences in the enumeration of people between the first and second enumeration weeks, we have applied weights to the parameter estimates given in table A.3 depending on whether an event is observed in the first or second week respectively. If an event usually occurs in the first reference week of the LFS, when around 65% of people are enumerated, we apply a weight of 1/0.65 or 1.54. If an event usually occurs in the second reference week of the LFS, when around 35% of people are enumerated, we apply a weight of 1/0.35 or 2.86.

In this step we also assume that employed people in metropolitan areas and employed people living outside of metropolitan areas have the same propensity to reduce their hours worked when there is a public holiday.

Table A.3 shows how the Easter, June Queen's Birthday holiday and New Year's Day shift and January start date effects are estimated.

A.3 Re-estimation of observed public holiday effects

Holiday	*Observed in week*	*Parameter estimate*	*Weight*	*Estimated effect on week*	*Applied effect*
Good Friday & Easter Monday	1 & 2	–18.8%	0.00	not observed	not observed
Good Friday	2	–6.5%	2.86	–18.6%	–18.8%
Easter Monday	1	–11.9%	1.54	–18.3%	–18.8%
Queen's Birthday	2	–4.2%	2.86	–12.0%	–12.0%
New Year's Day holiday	1	–7.1%	1.54	–10.9%	–10.9%
January start date effect	1	–1.6%	1.54	–2.5%	–2.5%

Note: the applied effect for the Good Friday and Easter Monday week is –18.8% since we believe this is a more accurate estimator for the effect of the events on all people during these weeks.

We describe the re-estimation of the Easter parameter estimates as an example of the technique we use in this step.

- Since Easter is a moving holiday, at times the April LFS reference weeks will capture both Good Friday and Easter Monday (Friday of the first reference week and Monday of the second reference week). When this occurs the effect on the two week reference period is –18.8%.
- At times only Good Friday is observed in the LFS (Friday of the second reference week). After applying a weight of 2.86 for being observed in the second week, our estimated effect of Good Friday is –18.6%.
- Similarly at times only Easter Monday is observed in the LFS (Monday of the first reference week). After applying a weight of 1.54 for being observed in the first week our estimated effect of Easter Monday is –18.3%.
- Since the estimated effects of Easter Monday alone and Good Friday alone are so similar to the parameter estimate of Good Friday & Easter Monday, we have decided to apply the parameter estimate to the week containing Good Friday and the week containing Easter Monday rather than our weighted estimates.

The effect of observed school holidays on a standard week requires a different type of estimation. The holiday correction parameter estimates in Section 4 are obtained by hypothetically assuming that all states experience school holidays at the same time for the entire two week reference period.

For each week of the year we need to estimate the proportion of the employed population affected by school holidays. We then weight the school holiday effect by the proportion of employed people living in states with school holidays. If school holidays do not extend for the entire week, the school holiday effects are also weighted to reflect this. [15]

Table A.4 shows how the school holiday effects for observed weeks are estimated.

15 For each weekday affected by the school holidays we apply a weight of 0.2% to the school holiday effect.

A.4 Estimation of observed school holiday effects for individual weeks

Month	*Observed week begins*	*States with school holidays*	*Proportion of employed affected*	*Parameter estimate*	*Estimated effect on week*
May	3 May 04	None	0.00%	–6.6%	0.0%
	10 May 04	None	0.00%	–6.6%	0.0%
	5 Jul 04	NSW, Vic., Qld, SA, WA (2 days), NT, ACT	87.6%	–4.0%	–3.5%
July	12 Jul 04	NSW, Qld (1 day), SA, WA, NT, ACT	57.6%	–4.0%	–2.3%
August	30 Aug 04	None	0.00%	–8.8%	0.0%
September	6 Sep 04	Tas.	2.18%	–8.8%	0.2%
	27 Sep 04	NSW, Vic., Qld, SA, NT, ACT	87.6%	–8.2%	–7.2%
October	4 Oct 04	NSW, SA, WA, ACT	52.7%	–8.2%	–4.3%

Step 6: Estimate holiday corrections for unobserved non-random events

In step 6 we estimate the effect on average weekly hours worked of unobserved non-random events such as Australia Day, Anzac Day, the Christmas period and unobserved school holidays. The first stage in estimating the effects of unobserved holidays is to utilise the information available on the effects of observed holidays.

School holiday effects

There are a number of decision rules used to assign school holiday effects to each week of the year.

1. If the week falls within December, January, February, includes Good Friday or Easter Monday we assume there are no additional school holiday effects, once public holiday and the January start date effects have been taken into account.
2. If there is an observed school holiday effect for the reference period of the month, all full and partial weeks are assumed to experience the same school holiday effect.
3. If there is no observed school holiday effect for the reference period of the month, all full and partial weeks are assumed to experience the average school holiday effect of all observed school holiday effects.

Public holiday effects

One of the difficulties in estimating the effects of unobserved public holidays is that each of the unobserved national public holidays occurs on a fixed date. For example, Christmas is observed on the 25th of December. Apart from New Year's Day, which we only observe if the holiday falls on a Monday, each of the public holidays observed in the LFS occurs on a fixed day – usually on either a Monday or a Friday.

The effect a public holiday on hours worked is likely to differ depending on which day of the week the event falls. For example, in 2006 Australia Day fell on a Thursday and Anzac Day fell on a Tuesday. There is quite a bit of anecdotal evidence to suggest that a significant proportion of employed people chose to have a four day long weekend rather than working on the Friday following Australia Day, or the Monday preceding Anzac Day. This means that if the holiday falls on a Tuesday, or Thursday, there will be a larger reduction in hours worked than if the holiday falls on a Monday, Wednesday, or Friday. If the holiday falls on a Saturday, or Sunday, the effect on the holiday week will be even lower. However, if the holiday does fall on a Saturday, or Sunday, there will also be an effect on the following week, since the official public holiday will be held on the following Monday.

These factors must be taken into account when estimating the effects of these holidays. In general, the effects of unobserved public holidays are based on similar observed public holidays as shown in table A.5. Details of the effects applied for Australia Day and Anzac Day are outlined in Appendix C.

A.5 Basis for estimation of unobserved public holiday effects

Type of event	*Estimation based on the observed effects of*
Basic public holiday	Queen's Birthday and New Year's Day
Public holiday on Tuesday, Thursday and Christmas	Combined effect of Easter Monday and Good Friday
Event falls on Saturday or Sunday	Proportional effect of a basic public holiday (or Easter effect) on Saturday or Sunday

The Christmas period

Calculating estimates of average annual hours worked across the Christmas and New Year's period is a challenge. This is a significant holiday period but there is little data available on the working arrangements of Australians during the period.

While the December LFS reference period indicates that people work long hours in early December, we have anecdotal evidence to suggest that average hours worked are relatively low over the Christmas and New Year's period. Although working behaviour in the last weeks of December is never observed in ABS surveys, in the

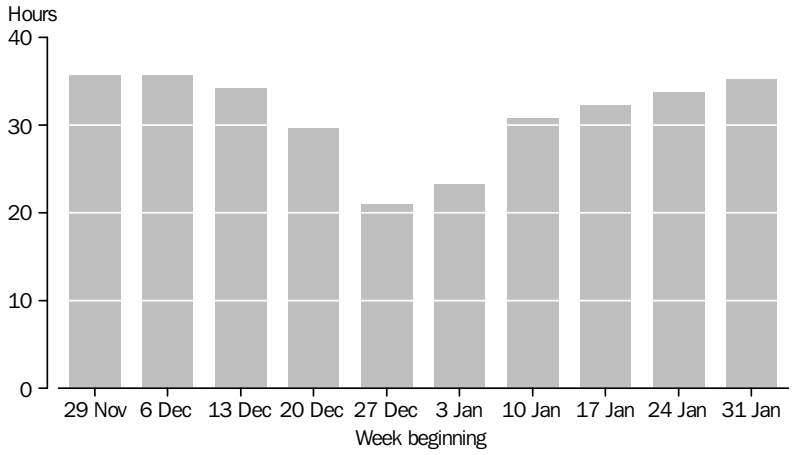
January reference period average hours worked are always low. In fact the holiday correction estimates take account of how early the January reference period begins, with a higher holiday correction when there is an earlier start date.

After considering a number of options, we found that the combined effect of the public holidays and linear interpolation appeared to provide fairly intuitive results. As before, we used the observed effects of public holidays to estimate the effects of the unobserved public holidays over the Christmas period. Due to the cultural significance of Christmas Day we applied the observed Easter effect to Christmas Day. The estimated effect of Boxing Day on hours worked is based on the observed effects of a basic public holiday. If either Christmas or Boxing Day falls on a weekend, as in 2004 and 2005, the effects are weighted to reflect this. The effect of the official holiday is then included in the following week based on a basic public holiday. The details of the applied effects for Christmas Day and Boxing Day are outlined in Appendix D.

The effect of New Year's Day is based on the observed effect of New Year's Day given in table A.1. If New Year's Day falls on a Saturday or Sunday then a proportional effect is applied to the week containing New Year's Day. Since the official holiday is held on the following Monday, the full effect of the New Year's Day holiday is also applied to the following week. We also know that while many people are on holidays over the Christmas period, after New Year's Day people will gradually return to work and average hours worked will slowly rise. We need to include this effect in our estimates of average hours worked over the Christmas period. In Section 4 it was noted that the start date of the January LFS was found to have a significant effect on hours worked estimates. The holiday correction parameter estimate for the January start date is highest if the LFS starts on the 6th January (first reference week begins on the 1st) and then decreases as the start date gets later. The estimate becomes zero when the survey starts on the 12th January (first reference week begins on the 7th). Appendix E shows the details of how these the January start date effects have been included in our observed and estimated weeks.

Figure A.6 shows the estimated pattern of average hours worked for December 2004 to January 2005 once the observed and estimated non-random effects have been applied. These estimates are an intermediate input into the annual estimates. They are included in this paper for illustrative purposes only and should not be used as an indicator of hours actually worked in those individual weeks.

A.6 Estimated average hours worked per week 29 November 2004 – 31 January 2005



Step 7: Adjusting for non-random events

Once the magnitude of each non-random event has been estimated in steps 5 and 6, step 7 is a relatively simple matter of adjusting the average number of hours worked in a week to take into account the effect of each non-random event.

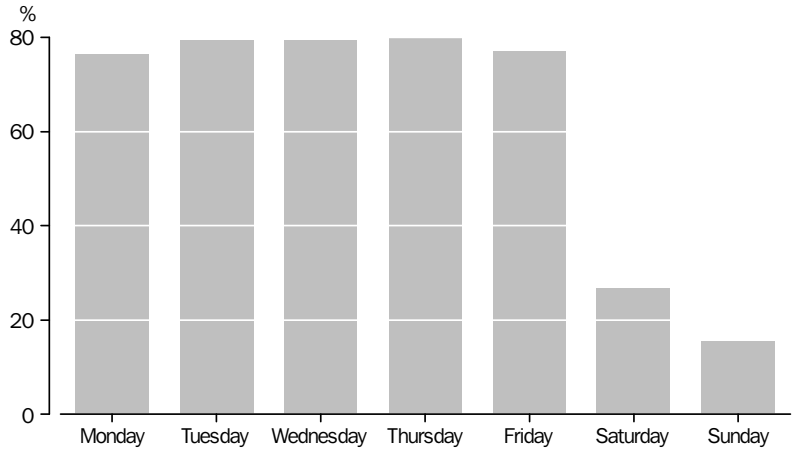
Step 8: Estimate partial weeks

Not all years begin on a Monday, or end on a Sunday. Because of this we need to estimate the proportion of hours worked on each day of the week. While the LFS does not contain this information, the survey does collect information on whether a person worked in their main job on each day of the week. From this we can estimate the proportion of employed people who work on a Monday, Tuesday, and on all other days of the week.

The current Australian estimates of average annual hours worked use the assumption that one seventh of weekly hours are worked on each day of the week. Figure A.7 shows the proportion of all employed people who actually worked on each day of the week based on an average of the mid-quarter months. [16]

16 To create these estimates we excluded Tuesdays in November (due to Melbourne Cup Day effects) and Mondays in May (Queensland Labour Day and Northern Territory May Day combined effect).

A.7 Proportion of all employed people who worked (in their main job) on each day of the week



With less than 20% of employed people working (in their main job) on an average Sunday and almost 80% of employed people working (in their main job) on an average weekday, distributing hours worked evenly over the seven days does not seem to be a valid assumption. In a preliminary analysis of this data we found that average hours worked per day, by people at work on that day, seems to be fairly consistent between people who work (in their main job) only on weekdays and people with more varied work day patterns.

In order to estimate partial weeks, we assume that:

> average hours worked per day, by people who worked on that day (eg average hours worked on Saturday by people who actually worked on Saturday), is the same for each day of the week.

This assumption is explained in a simple example in Box 3. With this assumption, we can use the information shown in figure A.7 to weight partial weeks.[17] Using this assumption, if the target year begins on a Thursday, as in 2004, then 45.9% of hours worked in the week beginning on the 29th of December in the previous year are assigned to our target year. Similarly, if the target year ends on a Friday, as in 2004, then 90.3% of hours worked in the week beginning on the 27th of December in the target year are assigned to our target year.

17 We also used the information in figure A.7 in the estimation of the effects of fixed date public holidays when they fell on a weekend.

BOX 3

EXAMPLE OF ASSUMPTION OF DAYS OF THE WEEK

Imagine a simple labour force where 1000 people work on each weekday, 100 people work on Saturdays and 50 people work on Sundays. The total hours worked and the average number of hours worked per day, by people at work on that day, are given in the table below.

Example of average hours worked per day by people at work on that day

Day of the week	*Total hours worked per day*	*Total number of people at work*	*Average hours worked per day by people at work on that day*
Each weekday	8,000	1,000	8.0
Saturday	800	100	8.0
Sunday	400	50	8.0

Step 9: Average annual hours worked

The final step of estimating average annual hours worked is to add together all full weeks and the two partial end weeks of the target year. This provides us with our estimate of the average annual hours worked in that year.

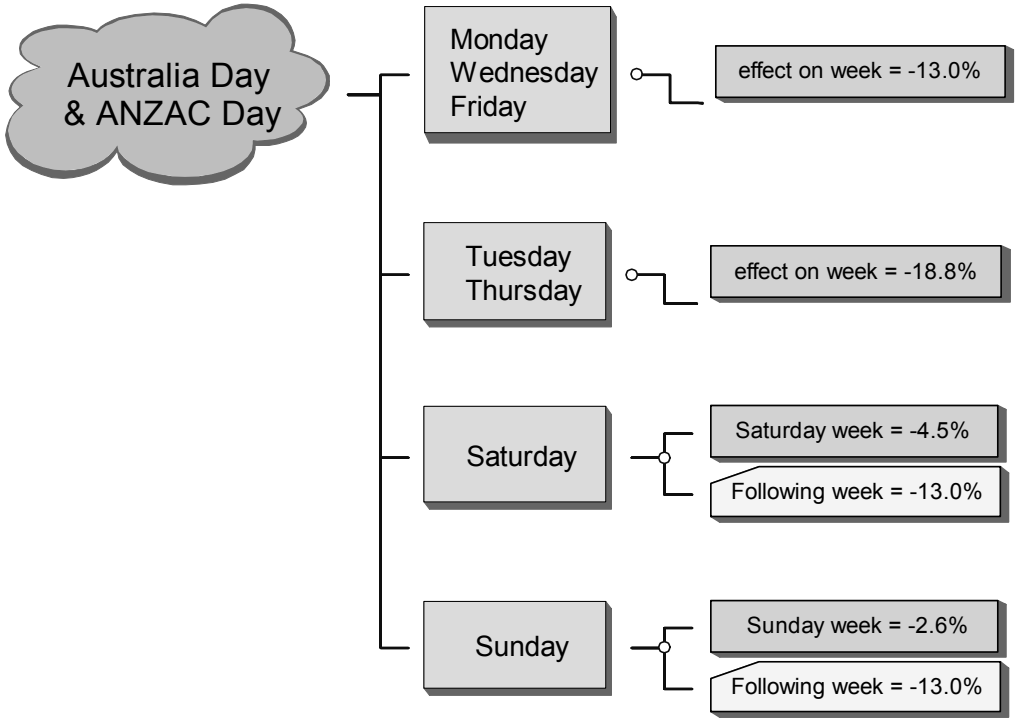
B. SAMPLE OF LFS QUESTIONS ON HOURS WORKED

In this section we list some of the questions on hours worked which have been used in the LFS questionnaire since April 2001.

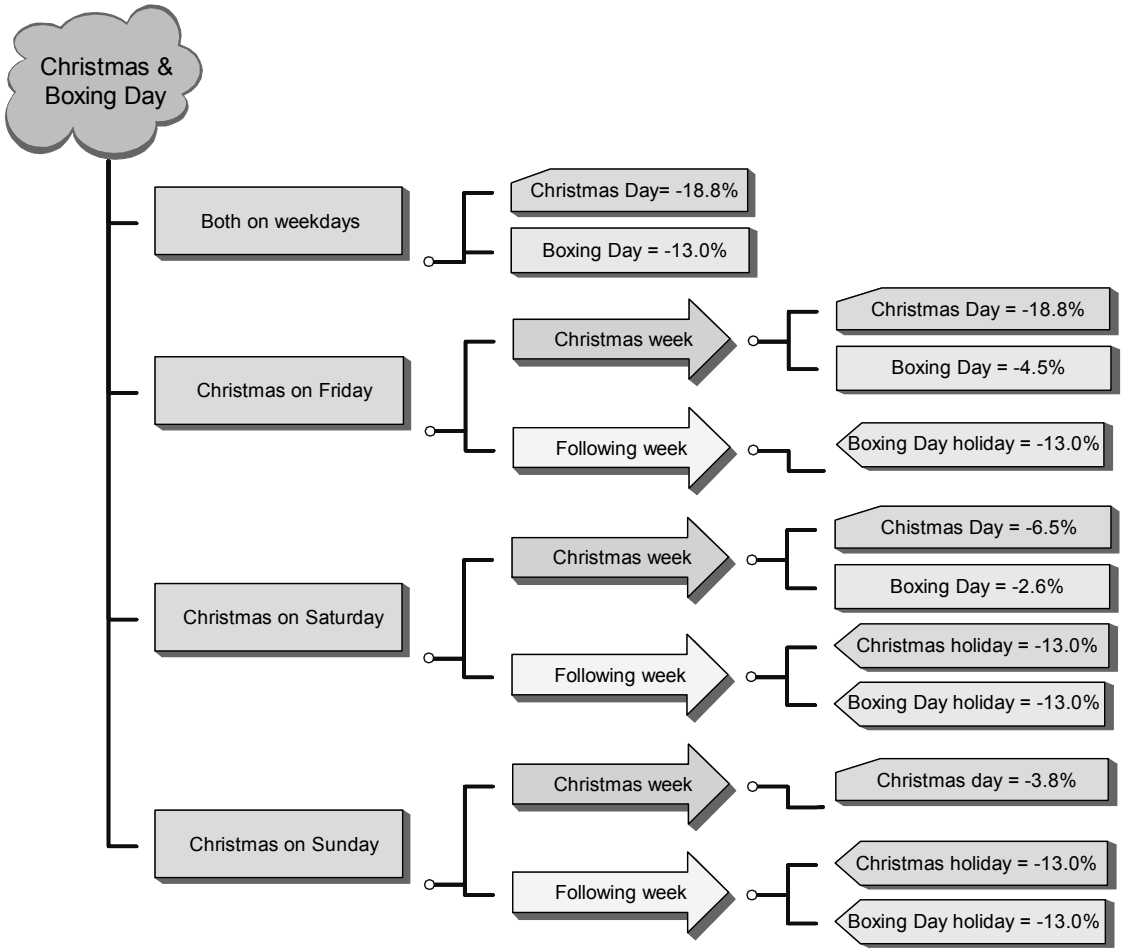
- I would now like to ask about when you worked (in your main job) last week
- [remembering that (day) was a public holiday,] did you work on Mon, Tues, Wed, Thu, Fri, Sat, Sun?
- On the days that you worked (in that job) did you have any time off?
- Did you work any extra hours or overtime?
- How many hours did you ACTUALLY work in your MAIN job last week (less the time off but counting the extra hours worked)?
- How many hours did you ACTUALLY work in ALL your jobs last week (less the time off but counting the extra hours worked)?
- How many hours do you USUALLY work each week in (that job/that business/all...jobs)?
- What was the main reason you worked less than 35 hours last week?
- What was the main reason you were away from work last week?

The LFS also includes a number of questions which aim to identify people who are underemployed.

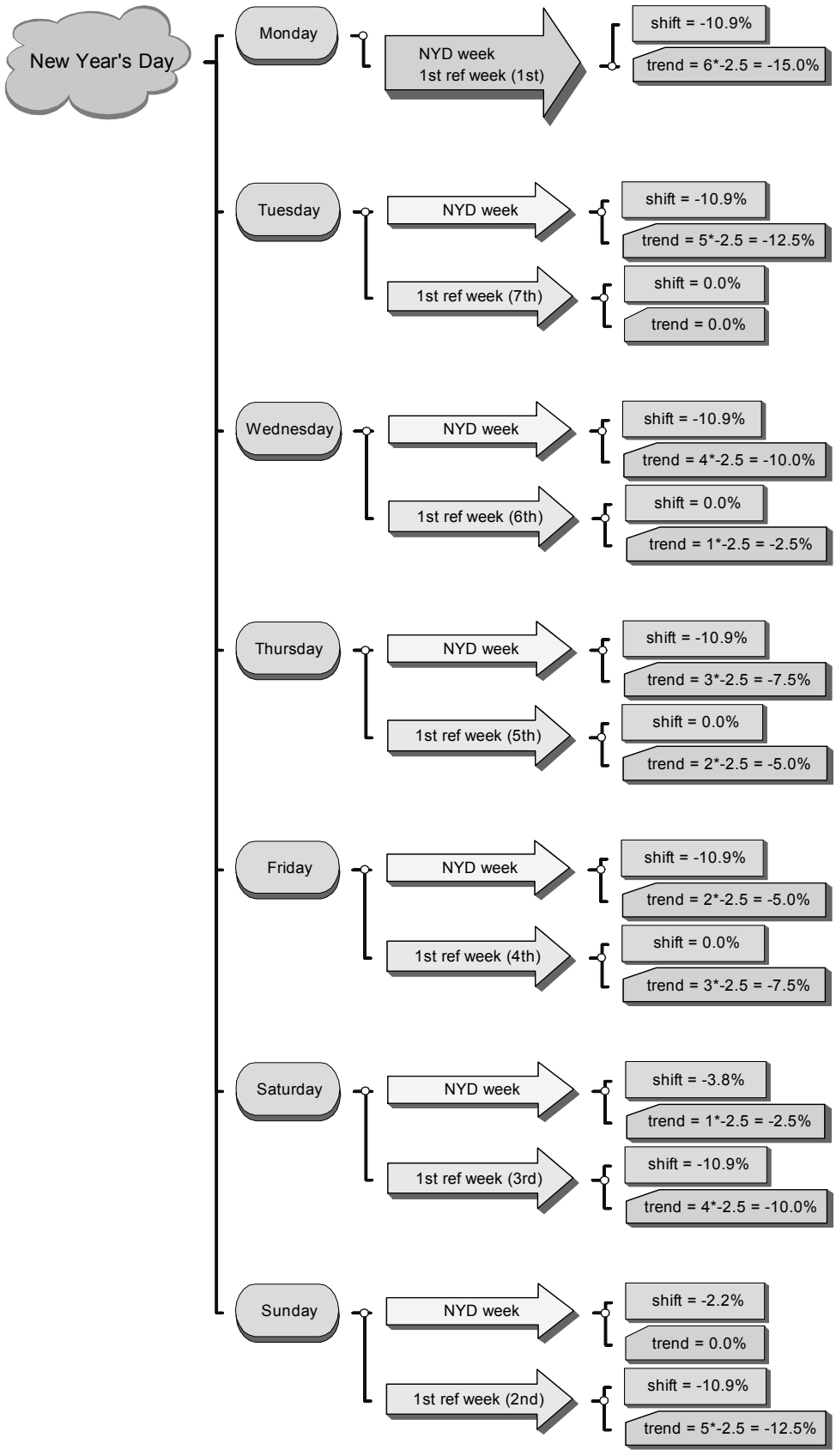
C. AUSTRALIA DAY AND ANZAC DAY: ESTIMATED EFFECTS



D. CHRISTMAS DAY AND BOXING DAY: ESTIMATED EFFECTS



E. NEW YEAR'S DAY AND GRADUAL RETURN TO WORK: ESTIMATED EFFECTS



F. SENSITIVITY TESTING

Table F.1 provides a summary of the summary of the impact on the holiday adjustments made. Table F.2 provides a further breakdown of each step in the adjustments – the impact of the linear interpolation (consistent for estimates), the holiday adjustment and the adjustment for the day of the week which the year starts and ends.

F.1 Impact of holiday adjustments on estimates of annual hours worked

Assumption	*2002*	*2003*	*2004*	*2005*	*Average percentage change on OECD figures*
Mid-quarter month (OECD figures)	1,824	1,814	1,816	1,810	
Preliminary estimates (all holidays adjusted for)	1,737	1,734	1,733	1,724	–4.6
Easter Holidays not adjusted for	1,750	1,747	1,746	1,737	–3.9
Queen's Birthday holiday not adjusted for	1,740	1,738	1,737	1,728	–4.4
New Years Day and reverse trend not included	1,745	1,742	1,739	1,731	–4.2
Anzac Day and Australia Day not adjusted for	1,745	1,740	1,738	1,733	–4.2
Christmas Day and Boxing Day not adjusted for	1,747	1,745	1,736	1,725	–4.3

Not adjusting for Easter holidays results in the smallest average percentage change in the figures compared to the OECD figures.

F.2 Impact of linear interpolation, holiday adjustments and day of week on estimates of annual hours worked

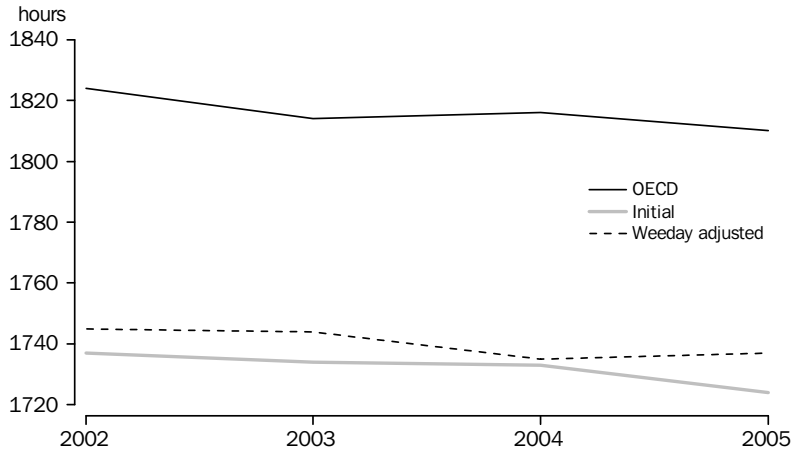
Assumption		*2002*	*2003*	*2004*	*2005*	*Average percentage change on OECD figures*
Mid-quarter month (OECD figures)		1,824	1,814	1,816	1,810	
Preliminary Estimates	Linear interpolation	1,788	1,783	1,773	1,775	–2.0
	Holiday effects (all)	1,733	1,730	1,724	1,723	–5.0
	Day of the week effect	1,737	1,734	1,733	1,724	–4.6
Easter Holidays not adjusted for	Linear interpolation	1,788	1,783	1,773	1,775	–2.0
	Holiday effects	1,746	1,743	1,736	1,736	–4.2
	Day of the week effect	1,750	1,747	1,746	1,737	–3.9
Queen's Birthday holiday not adjusted for	Linear interpolation	1,788	1,783	1,773	1,775	–2.0
	Holiday effects	1,737	1,734	1,728	1,727	–4.7
	Day of the week effect	1,740	1,738	1,737	1,728	–4.4
New Year's Day and reverse trend not included	Linear interpolation	1,788	1,783	1,773	1,775	–2.0
	Holiday effects	1,740	1,737	1,727	1,730	–4.6
	Day of the week effect	1,745	1,742	1,739	1,731	–4.2
Anzac Day and Australia Day not adjusted for	Linear interpolation	1,788	1,783	1,773	1,775	–2.0
	Holiday effects	1,741	1,735	1,729	1,732	–4.5
	Day of the week effect	1,745	1,740	1,738	1,733	–4.2
Christmas Day and Boxing Day not adjusted for	Linear interpolation	1,788	1,783	1,773	1,775	–2.0
	Holiday effects	1,743	1,740	1,727	1,724	–4.5
	Day of the week effect	1,747	1,745	1,736	1,725	–4.3

G. ADJUSTING FOR THE NUMBER OF WEEKDAYS

Calculating quarterly estimates of average hours worked highlighted an issue that was not evident when we calculated the annual average hours worked estimates. Differences between years and quarters appeared to be driven by the number of weekdays per quarter or month. The majority of Australians work weekdays, so we would expect the number of weekdays per quarter to have some impact on the total number of hours worked per quarter. For analysis of average annual hours worked over time, we need to standardise the estimates for the number of weekdays so we can identify whether changes in the estimates are due to underlying changes in patterns of hours actually worked.

Preliminary weekday adjusted estimates were derived and are presented in the following figure along with the initial estimates calculated using the method described in Appendix A.

G.1 Average annual hours worked – Initial estimate and weekday adjusted estimate



The weekday adjustment slightly increases average annual hours worked in each year since the standardisation approach is based on the maximum number of weekdays. Table G.2 shows the impact of the weekday adjustment on the preliminary estimates.

G.2 Impact of weekday adjustment on estimates of annual hours worked

Assumption	*2002*	*2003*	*2004*	*2005*	*Average percentage change on OECD figures*
Mid-quarter month (OECD figures)	1,824	1,814	1,816	1,810	
Preliminary estimates (initial estimate)	1,737	1,734	1,733	1,724	–4.6
Preliminary estimates (weekday adjusted)	1,745	1,744	1,735	1,737	–4.2

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