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Exploring Methods to Estimate the Intercensal Population of Aboriginal and Torres Strait Islander Australians

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Exploring Methods to Estimate the Intercensal Population of Aboriginal and Torres Strait Islander Australians

Guangyu Zhang

Analytical Services Branch

Methodology Advisory Committee

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EXPLORING METHODS TO ESTIMATE THE INTERCENSAL POPULATION OF ABORIGINAL AND TORRES STRAIT ISLANDER AUSTRALIANS

Guangyu Zhang
Analytical Services Branch

QUESTIONS FOR THE COMMITTEE

1. What other factors might explain the observed 'catch up effect', the large difference in fertility estimated for the same reference period from two adjacent Censuses?
2. Is it reasonable to estimate the potential identification change in the next Census using births registered in the last intercensal period?
3. Does the Committee agree with the proposal to use an enhanced demographic balancing equation method to estimate intercensal population?
4. Does the Committee have suggestions to improve the proposed iterative approach for estimating the intercensal population?
5. Does the Committee consider that it is worthwhile exploring the microsimulation approach used by Statistics Canada as a potential method in the future?

CONTENTS

EXPLORING METHODS TO ESTIMATE THE INTERCENSAL POPULATION OF ABORIGINAL AND TORRES STRAIT ISLANDER AUSTRALIANS

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ABSTRACT

Since the 1981 Census, the ABS has been producing estimates of estimated resident population (ERP) on Census year, and updates these with vital statistics for the intercensal periods. Estimates of Aboriginal and Torres Strait Islander ERP on each Census year have also been produced since the 1991 Census. However, the lack of sufficiently reliable births, deaths and migration data for Aboriginal and Torres Strait Islander people, and the intercensal volatility in the Census counts of Aboriginal and Torres Strait Islander people, do not make it possible to use the so-called *standard* approach to make intercensal estimates. Instead, ABS has produced population projections which have been widely used as a proxy for population estimates for various purposes. For some important users, however, this proxy is not sufficient or appropriate and therefore there has been significant demand from both government agencies and the community for intercensal population estimates.

This paper investigates methods for producing intercensal population estimates. Due to the complexity of this task, the paper focuses on methods for estimates at the Australian level only. After highlighting key issues in data quality, and making an assessment of a series of historical ABS projections, the paper examines three key factors driving the growth of Aboriginal and Torres Strait Islander population and which should form part of any estimation method: (1) fertility levels and trends; (2) mixed parentage and births to non-Indigenous mothers; and (3) the extent of changing identification for Indigenous status on Census form. The paper concludes that the identification change plays a very important role and finds promise in using births registered in the last intercensal period to project identification change in the next Census. Building from these analytical results, the paper proposes an enhanced demographic balancing equation method for estimating intercensal population, and an iterative approach for estimating the intercensal population. The limitations of the proposed method and future directions are also discussed.

1. INTRODUCTION

The official population estimates in Australia are termed estimated resident population (ERP) with a reference date of 30 June each year. The ERP includes any people usually living in Australia regardless of nationality, citizenship or legal status, with the exception of foreign diplomatic personnel and their families. The ABS started to produce ERP estimates following the 1981 Census. The population estimates of single year of age by sex at both national and state/territory levels are released on an annual basis. The aggregate ERP estimates at both national and state/territory levels are updated on a quarterly basis and released in *Australian Demographic Statistics* (cat. no. 3101.0).

In Census years, ERP figures are estimated by adjusting census counts of usual residents to include those who were missed in the Census and those who were overseas on Census Night and also take account of births and deaths occurring between 30 June and Census Night (usually early August). In the intercensal years, ERP estimates at the Australian level are brought forward with updated information from births and deaths registrations, and net overseas migration. For estimates at the state/territory levels, net interstate migration is taken into account (ABS, 2009c).

Following the 1991 Census, the ABS started to produce Census year ERP estimates for Aboriginal and Torres Strait Islander Australians. However, due to the lack of quality data on births, deaths and migration, and the frequently occurring unexplained intercensal population growth, the ABS does not produce intercensal estimates. Instead, it produces population projections of the Aboriginal and Torres Strait Islander people for a 10–20 year period following each Census. These projections are typically released over two years after each Census with a number of scenarios subject to different combinations of demographic parameters. In the absence of intercensal estimates, the projection results have been widely used by stakeholders/clients as *de facto* population estimates.

There has been significant demand from both governments and the community for annual estimates of Aboriginal and Torres Strait Islander population to be produced (Black, 2011). This paper explores the methods for intercensal population estimates and is structured in the following way. Section 2 introduces the key issues concerning the quality of Aboriginal and Torres Strait Islander data on births, deaths and Census counts. These issues have implications for any methodology to develop intercensal population estimates. Section 3 makes a brief assessment on the performance of previous ABS projections. Section 4 examines key demographic phenomena driving Aboriginal and Torres Strait Islander population changes. Section 5 proposes an enhanced demographic balancing equation method to estimate the intercensal population, and an iterative approach for estimate the intercensal population. Section 6 concludes and identifies possible future directions for this investigation.

2. DATA QUALITY ISSUES IN ABORIGINAL AND TORRES STRAIT ISLANDER DEMOGRAPHIC STATISTICS

The quality issues concerning Aboriginal and Torres Strait Islander population data have been well documented in a number of ABS publications, including *Births Australia* (cat. no. 3301.0), *Deaths Australia* (cat. no. 3302.0) and *Life Tables for Aboriginal and Torres Strait Islander Australians* (cat. no. 3302.0.55.003) among others (see, for example, ABS, 2009b; ABS, 2011; ABS, 2013a; ABS, 2013b; ABS, 2013d). In addition, researchers also undertook a number of studies on this topic (Barnes, 1997; Hunter, 1998; Taylor, 2012).

This section highlights some key issues in data quality which are relevant to the aim of producing intercensal population estimates. Since this paper explores methods for population estimates at the national level, and international migration is negligible for Aboriginal and Torres Strait Islander people, there will be no discussion on migration data.

2.1 Births registration data and fertility estimates

The registration of births and deaths are managed by the Registrar of Births, Deaths and Marriages (RBDM) of each State and Territory. The ABS births and deaths registration data collections are compiled using information supplied by RBDMs. It is considered that both births and deaths registrations are reasonably complete in Australia, however, not all births and deaths of Aboriginal and Torres Strait Islander people were identified as such.

Parents of newborns are legally required to register their births within a time frame. A birth is registered as being an Aboriginal and Torres Strait Islander birth where at least one parent reported themselves as being an Aboriginal person, Torres Strait Islander, or both on the birth registration form. In the Birth Registration Form, parents are asked whether they are of Aboriginal and Torres Strait Islander origin, and in some jurisdictions, parents are also asked about the Indigenous status of the newborns (ABS, 2011). In the case of the status of children not being asked, the ABS uses parents' reported Aboriginal and Torres Strait Islander status to derive that of their children. For various reasons, some parents did not report their Aboriginal and Torres Strait Islander status nor of their newborns.

There are two outstanding quality issues on Aboriginal and Torres Strait Islander births registration data, which affect both the timeliness and accuracy of estimates of population growth. The first issue is registration delay for births. For example, only 73 per cent of births registered in 2012 were those actually occurred in 2012. Also, eight per cent of the births registered in 2012 were for births that occurred in 2005 or earlier (ABS, 2013a). However, large fluctuations from year to year were observed for births registrations, which significantly affect estimates of 'true' fertility levels.

The second quality issue is the significant under-identification of Aboriginal and Torres Strait Islander births in registrations. Compared to the 2011 Census counts of children aged 5–14 years, corresponding to births that have occurred between 1996 and 2006, the births registration data likely under-identified about eight per cent, or on average 1,000 Aboriginal and Torres Strait Islander births, each year.

The registration data for Aboriginal and Torres Strait Islander births at the Australian level have been available since 1996. Before this, fertility estimates were made based on Censuses (Jain, 1989; Gray 1990; Dugbaza 1994). Nonetheless, the ABS used births registration data to estimate fertility to feed into every Census round projections. Since 2005, the ABS has released fertility estimates based on registrations in *Births Australia* (cat. no. 3301.0). Caution is required to interpret these estimates, because they were calculated based on the year of registration, and large fluctuations from year to year are expected.

2.2 Deaths registration data and mortality estimates

For statistics on deaths, the Aboriginal and Torres Strait Islander status information is primarily sourced from the Death Registration Form, in which family members or relatives, or funeral directors provided an answer about the Aboriginal and Torres Strait Islander origin of the deceased. In many cases, family members/relatives and funeral directors did not report or did not know the Indigenous status of the deceased person. There are also cases for which Aboriginal and Torres Strait Islander deaths were registered as non-Indigenous. In recent years, due to efforts from both the ABS and RBDMs, the Medical Certificate of Cause of Death has been used in some jurisdictions to source the Indigenous status information, which is likely to contribute to improving the coverage of Aboriginal and Torres Strait Islander deaths in registrations (ABS, 2011).

Similar to births registration data, there is registration delay in deaths registrations. Each year about five per cent of the registered Aboriginal and Torres Strait Islander deaths are for deaths that have occurred in previous years. However, it appears that there is no significant variation in the annual number of deaths (ABS, 2013d). For death statistics, the more outstanding quality issue is the under-identification of Indigenous status. Like fertility estimates using registration data, there is also the 'denominator shift' issue in estimating age-specific mortality rates using deaths registration and Census-based ERP data (Barnes 1997). A reliable estimate of mortality level is achieved through compiling a life table, which summarises the age-specific mortality experience observed in a specific reference period. Before the 2006 Census, an indirect estimation method was used to produce life tables, which was likely to have over-estimated the level of mortality of Aboriginal and Torres Strait Islander people (ABS, 2008; Barnes *et al.*, 2008).

The ABS undertook two Indigenous Mortality Quality Studies which directly linked the 2006 and 2011 Censuses data with deaths data for the year after each Census (ABS 2010). The data linking outcomes indicated that about 8–18 per cent Aboriginal and Torres Strait Islander deaths were under-identified (ABS, 2009b; ABS, 2013d). The life tables compiled for 2005–2007 and 2010–12 periods incorporate adjustments for this under-identification, and are the best available estimates of Aboriginal and Torres Strait Islander mortality. Both the level and age pattern of mortality from these two life tables can be used directly in population estimates and projections until the next Census undertaken in 2016.

2.1 Census and PES response to Indigenous status question, 1991–2011 Censuses

	Census response				*Proportion of Census respondents consistently identifying as Aboriginal and Torres Strait Islander*
PES response	*Non-Indigenous*	*Aboriginal & Torres Strait Islander*	*Not stated*	*Total*	
1991 Census					
Non-Indigenous	63,888	192		64,080	
Aboriginal & Torres Strait Islander	174	904		1,078	
Total	64,062	1,096		65,158	82.5%
1996 Census					
Non-Indigenous[(a)]	61,619	227	1,069	62,915	
Aboriginal & Torres Strait Islander	86	1,239	23	1,348	
Total	61,705	1,466	1,092	64,263	84.5%
2001 Census					
Non-Indigenous[(a)]	56,101	252	838	57,191	
Aboriginal & Torres Strait Islander	133	1,210	37	1,380	
Total	56,234	1,462	875	58,571	82.8%
2006 Census					
Non-Indigenous	75,406	283	1,218	76,907	
Aboriginal & Torres Strait Islander	116	2,576	38	2,730	
Total	75,522	2,859	1,256	79,637	90.1%
2011 Census					
Non-Indigenous	82,160	316	1,041	83,517	
Aboriginal & Torres Strait Islander	268	5,083	77	5,428	
Total	82,428	5,399	1,118	88,945	94.1

Source: Reproduced from a number of ABS publications (ABS, 1996; ABS, 1998; ABS, 2004; ABS, 2007; ABS, 2012).
In 1996 and 2001 Censuses, a small number of PES respondents with unknown Indigenous status treated as non-Indigenous.

2.3 Under-coverage in Census counts

Following the 1967 Referendum, ABS included a question on Indigenous status in all Censuses following the 1971 Census. However, not all respondents respond to that question, creating a category of 'not stated' for Indigenous status amounting to about one million Census records in each of the Censuses from 2001 to 2011. In addition, some people of Aboriginal or Torres Strait Islander origin were not identified as such. As a result, the Census under-coverage of Aboriginal and Torres Strait Islander people includes both Census undercounts, that is people who were missed in the Census, and under-identification, that is, people were counted in the Census but did not identify as Indigenous. This issue can be illustrated by the misclassification of Indigenous status for the same respondents presenting in both the Census and the Post-Enumeration Survey (PES) from 1991 to 2011 (table 2.1).

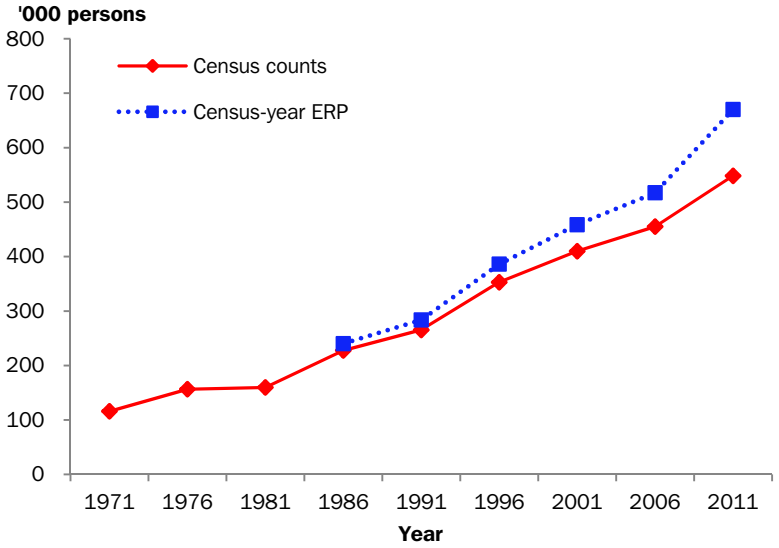
The ABS undertakes an interview-based PES about one month following each Census, which is different from the mainly self-enumerated Census, and may reveal some inconsistencies in responses. Over time, the proportion of Census respondents who identify themselves as of Aboriginal and Torres Strait Islander origin and also reported consistently in PES has been on a steady rise. In the 2011 Census, of the matched Census-PES respondents, about 94% of Census respondents reported consistently in both data sources. This may also represent improvements in Census scope and procedures.

Based on PES, the net undercount rates for Aboriginal and Torres Strait Islander people in Censuses were 3.6%, 7.1%, 6.1%, 11.7% and 17% in the 1991, 1996, 2001, 2006 and 2011 Censuses, respectively (ABS 1995; ABS1997; ABS 2003; ABS, 2007; ABS 2012). These net undercount rates, however, are not directly comparable due to changes in scope and procedures in PES. For example, the 2006 PES included respondents from remote areas and discrete Indigenous communities, while the 2001 PES and earlier ones did not (ABS, 2007). It is also important to note that the Census under-coverage of Aboriginal and Torres Strait Islander people was not evenly distributed geographically. The Census coverage was better in south and eastern Australia than that in north and west Australia, with the Northern Territory as an outstanding example (Condon *et al.*, 2004).

2.4 Unexplained intercensal population growth

From 1971 to 2011, the number of Aboriginal and Torres Strait Islander people counted in Censuses has increased by 373%. In the last Censuses, the counts increased by 33%, 16%, 11% and 21% during the 1991–1996, 1996–2001, 2001–2006 and 2006–2011 intercensal periods, respectively (figure 2.2).

2.2 Census counts and Census-year ERP estimates of Aboriginal and Torres Strait Islander people, 1971–2011[(a)(b)]



Source: (a) ABS Census data, excluding overseas visitors, (b) ERP estimates from a series of ABS publications (1994; 1998; 2004; 2009; 2013).
Lines were used to show the growth trend of Census counts and ERP estimates.

Both the ABS and academic researchers have undertaken a number of studies to understand this unusual intercensal increase over the years. It is well known that the level of fertility of Aboriginal and Torres Strait Islander women is higher than that of non-Indigenous women (Smith, 1980; Gray, 1990; Gray, 1997; Kinfu and Taylor, 2003). However, it was found that demographic factors, i.e. births over deaths, could only account for part of this unusual growth. The ABS termed the remaining part as 'unexplained growth'. In addition to changes in Census procedures, it was identified that the most important contributing factor is that a significant number of individuals changed their propensity to identify as Aboriginal and Torres Strait Islander origin (Ross, 1999; ABS, 2013f). This phenomenon, known as 'ethnic mobility' in the literature, occurred similarly in censuses of other countries with Indigenous population, such as the Unites States, Canada and New Zealand (Eschbach, 1993; Guimond, 2006; Brown *et al.*, 2010).

Census and PES outcomes are two primary sources for making ERP estimates, which starts from the estimates of usual residents on Census night. The Census counts are adjusted for net undercounts, Australian residents temporarily overseas on Census night, and temporary visitors from overseas. Subsequently, these estimates are backdated from Census night to the ERP reference date of 30 June using data on births, deaths and migration (ABS, 2009c).

However, the estimation of usual residents of Aboriginal and Torres Strait Islander people on Census night is more complicated. In addition to adjustments for Census net undercount, further adjustments are made for non-response to the Indigenous status question on the Census form, and unexplained intercensal increase in Census counts. Due to quality issues with the births and deaths registrations data, assumptions are used to backdate Census night ERP to the ERP at the reference date of 30 June (Shahidullah, 2001; ABS, 2009c; ABS, 2013c).

The large unexplained intercensal increase in Census counts resulted in the significant increase between Census-year ERP estimates (figure 2.2). The ERP growth rate was 18%, 36%, 19%, 13% and 30% for 1986–1991, 1991–1996, 1996–2001, 2001–2006 and 2006–2011, respectively. These growth rates were larger than those in Census counts in each corresponding reference period. It is important to bear in mind that the ERP estimates have been adjusted for Census under-coverage and other factors. Due to higher level of Census under-coverage of Aboriginal and Torres Strait Islander people in the northern and western part of Australia, changes in ERP estimates better reflect the intercensal population growth in comparison to Census counts.

3. POPULATION PROJECTIONS FOR ABORIGINAL AND TORRES STRAIT ISLANDER AUSTRALIANS

The ABS produces both Census-year and intercensal ERP estimates for all Australians following the 1981 Census. In non-Census years, ERP estimates for all Australians by sex are updated on a quarterly basis, and by sex and single year of age on an annual basis, using vital statistics. After each Census, a revision of ERP estimates since last Census is undertaken to obtain final ERP estimates.

'Experimental' estimates of Aboriginal and Torres Strait Islander population were produced for each Census year from 1991 to 2006. The reason for labelling these estimates as 'experimental' is because

> "significant volatility in Aboriginal and Torres Strait Islander census counts and the quality of data on births, deaths and migration of Aboriginal and Torres Strait Islander Australians do not support the use of standard approach to population estimation." (ABS, 2009a)

For the same reason, it was decided that both projections and back-casted population estimates of Aboriginal and Torres Strait Islander people are produced following each Census. The latest series of population projections based on the 2011 Census was just released on 30 April 2014, for which the term 'experimental' was dropped following a consultation with stakeholders / clients (ABS, 2014).

3.1 Methods and assumptions for population projections

The ABS population projections use the cohort-component method which begins with a base population for each sex by single years of age and advances it year by year by applying assumptions regarding future fertility, mortality and migration. This procedure is repeated for each year in the projection period for each State and Territory and for Australia. The resulting population projections for each year for the States and Territories, by sex and single year of age, are adjusted to sum to the Australian results (ABS, 2009c).

However, for projections of Aboriginal and Torres Strait Islander population, in addition to standard assumptions on fertility, mortality and migration, two more components are included:

1. the intercensal change in identification; and
2. births to non-Indigenous mothers and Aboriginal and Torres Strait Islander fathers, for which the birth rate is termed as paternity rate (ABS, 1996).

Table 3.1 presents the assumptions used at the Australian level in a series of projections following the 1991 to 2011 Censuses. For 1996 and 2001 Census-based projections, both high and low series of projections were included because they were distinguished by the assumptions on changes in the propensity to identify. For all population projections, paternity rates were used, though the assumption of increasing paternity rates was used only in the 2006 Census-based projections. Due to significant increases in Census counts during the 1991–1996 and 1996–2001 periods, assumptions on changes in the propensity to identify are used in high series projections based on both the1996 and 2001 Census. In the other projection periods, no assumption of changing propensity to identify was made.

3.1 Assumptions used in ABS projections for Aboriginal and Torres Strait Islander population, 1991–2011 Census-based series

Projection series	*Projection period*	*Fertility*	*Mortality*	*Paternity*	*Change in propensity to identify*
1991 medium series	1991–2001	TFR 2.63, constant	Small decline	0.698, constant	No change
1996 high series	1996–2006	Declining TFR from 2.53 to 2.29	Constant	0.894, constant	33%, observed rates during 1991–1996
1996 low series	1996–2006	Declining TFR from 2.53 to 2.29	Constant	0.894, constant	No change
2001 high series	2001–2009	Declining TFR from 2.28 to 2.11	Constant	0.944, constant	16%, observed rates during 1996–2001
2001 low series	2001–2009	Declining TFR from 2.28 to 2.11	Constant	0.944, constant	No change
2006 series B	2006–2021	Declining TFR from 2.29 to 2.13	Annual increase of 0.3 years in life expectancy	Increasing paternity rates from 1.04 to 1.19	No change
2011 series B	2011–2021	Declining TFR from 2.25 to 2.09	Annual increase of 0.3 years for males and 0.25 years for females in life expectancy	Increasing paternity rates from 0.94 to 1.08	No change

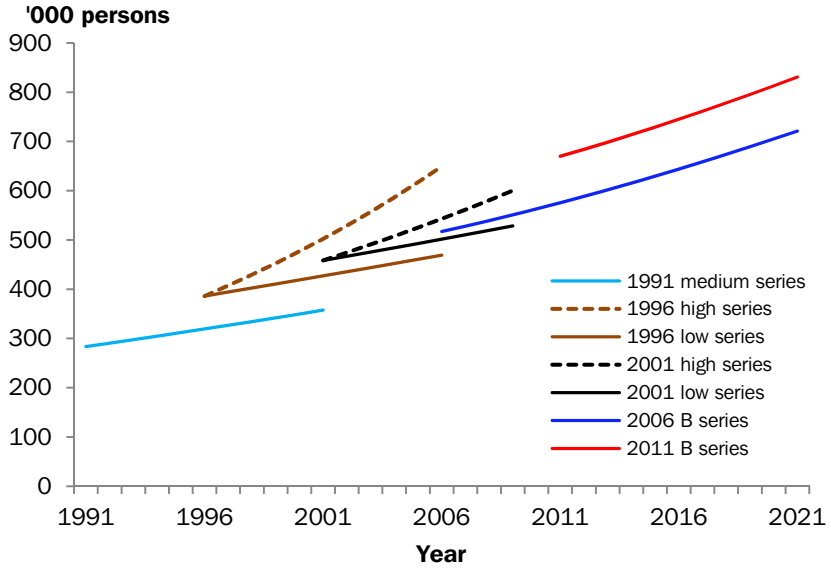
Source: Australian Bureau of Statistics (1996, 1998, 2004, 2009a and 2014).

In the absence of intercensal estimates, the ABS projections have been widely used by government and non-government agencies and research institutions for planning and evaluation purposes. The projections have been used as denominators in calculating rate/ratio statistics for evaluating performance indicators, for example. As described by researchers, 'over the years, projections of Indigenous population have been one of the more useful products of postcolonial demography especially in determining macro-policy setting' (Taylor, 2012, p. 123).

3.2 Performance of projections and the key challenge

The performance of projections with different assumptions differed significantly. All medium and low series projected ERP on the next Census year were lower than the ERP estimates from the subsequent Census. Meanwhile, high series based on the 1996 and 2001 Censuses were much higher than the Census year ERP estimates (figure 3.2).

3.2 Comparison of population estimates and projections based on different Censuses, 1991–2021[(a)(b)]



Source: Australian Bureau of Statistics (1996, 1998, 2004 and 2009a).
(a) For 1996 and 2006 Census-based projections, high series marked with dash lines.
(b) The projection span for the 2011 Census-based projections is between 2011 and 2026. For illustrative purpose, only projections between 2011 and 2021 are presented.

A detailed comparison of ERP estimates in 2011 with projections from both the ABS and academic researchers found that all projections significantly underestimated the population size and composition, in particular of younger age groups (Biddle and Wilson, 2013). For example, the respective projected ERP figures on 30 June 2011 were 574,874, 575,552 and 574,503 from ABS Series A, Series B and Biddle and Taylor (2009), while the final ABS estimates were 669,900 (ABS, 2013c). It is important to note that all 2006 Census-based projections did not use assumptions on changing propensity in identification.

From these comparisons, it can be reasonably concluded that the assumption on changing propensity to identify has played a more important role in determining the performance of projections than other assumptions in fertility, paternity, mortality, and migration. It appears that it would be difficult for projections that do not incorporate this factor to fully capture the population growth of Aboriginal and Torres Strait Islander Australians.

4. UNDERSTANDING POPULATION CHANGE OF ABORIGINAL AND TORRES STRAIT ISLANDER AUSTRALIANS

ABS publications as well as those from academia suggest that three factors have made significant contributions to the unusual Aboriginal and Torres Strait Islander population growth during each intercensal period: (1) a higher level of fertility of Aboriginal and Torres Strait Islander women than non-Indigenous women; (2) a significant number of children born to non-Indigenous mothers joining the population as a result of increasing mixed marriage and parentage; and (3) a significant number of people, likely in the entire household, joining the population through being identified as Aboriginal and Torres Strait Islander origin for the first time in each Census (see, for example, Smith 1980; Jain, 1989; Dugbaza, 1994; Gray, 1997; Ross, 1999; Kinfu and Taylor, 2005; ABS, 2013c; ABS, 2013f).

Using a number of demographic techniques, this section analyses five Censuses undertaken from 1991 to 2011, focusing on the above three demographic phenomena. Implications on estimating intercensal identification change are discussed.

4.1 Data and methods

Census is the principal source of information about Australia's population. The analysis in this section examines five recent Censuses in combination. The advantage of doing this is that there is likely a good chance to identify, and possibly explain, consistent and inconsistent patterns over a longer time span. Nonetheless, it is important to note that there are significant geographic variations in the Census coverage of Aboriginal and Torres Strait Islander people in each Census. As a result, patterns identified from Census counts might be biased when referring to sub-population living in remote areas. Where applicable, the paper also investigates ERP data, which have been adjusted for Census undercounts and non-response for Indigenous status. In addition, births registrations data are also used in the analysis.

Most Census respondents are enumerated on a household basis, and previous studies also suggest that people in the entire household may or may not identify as Aboriginal and Torres Strait Islander together (Gray, 1997; Kinfu and Taylor, 2005). However, this phenomenon not only occurred in recent Censuses, but also in earlier Censuses in the 1960s and 1970s as found by Smith (1980) in his landmark book on *The Aboriginal Population of Australia*. As a result, this paper uses the own-children method, and its extension, the Family-Tree method, to employ the rich family interrelationships contained in Census data.

The own-children method for fertility estimation uses the Census variable 'relationship in household' to match mothers with their 'biological' children to obtain detailed age distribution of mothers by age of children, and subsequently reversely survive them to estimate age-specific fertility rates for a period up to 15 years prior to the Census (Cho *et al.*, 1986). The main purpose is to obtain the age pattern of mothers through matching mothers with their children.

The Family-Tree method is an ABS in-house program to append spouse, parents and/or grandparents' information to each individual, where applicable, borrowing on the idea from the own-children method to use reported family relationships in Census (Zhang and Campbell, 2012; ABS 2013e). This method facilitates the analysis of intermarriage, paternity rates and differential reporting of Indigenous status within a family household.

The own-children method is a reverse-survival method, which requires life tables to reversely estimate the number of births and corresponding women aged 15–49 years in each year up to 15 years prior to the Census (Cho *et al*., 1986). For estimates based on 2006 and 2011 Censuses, the ABS life tables for Aboriginal and Torres Strait Islander Australians were used, which reported life expectancy at birth of 67.5 and 69.1 years for males, and 73.1 and 73.7 for females during 2005–2007 and 2010–2012, respectively (ABS, 2009b; ABS, 2013d). For estimates based on earlier Censuses, interpolation techniques were used to obtain life expectancy figures using the same assumptions in the 2011 Census-based population projections, i.e. an increase of 0.2 years for males and 0.15 years for females per year between 1996 and 2006 (ABS, 2014). These assumptions were further extended to the 1991 Census in this paper.

In addition to these two methods, the cohort analysis technique is also used to illustrate the intercensal change in Census counts by age cohort, which has been used in previous ABS studies (Ross, 1999; ABS, 2013f). In a demographically closed population such as the Aboriginal and Torres Strait Islander population, at the national level, the size of each cohort from one Census to the next is subject to mortality only. If the size of an age cohort becomes bigger in one Census relative to the previous Census, or the survival ratio is higher than 1.0, this could point to the evidence for identification change, although age misreporting and Census undercounts could also make contributions. Nonetheless, for analysis of Aboriginal and Torres Strait Islander population, the effect due to identification change has been far greater than other factors.

4.2 Levels and trends of fertility

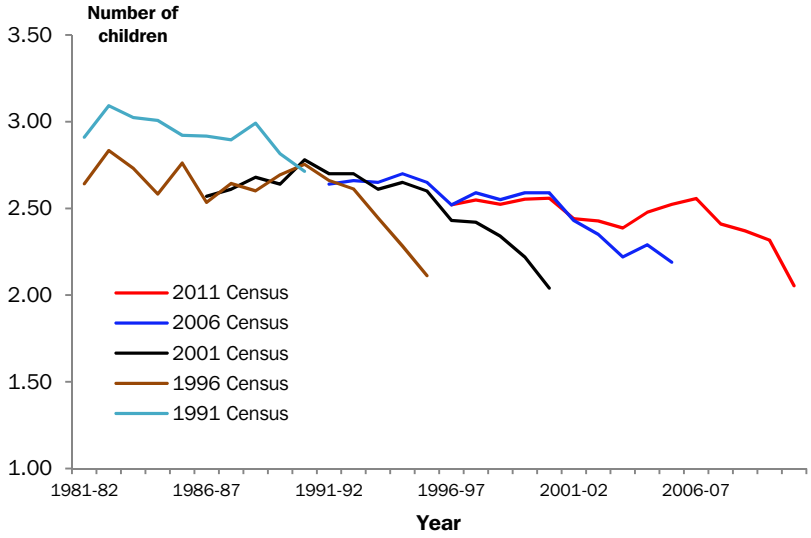
The standard approach to estimating fertility uses births from registrations data as the numerator and ERP figures as the denominator. However, this could create the numerator/denominator inconsistency, or the 'denominator shift' issue (Barnes, 1997), because Indigenous status identified in registrations reflects reporting behaviour at the time of registration, while the ERP is updated based on the most recent Census that incorporates people newly joining the population through identification change. This situation is further complicated by registration delays and under-identification in births registrations.

The own-children method applying to Census data can well address this challenge, as both numerators and denominators are from the same data source. Moreover, it is less affected by undercount of young children which is common to Censuses in most countries, because young children are more likely to live in the household with mothers and could be missed together (United Nations, 1983; Cho *et al.*, 1986). This method has been used by the ABS in 1986 and 1991 Censuses to estimate fertility levels of Aboriginal and Torres Strait Islander women back to the 1970s (Jain, 1989; Dugbaza, 1994). It was also used in 1981–2006 Censuses to analyse fertility patterns of all Australian women for forecasting births in the ABS Australian Census Analytic Program (McDonald and Kippen, 2011).

Total fertility rate (TFR) is the sum of age-specific fertility rates, which is a synthetic fertility measure indicating how many children a woman would bear supposing that she experienced current age-specific fertility rates at each age of her reproductive life. Because the own-children method can estimate fertility up to 15 years prior to the Census, there is a 10-year overlapping period in estimates between two adjacent Censuses, and a 5-year overlapping period as well between two Censuses 10 years apart.

Figure 4.1 presents the levels and trends in fertility during the 1981–2011 period, as estimated from 1991–2011 Censuses using the own-children method. An overall trend of gradual but continued fertility decline can be observed. In the 1980s, TFR estimated from the 1991 Census was around 3 children per woman, while in the 1990s, TFR estimated from 1996 and 2001 Census was about 2.6–2.7 children per woman, which declined to the level of around 2.5 children in the 2000s. By 2011, the latest Census estimated a TFR of 2.1. In general, these fertility estimates agree with each other in the same reference period, except for estimates from the most recent Census on the 5-year period immediately prior to the Census. This pattern has been quite consistent for estimates from 1996–2011 Censuses. Nonetheless, there is an exception for fertility estimated for the 1980s, for which estimates based on the 1996 and 2001 Censuses were significantly lower than those from the 1991 Census.

4.1 Total fertility rates of Aboriginal and Torres Strait Islander women, 1986–2011, estimated using the own-children method, 1991–2011 Censuses[(a)(b)]



Source: ABS unpublished Census data.
(a) Usual residence Census counts, excluding overseas visitors.
(b) Two assumptions used: 1. the same age distribution of mothers between 'own' and non-own children' and 2. the same proportional distribution of children from non-Indigenous mothers between 'own' and non-own children.

The Australian Census also collects information on the number of children ever born (CEB) from all women aged 15 years and above. This question was asked every 10 years in the 1986, 1996 and 2006 Censuses, and was also asked in the 1981 Census and 2011 Census. Fertility during each intercensal period or two adjacent intercensal periods can also be estimated from CEB information using indirect demographic techniques (United Nations, 1983). Table 4.2 presents fertility levels estimated using both the own-children method and CEB method for each intercensal period from 1981 to 2011. There is a general agreement between estimates from the two methods during each corresponding period, except the own-children estimates for the most recent intercensal period for each Census. In most comparable periods, the estimates from the CEB method seem lower than those from the own-children method. Based on this pattern, it is reasonable to consider that the fertility level for 2006–2011 that was estimated from the 2011 Census using both methods could be an under-estimate.

A close examination of figure 4.1 reveals a consistent pattern over the past 20 years, which is described here as the 'catch up effect'. The fertility level estimated from each Census was an under-estimate, up to five years preceding the Census. However, the fertility level estimated from the subsequent Census for the same reference period would always be at a higher level. In addition, estimates from the next Census 10 years apart from the first Census normally confirmed findings from the second Census. TFRs estimated from the 2011 Census declined quickly to a low level during the 2006–2011 period. However, if the observed pattern continues into the future, it could be expected that the 2016 and 2021 Censuses would produce estimates of a higher level of fertility for 2006–2011.

4.2 Total fertility rates estimated using both the own-children method and information of children ever born for each intercensal period, 1981–2011[(a)(b)(c)]

Source of information / period	*1981–1986*	*1986–1991*	*1991–1996*	*1996–2001*	*2001–2006*	*2006–2011*
1991 Census	2.99	2.87				
1996 Census	2.71	2.65	2.42			
2001 Census		2.66	2.65	2.29		
2006 Census			2.66	2.57	2.30	
2011 Census				2.54	2.45	2.34
CEB based estimates	3.10	3.00	2.71	2.43	2.43	2.48

Source: ABS unpublished Census data.
(a) Usual residence Census counts, excluding overseas visitors.
(b) TFR for 1981–1986, 1986–1991 and 1991–1996 derived from children ever information collected in 1986 and 1996 Censuses, taken from Gray (1993; 1997).
(c) TFR for 1996–2001 and 2001–2006 derived from children ever born information in 1996 and 2006 Censuses.

A number of factors could lead to such a 'catch up effect', including age misreporting and Census under-coverage of both mothers and their children. For Aboriginal and Torres Strait Islander people, Census under-coverage includes both undercounts and under-identification of people being counted in the Census. Due to the numerator/denominator consistency in the own children method, a much higher estimate of fertility from the later Censuses for the same reference period relative to the previous one can only happen when a large number of children and mothers were added simultaneously to the numerator and denominator. International studies suggest that the own-children method is in general not sensitive to Census undercount (United Nations, 1983; Cho *et al.*, 1986). It is a highly unlikely scenario that each Census would undercount both mothers and their children in a large scale over a 20-year period, which was not found in any post-enumeration survey (PES) following each Census. It was reported that age misreporting of either mothers or children could distort the own-child fertility estimate (Cho *et al.*, 1986). However, previous ABS studies did not find a serious age misreporting in Aboriginal and Torres Strait Islander population (ABS, 2009; ABS 2013f). Moreover, a series of detailed comparisons of age-specific fertility rates for the same reference period from different Censuses found that the increase of age-specific fertility rates occurred in almost every age group (see Appendix tables B.1–B.3). This suggests that age misreporting does not contribute to the observed 'catch up effect'. As a result, the only reasonable explanation is that a significant number of mothers together with their children were not identified in the previous Census, but were identified in the subsequent Census.

Question for the Committee: What other factors might explain the observed 'catch up effect', the large difference in fertility estimated for the same reference period from two different Censuses?

It is interesting to note that fertility levels estimated using the own-children method from the 1991 and earlier Censuses were higher in comparable years during the 1980s in comparison to those from the 1996 and 2001 Censuses. Previous studies suggest that the fertility levels and trends estimated from the 1991 Census were consistent with those estimated from 1986 and earlier Censuses (Jain, 1989; Gray, 1990). Something important must have happened during 1991–1996, which significantly changed the way how Aboriginal and Torres Strait Islander people were identified in the Census. As a matter of fact, compared to the 1991 Census, the 1996 Census counted more males and females in almost every age cohort, amounting to 87,500 persons, of which only part can be explained by demographic factors, i.e. births over deaths. It was also demonstrated that identification change played a significant role contributing to the unexplained part of population growth (Gray, 1997; Ross, 1999).

It was suggested that many important social and political events that occurred in the early 1990s facilitated this increase in Indigenous identification, including land rights in New South Wales, Queensland, the creation of the Aboriginal and Torres Strait Islander Commission (ATSIC), the *Mabo* decision, and the Stolen Generation Inquiry, among a number of events (Taylor 1997: 9). A cohort analysis of Census counts during 1991–2011 confirmed that the cohorts of women aged 15–49 years in 1991 significantly increased in every age in the 1996 Census, but remained stable in cohort size over the past 15 years (See Appendix figure A.1). This large increase in the number of women could inflate the denominator in the calculation of age-specific fertility rates, resulting to lower estimates of fertility in subsequent Censuses. Put it another way, a significant number of women aged 15–49 years in 1991 for the first time identified as Aboriginal and Torres Strait Islander origin in the 1996 Census, and continued to do so in following Censuses. This well explains why both the 1996 and 2001 Censuses provided similar estimates of fertility during 1986–1991, in comparison to those from the 1991 Census. Furthermore, this suggests that there were different patterns in the reporting of Indigenous status in Census before and after the 1996 Census.

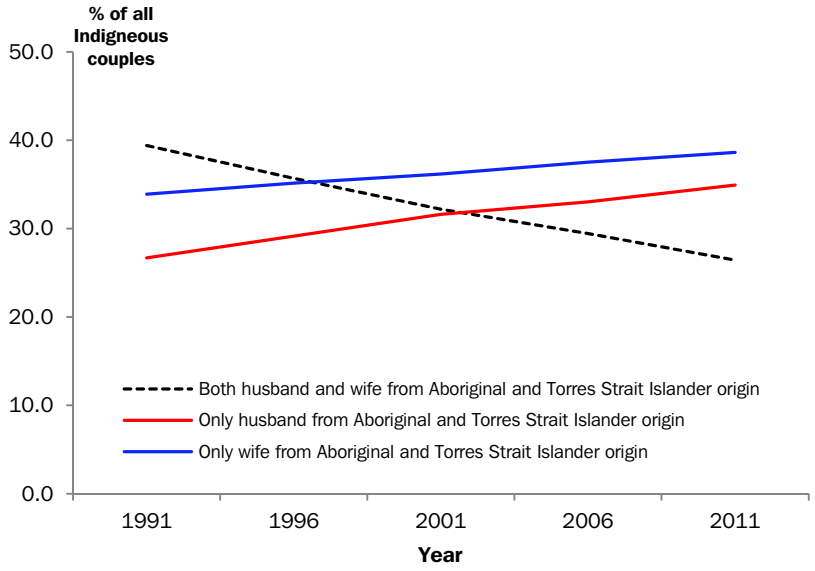
Detailed comparisons of age-specific fertility rates for the same year suggested that Census-year fertility was in general under-estimated using both registrations and the current Census data (see Appendix tables B.1–B.3). It is clear that all estimates from registrations data used in ABS previous projections were lower than those estimated using Censuses. For Census-based estimates, a clear pattern can be observed that in each Census fertility rates for women aged 15–34 years, in particular for those aged 20–29 years were underestimated, and were always upwardly corrected by estimates from the subsequent Census, in which these women were aged 20–39 years and 25–34 years, respectively. This consistent pattern suggests that women aged 15–34 years and their children who were not identified in one Census were more likely to be identified in the next Census when they became aged 20–39 years.

The general agreement in fertility estimates in corresponding reference periods from different Censuses offers confidence for us to make a reasonably reliable estimates over the past 30 years. If we combine estimates from different sources for the same period, the likely scenario for fertility levels and trends could be: TFR of around 3.1 children per woman during 1981–1986, 2.7 children during 1986–1996, 2.6 children during 1996–2006, and likely about 2.5 children during 2006–2011, and possibly to 2016.

4.3 Levels and trends of paternity

The significant contribution to population growth of births to non-Indigenous mothers and Aboriginal and Torres Strait Islander fathers has long been recognised (see, for example, ABS 1996). This resulted from increasing intermarriage or inter-partnership between Aboriginal and Torres Strait Islander and non-Indigenous people (Dugbaza, 1995; Gray, 1998; Biddle, 2013). It was reported that in the mid-1980s, about 51% of Aboriginal and Torres Strait islander couples had one non-Indigenous partner (Ross, 1999). Over the years, this proportion has been on a steady rise, which increased to 74% by 2011 (ABS, 2013f).

4.3 Indigenous status of couples with at least one side with Aboriginal and Torres Strait Islander origin[(a)(b)]



Source: ABS unpublished Census data.
(a) Usual residence Census counts, excluding overseas visitors.
(b) Same sex couples and lone parents excluded. One partner being absent on Census night not included.

As shown in figure 4.3, there was a steady decline in the proportion of both partners from Aboriginal and Torres Strait Islander origin, and continued increase in the proportions of couples with either husband or wife from the Aboriginal and Torres Strait Islander origin. Nonetheless, more Aboriginal and Torres Strait Islander women are married to non-Indigenous men than their male counterparts being married to non-Indigenous women. A note of caution on figure 4.3 is that this comparison could be biased due to higher level of Census undercounts in regions with very low level of intermarriage, in particular in the Northern Territory. Nonetheless, its small share of the population does not affect the overall level and trend of intermarriage and mixed parentage.

Due to increasing mixed marriage and parentage, increasingly more people with multiple ancestries are being differentially identified in Census either as Aboriginal and Torres Strait Islander origin or not. Table 4.4 presents the percentage distribution of children aged 0–4 years who were identified as Aboriginal and Torres Strait Islander origin by the Indigenous status of their parents, with at least one side being of Aboriginal and Torres Strait Islander origin. A consistent pattern of reported Indigenous status between parents and their children can be observed over the period 1991 to 2011. During the past two decades, over 96% of children with both parents from Aboriginal and Torres Strait Islander origin were identified as such. These proportions ranged from 83% to 88% for children with fathers only from Aboriginal and Torres Strait Islander origin, and from 87% to 93% for those with mothers only from Aboriginal and Torres Strait Islander origin during the same period.

4.4 Aboriginal and Torres Strait Islander children aged 0–4 years in Census, as a proportion of all children from parents with at least one side of Aboriginal and Torres Strait Islander origin, 1991–2011 Censuses[a][b]

Indigenous status of parents	*1991 Census*	*1996 Census*	*2001 Census*	*2006 Census*	*2011 Census*
Aboriginal and Torres Strait Islander origin					
Both parents	97	96	96	98	98
Father only[b]	83	85	85	88	88
Mother only[b]	87	91	89	93	93

Source: ABS unpublished Census data.
(a) Usual residence counts, excluding overseas visitors.
(b) Lone parents included. Couple family with on partner absent on Census night also included.

The overall trend is that in recent decade more and more children from mixed parentage were identified as from Aboriginal and Torres Strait Islander origin. Compared to children born to Aboriginal and Torres Strait Islander fathers, children born to non-Indigenous mothers were less likely to be identified. This suggests that the contribution to population growth from births to non-Indigenous mothers was not fully realised through identification change in Censuses.

To incorporate the contribution to population growth of births from non-Indigenous mothers, the ABS introduced the concept of total paternity rates in the 1990s, which sums the age-specific rates of children to Aboriginal and Torres Strait Islander fathers that are born to non-Indigenous mothers (ABS, 1996). Estimates of these rates were obtained from births registration data, and like TFR estimates, they are also affected by the numerator/denominator inconsistency. Using the Family-Tree method, this analysis matched all Aboriginal and Torres Strait Islander children to their 'biological' fathers in each Census and then recalculated total paternity rates for the period 1986–2011 (table 4.5).

4.5 Paternity rates estimated from Censuses, 1996–2011 Censuses

Census	*1981–1986*	*1986–1991*	*1991–1996*	*1996–2001*	*2001–2006*	*2006–2011*
1991 Census	0.859	0.869				
1996 Census		0.953	0.962			
2001 Census			0.982	0.920		
2006 Census				0.997	0.965	
2011 Census					1.002	1.067

Source: ABS unpublished Census data.
Usual residence Census counts, excluding overseas visitors.

Surprisingly, all estimates suggest a high level of total paternity rates just under 1.0 during the past 30 years. They suggest that children born to non-Indigenous mothers did play a more important part in driving population growth than generally believed. As a matter of fact, these estimates are higher than those used in a series of ABS population projections except for the more recent one based on the 2006 Census (see table 3.1 and Appendix tables C.1–C.3). This implies that previous projections could have significantly underestimated young children from non-Indigenous mothers.

Like in the own-children estimates of TFRs for Aboriginal and Torres Strait Islander women, each Census provides higher estimates of total paternity rates for the last intercensal period relative to the previous Census with the similar 'catch up effect'. This constitutes evidence that in previous Censuses, the Aboriginal and Torres Strait Islander children that were under-identified were not only from Aboriginal and Torres Strait Islander women, but also from non-Indigenous women. Table 4.6 presents the proportional distribution of children who were born to Aboriginal and Torres Strait Islander mothers by 5-year age groups in the 1991 to 2011 Censuses. Except for the earlier two Censuses, all recent three Censuses suggest a very close and stable distribution. This suggests that there was a concurrent increase in the number of children born to both Aboriginal and Torres Strait Islander and non-Indigenous women. It also suggests that in each Census, children born to both Aboriginal and Torres Strait Islander and non-Indigenous women had equal chances of being undercounted and under-identified.

The proportions of children born to Aboriginal and Torres Strait Islander women from births registration data were 75%, 73% and 71% for the 1996–2000, 2001–2005 and 2006–2010 periods, respectively. Given the consistency in Census estimates, it is reasonable to conclude that birth registrations could routinely under-register births from non-Indigenous mothers. Nonetheless, this situation has significantly improved in recent years due to efforts of both the ABS and Registrar of each State/territory.

4.6 Proportional distribution of children born to Aboriginal and Torres Strait Islander mothers, 1991–2011 Censuses[(a)(b)]

Age of children	*1991 Census*	*1996 Census*	*2001 Census*	*2006 Census*	*2011 Census*	*Average*
0–4 years	75	72	70	70	68	71
5–9 years	77	74	71	70	69	72
10–14 years		73	71	70	68	70

Source: ABS unpublished Census data.
(a) Usual residence Census counts, excluding overseas visitors.
(b) Calculated using the own-children method.

4.4 Intercensal identification change in Census

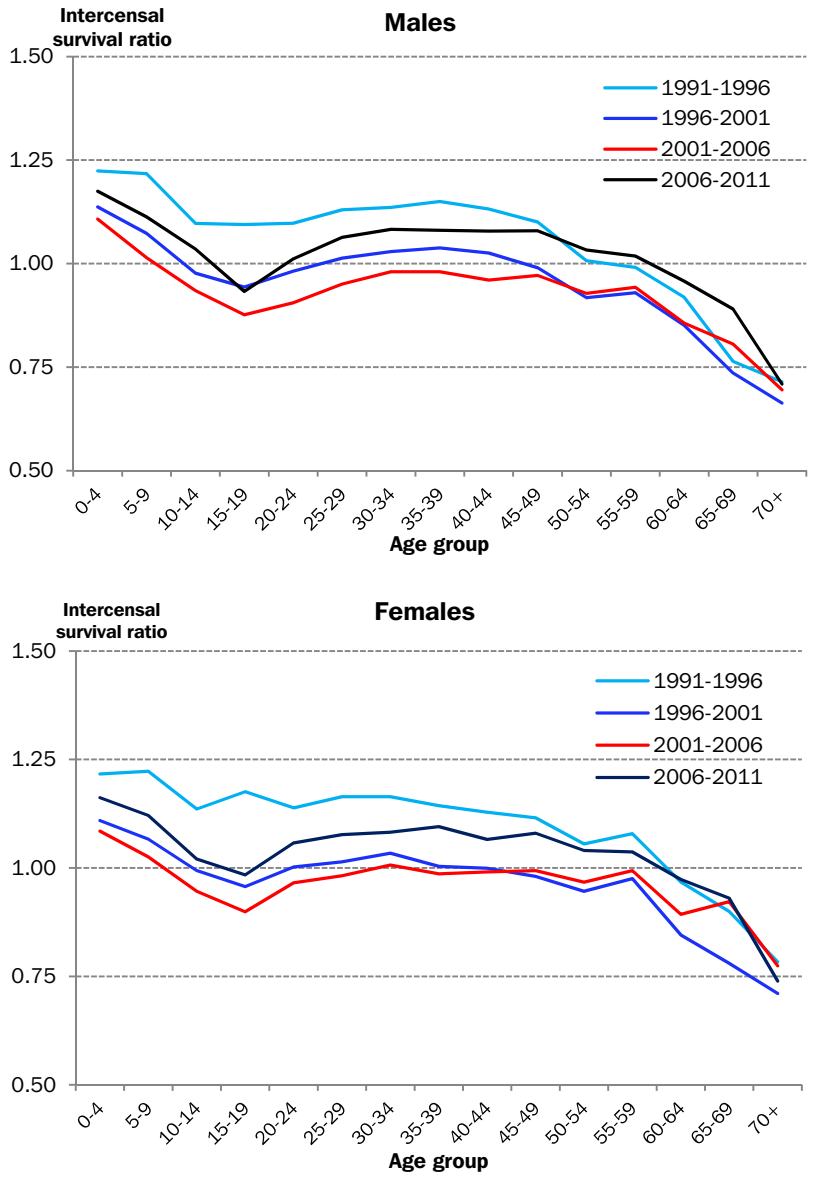
The under-identification of Indigenous status in each Census can be well addressed in estimating Census year ERP after a series of adjustments, in particular from results of the PES. However, estimating the level of identification change across Censuses is a challenge, and so far little success has been achieved, primarily due to lack of quality data. The recent release of the 2006–2011 Australian Census Longitudinal Dataset (ACLD) provides some hope, but the fact that the data are linked without using names and addresses makes it complicated to estimate intercensal identification change. As a result, this paper still relies on historical Census data to search for clues in estimating the extent of intercensal identification change.

In the high series population projections based on the 1996 and 2001 Censuses, assumptions of the same level of identification change observed in previous intercensal period were used (table 3.1), but the projection results of the next Census year were much higher than ERP estimates from the Census. This suggests that it is important to investigate the different age cohorts to find clues for intercensal identification change, as some population subgroups are more likely to change identification than others.

Figure 4.7 presents the age pattern of increase in Census counts by 5-year age cohorts during four intercensal periods between1991and 2011. Here intercensal survival ratios are used to illustrate the age-specific increase, which is the approach used in previous studies (Gray, 1997; Kinfu and Taylor, 2002). A comparison of the age patterns in increases in Census-based ERP estimates is also presented in Appendix tables D.1 and D.2. Ideally, the survival ratio should be lower than 1.0 if mortality is

the only factor of importance. However, it appears that teenagers and people aged 55 years and over would have intercensal survival ratios lower than 1.0 in most periods and for both males and females. This suggests that they were less likely to experience 'unexplained' increases. On the other hand, young children, in particular those aged under 10 years, and middle age adults, both males and females aged between 20 and 44 years, were more likely to have intercensal survival ratios higher than 1.0, indicating they were more likely to experience 'unexplained' increases.

4.7 Age pattern of intercensal increase in Census counts of Aboriginal and Torres Strait Islander people, 1991–2011 Censuses[(a)(b)]



Source: ABS unpublished Census data.
(a) Usual residence Census counts, excluding overseas visitors.
(b) Age is that reported in the last Census.

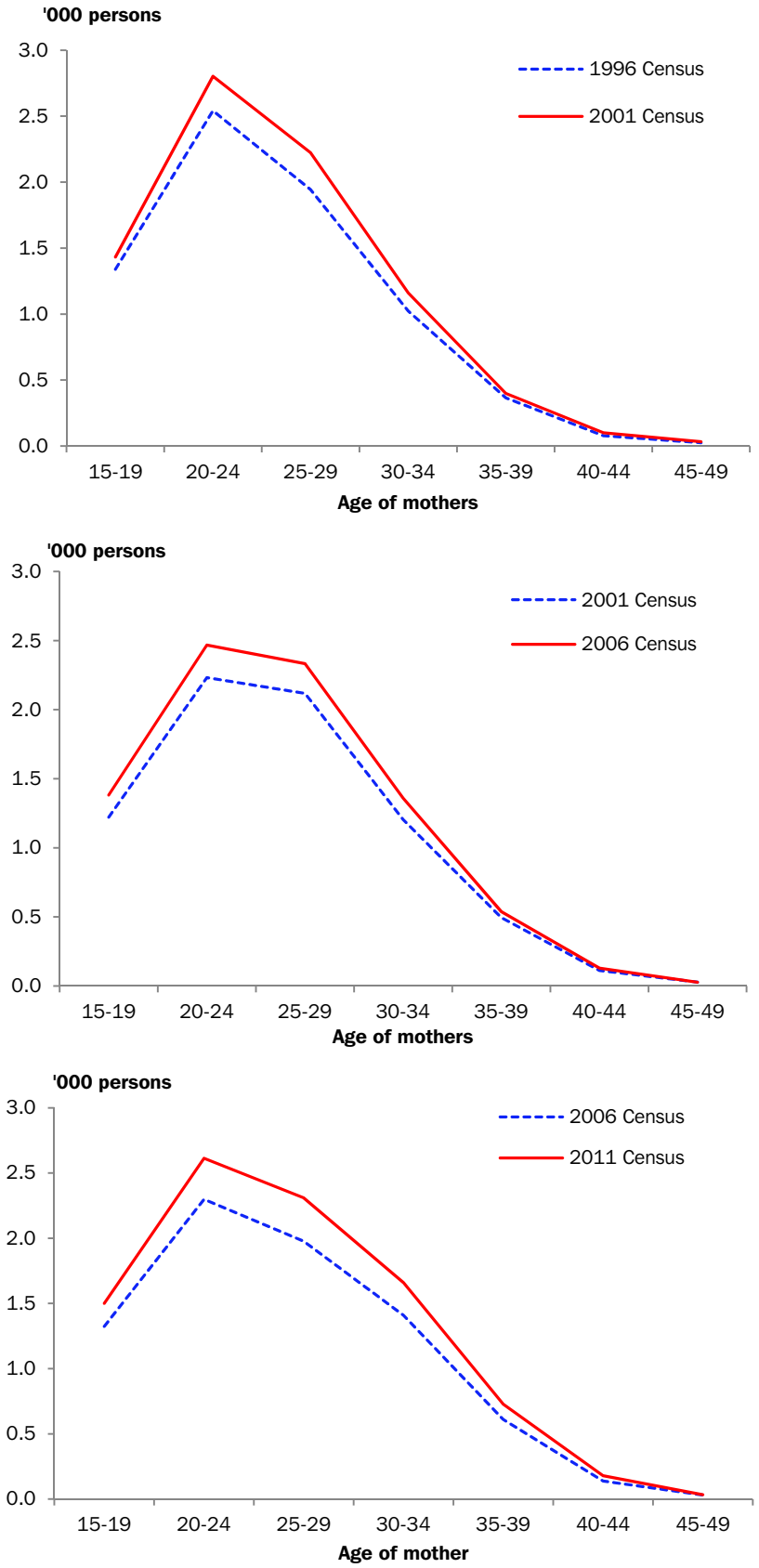
Nonetheless, during two intercensal periods (1991–1996 and 2006–2011) with high level of unexplained population growth, almost every age cohort experienced higher than expected increase. The patterns observed in Census counts were closely mirrored in Census-based ERP estimates (see Appendix tables D.1 and D.2).

One outstanding feature of the intercensal increase in Aboriginal and Torres Strait Islander Census counts is the large increase of young children by age cohorts, which has been observed since the 1981 Census (Ross, 1999). In the Census, parents and custodians complete the Census form, including the response to Indigenous status question, on behalf of children aged under 15 years living in the household. Since most parents in mixed families are identified in Census sooner or later, this change in identification has been accompanied by increasing count of Aboriginal and Torres Strait islander children. As a result, this makes it possible to estimate the changes in the identification of parents through that of their children.

The above phenomenon can be better understood using the own-children method to map out the age profiles of mothers from two adjacent Censuses but with children born during the same period. As shown in figure 4.8, in every subsequent Census, mothers aged 25–39 years, who were aged 20–34 years in the previous Census, were more likely to identify as Aboriginal and Torres Strait Islander origin together with their children for the first time in the Census. The same story also occurred for Aboriginal and Torres Strait Islander fathers (not shown in figure).

The connection between the concurrent increase in both parents and young children considerably enhances our understanding of the observed large intercensal increase. The 2011 Census counted about 93,300 more Aboriginal and Torres Strait Islander people than the 2006 Census. Of them, about 67,400 were children aged under 5 years, who were born during 2006–2011, and about 26,000 people in the same age cohorts who were aged 0 years and above in 2006. Comparatively, the 2006 Census counted about 55,600 children aged under 5 years (ABS, 2013e). As shown in Appendix table A.3, the average fertility level during 2001–2006 estimated from the 2006 Census and that during 2006–2011 from the 2011 Census was roughly the same. This large increase of 11,000 children born during 2006–2011 resulted from more parents who were identified as Aboriginal and Torres Strait Islander origin for the first time in the 2011 Census. Put this in another way, with the same fertility level, an addition of about 20,000 parents who changed their identification led to more children being identified as of Aboriginal and Torres Strait Islander origin.

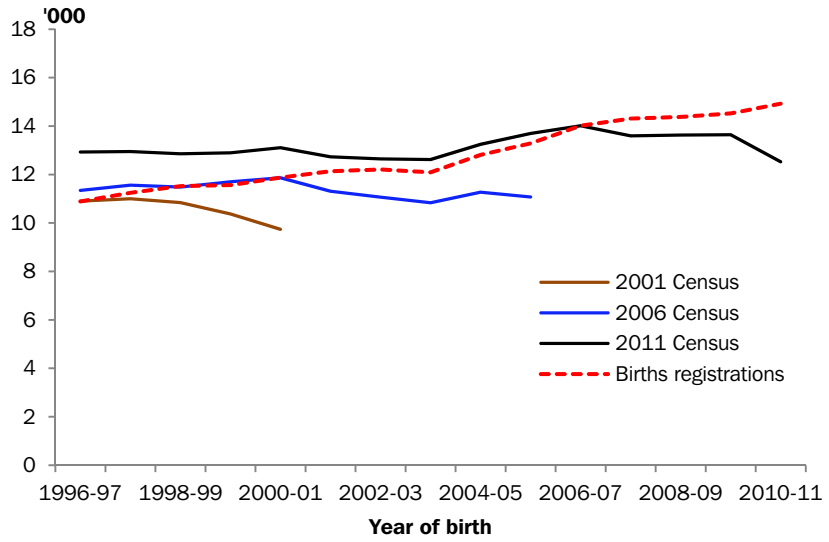
4.8 Average age profiles of mothers with children who were born during 1996–2001, 2001–2006 and 2001–2006, 1996–2011 Censuses



Source: ABS unpublished Census data.
The number of mothers refers to 5-year average during each intercensal period.

For each Census, most of children aged under 5 years on Census night were already registered by legal requirement, together with reported Indigenous status of mothers and/or fathers. Figure 4.9 makes a comparison of births registered each year with children counted in each Census, from which a clear pattern can be observed. Each Census was demonstrated to be undercounting young children aged 0–4 years on Census night in comparison to registered births during 1996–2001, 2001–2006 and 2006–2011 periods. However, each subsequent Census not only confirmed the undercount of children aged under 5 years in the previous Census, but also confirmed under-identification in births registrations.

4.9 Comparison of births registrations with Census counts of young children, by year of birth, 1996–2011 Censuses[(a)(b)]



Sources: (a) ABS unpublished Census data, and (b) ABS births registrations data collections. The births registered refer to those born between each August and the next July, in alignment with children counted in the Census.

The 2011 Census indicated that the 2006 Census at least undercounted about 9,400 children aged under 5 years on Census night. Meanwhile, births registrations already suggested that the 2006 Census could undercount at least 7,000 young children. Similarly, the 2006 Census suggested that the 2001 Census undercounted at least 5,000 children aged under 5 years on Census night. Nonetheless, births registrations of children born during 1996–2001 already suggested that the 2001 Census could undercount at least 4,000 young children. Previous analysis on paternity rates also suggested possible undercoverage of births born to non-Indigenous mothers. If we could use this information, and in combination with other information, such as the sex ratios of children, and the age structure of mothers, to upwardly adjust the births registrations, it appears that the number of births registered in previous intercensal period will even be more closely corresponding to that of children aged 5–9 years counted in the following Census.

A recent ABS publication *Understanding the Increase in Aboriginal and Torres Strait Islander Counts between 2006–2011* (cat. no. 2077.0) suggested that the changing propensity to identify is associated with different life stages. In each Census, most children aged under 15 years from mixed parentage were identified by their parents as of Aboriginal and Torres Strait Islander origin, if at least one parent was also identified in the same Census. However, as they become teenagers and young adults who completed the Census by themselves, some of them chose not to identify in the Census, which has been corroborated by higher undercounts suggested by PES and negative intercensal increase by age cohort comparisons. As they age, many people again changed their identification in the Census. This is the reason why we observed more increases in adults (ABS, 2013e). The analysis in this paper further complements this theory. When people with Aboriginal and Torres Strait Islander origin have newborns, they consider the event as an important opportunity to confirm their identification, through identifying themselves and their children in official births registrations. They may have not done so in previous Censuses, and will not necessarily do so in the following Census. However, when their children grow up and approach schooling age, the parents have to deal again with the identification question on more occasions. Consequently, many parents chose to confirm their Indigenous status by identifying in the Census.

If this theory stands, and if the pattern as observed in the relationship between births registrations and Censuses continues into the future, it may be possible to estimate the potential identification change in the next Census using information from available births registrations and Census data. A comparison between children aged under 5 years counted in the 2011 Census, and births registered during 2006–2011, clearly indicates the undercoverage, and most likely under-identification, of young children in the 2011 Census. Based on historical trends, it is then possible to estimate how many children aged 5–9 years would be counted in the 2016 Census, and hence their parents. This is an important clue in figuring out the identification changes between Censuses, and more importantly, to projecting the identification change of children together with their parents.

Question for the Committee: Is it reasonable to estimate the potential identification change in the next Census using births registered in the last intercensal period?

4.5 Summary of findings

This section uses demographic techniques to examine the trends and patterns in fertility, paternity and intercensal identification using the five recent Censuses. A number of important findings are obtained, which are very informative to develop a method to estimate intercensal population.

Fertility levels for Aboriginal and Torres Strait Islander people were still high but with a trend of gradual decline. Using five Censuses in combination, a reasonable estimate of the most likely scenario for fertility can be established: TFR of 2.7 children per woman during 1986–1996, 2.6 children during 1996–2006, and about 2.5 during 2006–2011. The age pattern of fertility rates have been roughly stable over time, with most births occurring to women aged 20–34 years. This trend and age pattern of fertility can be directly used in estimating the population during 2011–2016.

Consistent with previous studies, an increasing trend in intermarriage has been observed. Likewise, there is also a slightly increasing trend in children born in mixed families with at least one parent identifying as of Aboriginal and Torres Strait Islander origin. The total paternity rates which were found to be around 1.0 since the early 1990s, suggest that children born to non-Indigenous mothers were making significant contributions to Indigenous population growth. The fertility and paternity rates estimates coming out of the analysis suggest that the assumptions used in historical ABS projections were at the lower end, and could have contributed to the under-projection of population in Census year compared to the Census-based ERP estimates.

Applying the own-children method to consecutive Censuses has found a new pattern in fertility estimates. It was found that the fertility levels estimated from every Census after the 1996 Census was an under-estimate for the intercensal period immediately preceding the Census, which was subsequently 'corrected' by the next Census, and further confirmed by the next subsequent Census 10 years apart. This 'catch up effect' is found highly unlikely due to Census undercount or age misreporting. Instead, this suggests that a significant number of children aged 0–4 years, together with their parents, were not identified as Aboriginal and Torres Strait Islander origin in one Census, but was identified in subsequent Censuses.

The analysis of subsequent Censuses showed that in each Census there was an undercounting of young children. Also, it was found that there has been little unexplained growth in the population of teenage and older age cohorts. Because children aged 0–4 years at each Census were already recorded in births registrations – which also demonstrated the Census undercount of young children – the analysis has established a direct relationship between births registered in the previous intercensal period and the concurrent increase of the same age cohorts of children together with their parents in the subsequent Census. This provides a very useful clue to estimate the level of identification changes between Censuses.

5. PROPOSING AN ENHANCED DEMOGRAPHIC BALANCING EQUATION METHOD TO ESTIMATE THE INTERCENSAL POPULATION

This section investigates the feasibility of modifying the existing method for intercensal population estimates to account for the findings in Section 4. Since the focus is population estimates at the Australian level, migration is excluded due to its negligible contribution.

5.1 An enhanced demographic balancing equation method

The so-called *standard* method used for estimating non-Census year ERP of all Australians is based on the basic demographic balancing equation. It brings forward the Census year ERP, P_t, at the reference date of 30 June to next year ERP, P_{t+1}, at the reference date by updating with births, B_{t+1}, and deaths, D_{t+1}, occurring between year t and year $t + 1$ (ABS, 2009c).

This basic demographic balancing equation is expressed below:

$$P_{t+1} = P_t + B_{t+1} - D_{t+1} \quad (1)$$

However, as stated in previous ABS publications, it is not possible to use the standard approach to estimate and project Aboriginal and Torres Strait Islander population due to data quality concerns (ABS, 2009a). At least two challenges need to be addressed in making adjustments in the estimates of annual births. One challenge is that it is not possible to obtain a 'complete' number of births by the year of occurrence when making estimates on an annual basis. It often takes several years to have births born in a specific reference year registered and sorted out by the year of occurrence. Another challenge is the under-coverage of Aboriginal and Torres Strait Islander births. Even without considering the mortality factor, a comparison between births registered by year of occurrence during 1996–2011 and young children counted in 2001, 2006 and 2011 Censuses suggests a significant level of under-identification. It is in particular challenging that a significant number of parents who did not report their Indigenous status and their children's in registrations, were being identified in the Census up to 15 years later. This makes it nearly impossible to simply adjust registered births to estimate the 'true' number of births.

The more difficult challenge is that the existing method does not take into account intercensal identification change. Analysis of the performance of historical projections both from the ABS and academia suggests that the projected population would be an underestimate intercensal identification changes are not incorporated into the projections.

Developing adjustment factors for under-identification in deaths is a lesser challenge because there is no significant variation on the number of deaths each year, as

reported in the recent ABS publication *Life Tables for Aboriginal and Torres Strait Islander Australians, 2010–2012* (cat. no. 3302.0.55.003).

Adjustments to the standard method will need to be made to add three new components that address the above challenges:

1. Newly identified population subgroups, both males and females aged between 15 and 59 years over the next intercensal period, who are anticipated to join the population through identification change in the next Census. In year $t+1$, these include both males $P_{t+1,x}^{\text{new males}}$ and females $P_{t+1,x}^{\text{new females}}$, where x represents ages ranging from 15 to 54 years;

2. Births born to the newly identified population subgroups, B_{t+1}^{new} on an annual basis, including those from Aboriginal and Torres Strait Islander mothers, $B_{t+1}^{\text{new, mothers}}$, and those from non-Indigenous mothers and Aboriginal and Torres Strait Islander fathers, $B_{t+1}^{\text{new, fathers}}$; and

3. Deaths of the above population subgroups, D_{t+1}^{new} on an annual basis.

As a result, equation (1) can be rewritten below as an enhanced demographic balancing equation method, where the base population P_t, births B_{t+1} and deaths D_{t+1} are all replaced by new components, i.e. adjusted base population $P_t^{\text{adj.}}$, adjusted births and deaths $B_{t+1}^{\text{adj.}}$ and $D_{t+1}^{\text{adj.}}$ between year t and year $t+1$, respectively.

$$P_{t+1} = P_t^{\text{adj.}} + B_{t+1}^{\text{adj.}} - D_{t+1}^{\text{adj.}} \tag{2}$$

Equation (2) can be further rewritten to represent the components of changes, where x represents ages from 15 to 49 years for newly identified males and females:

$$\begin{aligned} P_{t+1} = &\left(P_t + P_{t+1,x}^{\text{new males}} + P_{t+1,x}^{\text{new females}}\right) + \\ &\left(B_{t+1} + B_{t+1,x}^{\text{new, mothers}} + B_{t+1,x}^{\text{new, fathers}}\right) - \\ &\left(D_{t+1} + D_{t+1}^{\text{new}}\right) \end{aligned} \tag{3}$$

For this proposed new method, the most difficult task is estimating the size and age distribution of the newly identified population subgroups that joined the population. This challenge was well described by Barnes (1997, p. 17) after the 1996 Census:

> "These difficulties could be overcome if population estimates and projections incorporated factors which accounted for the changing identification patterns of Indigenous people in Censuses which appears to be a fact of life, at least for the past generation. There is, in fact, no particular difficulty in changing the estimation methodology. The difficulty is to obtain the data which would satisfactorily monitor on-going changes in the identification behaviour of people, or to find some way of predicting this into the future."

However, a number of important findings presented in Section 4 laid a good foundation for addressing this challenge. These findings include: roughly stable levels of fertility and paternity and associated age patterns; the concurrent increase of both parents and young children; and the close relationship between births registered in the last intercensal period and identification change of young children and their parents in the following Census. The next sub-section explores an iterative approach using data currently available to develop adjustment factors for both annual births and their parents.

Question for the Committee: Does the Committee agree with the proposal to use an enhanced demographic balancing equation method to estimate intercensal population?

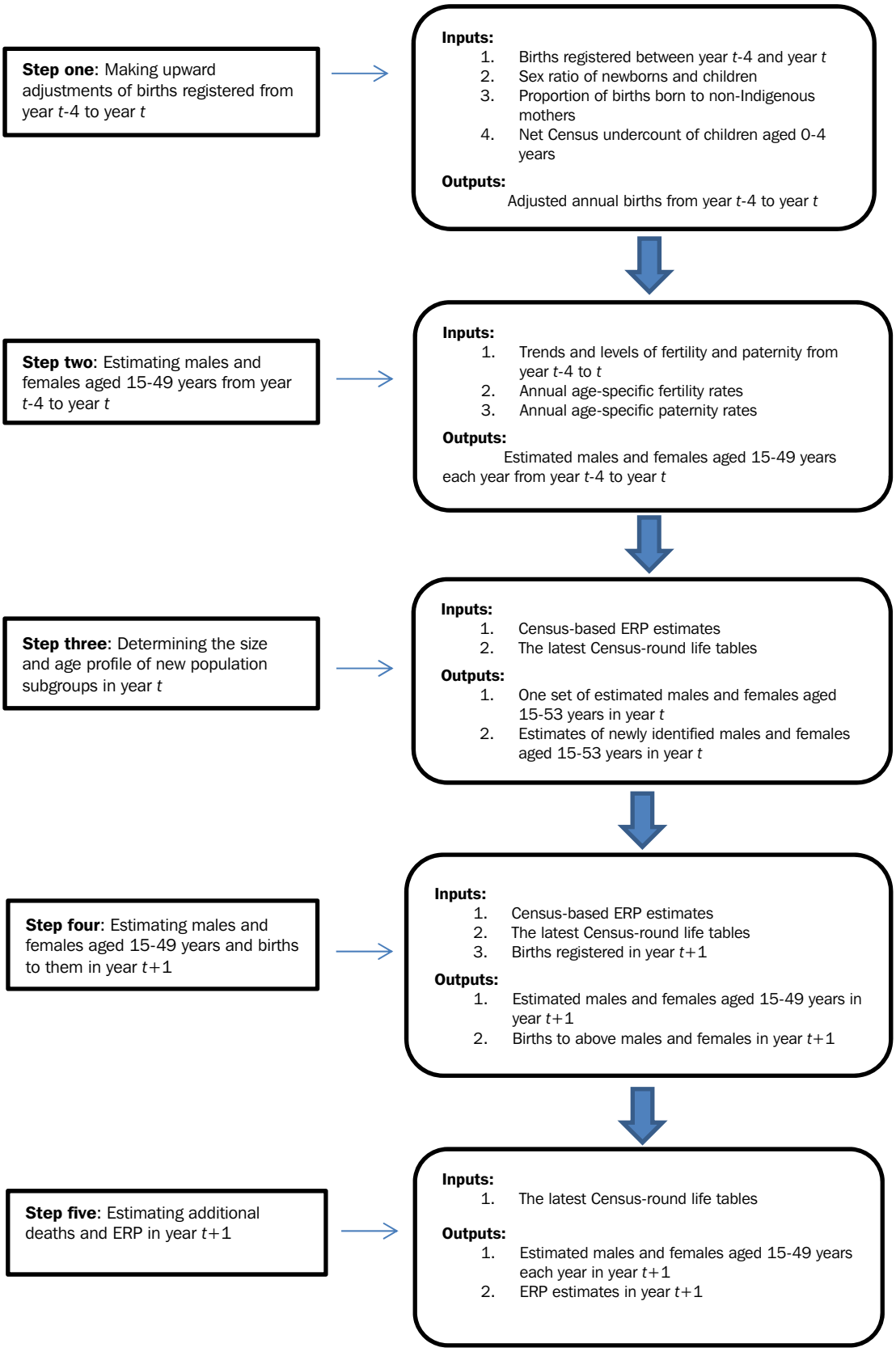
5.2 An iterative approach for estimating the intercensal population

This sub-section introduces how to estimate the intercnesal population in year $t+1$, the first post-censual year, from the base population Census-year ERP P_t in year t, primarily using births registered in the last intercensal period from year $t-4$ to year t together with other information. The adjustment process includes five major steps, of which some steps also include several sub-steps. The flow chart in figure 5.1 illustrates the general idea, and the texts below present more detailed explanations.

The first step is to make upward adjustments of the annual number of registered births from year $t-4$ to year t, corresponding to children aged 0–4 years counted in the most recent Census. The under-coverage in births registrations is a known fact. Three upward adjustments are made in a sequential order: (1) adjusting births registered using sex ratio; (2) adjusting the updated number of births using proportion of births born to non-Indigenous mothers; and (3) further adjusting the updated number of births based on the net undercount rate of children aged 0–4 years in the last Census.

The sex ratio information is obtained from historical Censuses, which may also be enhanced using information from other data sources, such as perinatal data. Adjustment at this sub-step first expands the number of either boys or girls depending on the actual registrations data and the assumed 'normal' sex ratio. An assumption is made that the newly added children have the same proportional distribution as births born to non-Indigenous mothers in the registrations. Subsequently, the annual number of young children is further upwardly adjusted by adding young children in respective year who were aged 0–4 years on last Census night from non-Indigenous mothers, and adjustments based on PES.

5.1 Flow chart for estimating the intercensal population



The second step is to estimate the male and female population who were aged 15–54 years during the last intercensal period. These adjusted population subgroups include the newly identified population subgroups who are likely to join the population through identification change in the next Census. Based on historical patterns, it is reasonable to assume what the 'true' levels of fertility and paternity rates and associated age patterns each year from year $t-4$ to year t. For example, for the last 2006–2011 intercensal period, it is reasonable, and reliable, to assume an average TFR of 2.5 children per woman with peak childbearing ages between 20–29 years, and an average total paternity rate of 1.10 with peak fathering ages between 25–34 years (see Appendix tables B.3 and C.3). With the upwardly adjusted annual number of children, the defined fertility and paternity levels and age patterns, the number of women and men aged 15–49 years each year during the last intercensal period can be reversely estimated. This is equivalent to solving the denominator in an equation with the estimated rate/ratio statistics and the numerator.

The third step is to obtain estimates of the new population subgroups, i.e. males and females aged 15–53 years in year t, who are anticipated to join the population through identification change in the last Census year, but did not do so in the last Census. The first sub-step is to survive those estimated men and women aged 15–49 years each year from year $t-4$ to t at step two to year t using the life table. There will be significant overlapping in these estimates by age cohorts. For example, women aged 15–49 years in year $t-4$ estimated from births registered in year $t-4$ will be aged 19–53 years in year t. Meanwhile, women aged 15–49 years in year $t-3$ estimated from births registered in year $t-3$ will be aged 18–52 years in year t, and so on. Due to fluctuations in the annual number of registered births, and different levels of adjustments received, it is highly likely that the numbers of both women and men of each age cohort will differ significantly estimated from yearly adjusted births. Because under-coverage is always the key challenge, a principle is decided that for each cohort the highest number of estimated men and women will be chosen. As a result, only one set of estimates of men and women aged 15–53 years in year t is produced. The age distribution of both males and females will be compared to the same age cohorts in Census-based ERP estimates. Some smoothing exercise using linear interpolation technique may be required if there are significant variations in age distribution of the new estimates. The second sub-step is to estimate the newly identified population subgroups through differencing the estimated males and females aged 15–53 years in year t with Census-year ERP in corresponding age cohorts, respectively.

The fourth step is to estimate the number of the new population subgroups of males and females aged 15–54 years in year $t+1$ and births to them. The first sub-step is to survive estimated newly identified males and females aged 15–53 years in year t to year $t+1$ using the life table. The second sub-step is to make additional estimates of males

and females aged 15 years in year $t+1$, with reference to Census-year ERP estimates and parents' information for births registered in year $t+1$. Assumption is required at this sub-step, and this procedure will be repeated each year from year $t+1$ to year $t+5$. The third sub-step is to estimate the births from these males and females aged 15–49 years in year $t+1$, which are obtained by multiplying the estimated age-specific fertility and paternity rates in year $t+1$.

The fifth and final step is to estimate the 'additional' number of deaths from the new population subgroups and their children, and then the ERP estimates in year $t+1$. The first sub-step is to estimated 'additional' deaths in year $t+1$ from the newly identified population subgroups aged 15–53 years in year t as estimated at step three using age-specific mortality rates from the most recent census-round life tables. The second sub-step is to estimate 'additional' deaths of births to the new population subgroups still using age-specific mortality rates from the life table. Finally, summing all the above estimates of new population subgroups and their births together with the base population and births and deaths as in Equation (3), the ERP estimates for year $t+1$ are obtained.

The proposed iterative approach for estimating population subgroups, who are likely to join the population through identification change in the next Census, is built upon a number of assumptions based on historical trends and patterns. There is a very low chance for sudden changes in levels and age patterns of fertility and paternity rates. Historical Censuses also support the pattern of concurrent increase in both young children and their parents. However, if there was a large scale 'unexplained' intercensal population growth in the next Census, occurring in almost every age cohort like what happened during 1991–1996, and to a lesser extent during 2006–2011, this approach will only be able to estimate most part of intercensal increase. As a result, the resulting estimates will be at a lower end in comparison to ERP estimates based on the next Census.

Question for the Committee: Does the Committee have suggestions to improve the proposed iterative approach for estimating the intercensal population?

5.3 Statistics Canada's experience in Aboriginal population projections

Like Australia, Canada also experienced significant intercensal increase in Census counts of Aboriginal population, which is primarily attributed to 'ethnic mobility' rather than demographic factors (Guimond, 2006). This 'ethnic mobility' was identified as both intra-generational and inter-generational, that is, many parents who changed their Aboriginal identity also did so for their children in the Census. This required the population projection method to account for the identification change of parents and their children simultaneously. To do this, Statistics Canada developed a microsimulation model, called Demosim, to project Aboriginal population following the 2006 Census (Statistics Canada, 2011; Caron-Malenfant, 2013). Demosim makes use of the Census population in the long questionnaire (20% sample) as the base population. One outstanding feature for the model is that it projects both Aboriginal and non-Aboriginal populations coherently and simultaneously, which can address the 'ethnic mobility' between non-Aboriginal and Aboriginal population. In addition to the Age-sex composition and geographic distribution, new components such as educational achievement and marital status can also be included.

The Demosim model produces dynamic population projections at the level of the provinces, territories, census metropolitan areas and selected smaller geographies. In comparison to the 2011 Census-enumerated Aboriginal population, i.e. 1.4 million, the projection scenario of Aboriginal population based on the 2006 Census, incorporating into 'ethnic mobility', performed very well, while the projection scenario without considering 'ethnic mobility' was significantly lower than the Census count (Statistics Canada, 2011).

Given the similar challenge faced by both the ABS and Statistics Canada in addressing the 'ethnic mobility' to accurately estimate Aboriginal population, it might be possible to borrow from the experience of Statistics Canada in applying microsimulation in the future.

Question for the Committee: Does the Committee consider it is worthwhile exploring the microsimulation approach used by Statistics Canada as a potential method in the future?

6. CONCLUSIONS AND FUTURE DIRECTIONS

There has been significant demand for supplying intercensal population estimates for Aboriginal and Torres Strait islander people in a timely manner with more certainties. The ABS has produced Census-year ERP estimates since the 1991 Census. However, due to data quality concerns, the ABS only produces population projections in each census round, which have been used widely as *de facto* population estimates over the years. Nonetheless, a comparison between projection outcomes and Census-year ERP estimates confirmed that the low and medium series of projections have most often under-projected the population. It suggests that the intercensal identification change plays a more important role than fertility, paternity, and mortality in driving the growth of Aboriginal and Torres Strait Islander population.

This paper analysed five recent Censuses undertaken during 1991–2011 using demographic techniques to examine trends and patterns of a number of important demographic parameters, including, fertility, intermarriage, paternity, and identification change. The use of rich family interrelationships in Census enhanced our understanding on population change of Aboriginal and Torres Strait Islander Australians. Moreover, the advantage of numerator/denominator consistency in estimating rate/ratio statistics using the own-children and the Family-Tree method proved a powerful tool to address the under-identification issue.

Both fertility and paternity rates estimated from consecutive Censuses are in general agreement in levels, trends and age patterns. It was found that fertility and paternity assumptions used in historical ABS projections have been at the lower end. A very important 'catch up effect' was found in estimating fertility, and paternity as well, from consecutive Censuses using the own-children method. Because it was unlikely due to Census undercount and age misreporting, it constitutes convincing evidence suggesting that a significant number of young children, together with their mothers and fathers, were not identified in one Census, would be identified in the following and subsequent Censuses. More importantly, a comparison between births registrations and Census data established a close link between births registered in the last intercensal period and increase in Census counts of both young children and their parents in the next Census.

Consequently, this paper proposed an enhanced demographic balancing equation method to estimate intercensal population. The key idea is to incorporate the newly identified population subgroup, males and females aged between 15 and 59 years, and primarily in 20–34 age groups, who are likely to join the population in the next Census through identification change, into the base population, in addition to adjust under-coverage of births and deaths in registration data. The paper proposed an iterative approach to estimate the intercensal population, which are based on the following findings of this paper: (1) roughly stable levels and age patterns of fertility and

paternity rates; (2) concurrent intercensal increase between young children and their parents; and (3) the close relationship between births registered in the last intercensal period and counts of young children together with their parents in the next Census.

This paper recognises several limitations in the proposed method. Firstly, the method focused on population estimation at the Australian level only. To address this, future research will examine the variations of observed patterns and trends of fertility and paternity and implications for population estimation at state/territory levels. In addition, the component of inter-state migration will be included. Secondly, there is the large 'unexplained' population growth during the 1991–1996 and 2006–2011 intercensal periods, which was observed for almost all age groups. How the proposed method performs can be tested using historical Census and ERP data, but the more powerful testing will have to wait for the 2016 Census outcomes. Lastly, the proposed method undertakes multiple adjustments of young children and their parents in a sequential order, which may be prone to human mistake. It is desirable to develop a coherent method to estimate intercensal population.

With similar challenges to accurately estimating their Aboriginal population, Statistics Canada used a microsimulation approach to incorporate simultaneously both inter-generational and intra-generational 'ethnic mobility into the projections. Although the proposed enhanced demographic balancing equation method in this paper takes into account this factor, a microsimulation method can produce detailed and robust results with internal consistency, as demonstrated by the Canadian experience. It is desirable for any future study to include the investigation of the merits of the microsimulation approach in estimating the intercensal population of Aboriginal and Torres Strait Islander Australians.

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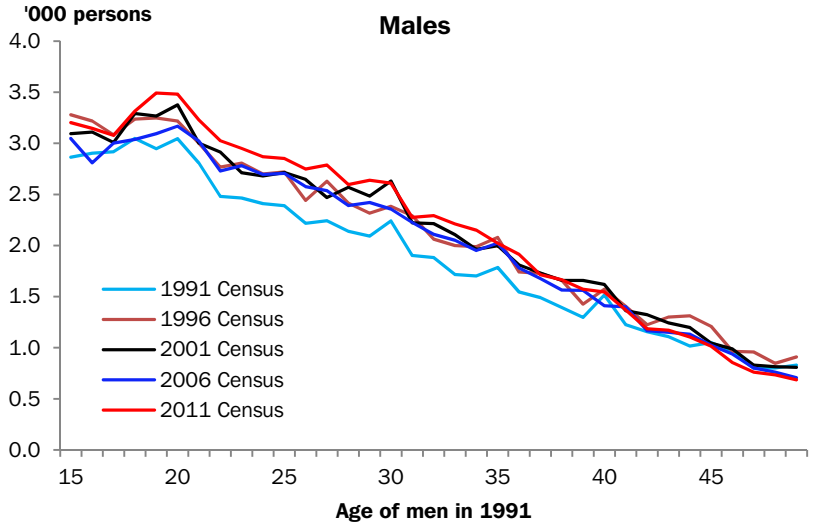
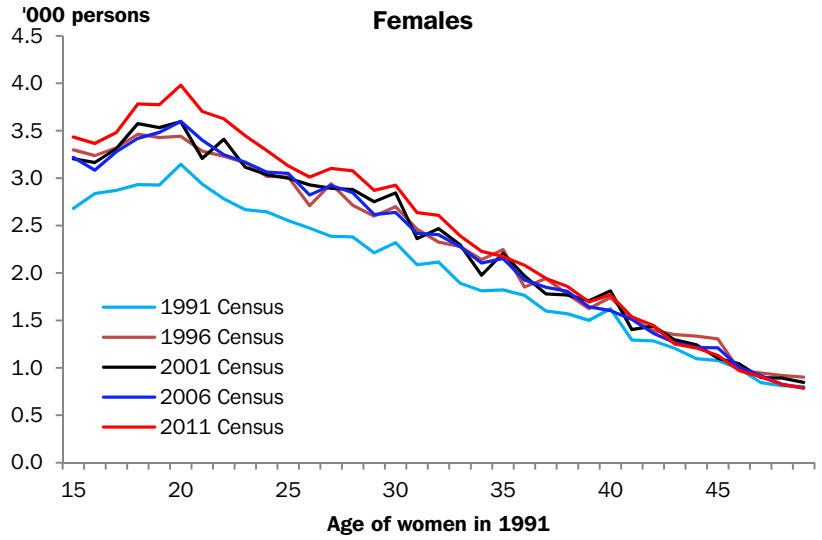
APPENDIXES

A. ABORIGINAL AND TORRES STRAIT ISLANDER CENSUS COUNTS, BY AGE COHORT, 1991–2011

A.1 Census counts of Aboriginal and Torres Strait Islander men, 1991–2011 Censuses[(a)(b)]



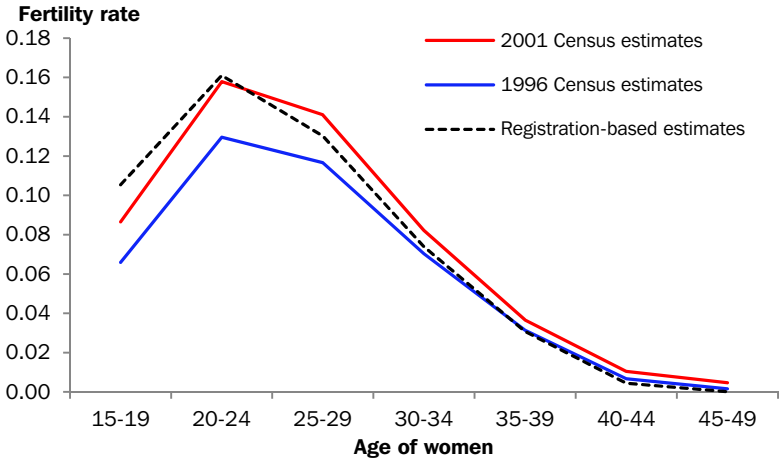
A.2 Census counts of Aboriginal and Torres Strait Islander women, 1991–2011 Censuses [(a)(b)]



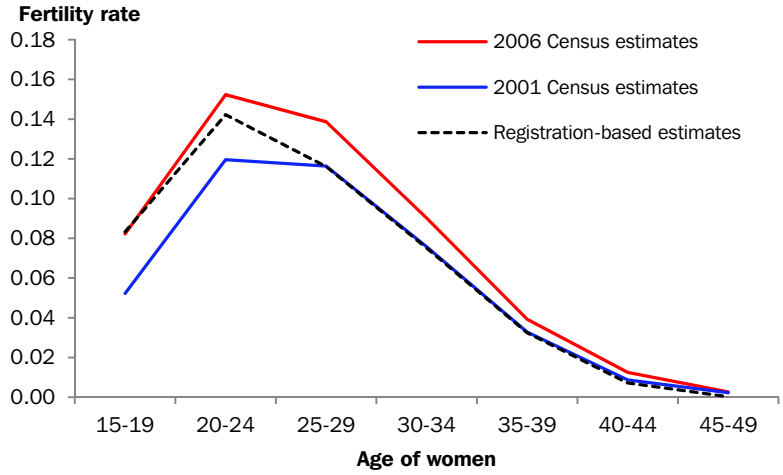
Source: ABS unpublished Census data.
(a) Usual residence Census counts, excluding overseas visitors.
(b) Age refers to that reported in the 1991 Census. For females aged 15 years in 1991, they were aged 20 years in 1996, 25 years in 2001, 30 years in 2006 and 35 years in 2011.

B. COMPARISON OF AGE-SPECIFIC FERTILITY RATES BETWEEN CENSUS-BASED AND REGISTRATION-BASED ESTIMATES

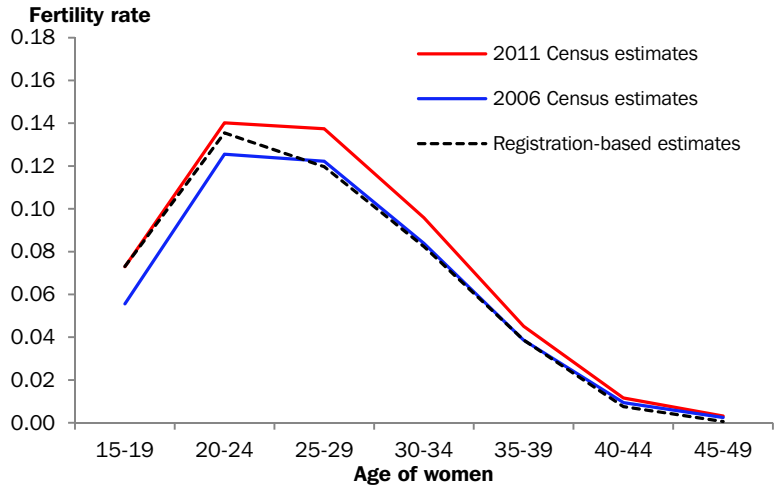
B.1 Age-specific fertility rates, 1996



B.2 Age-specific fertility rates, 2001



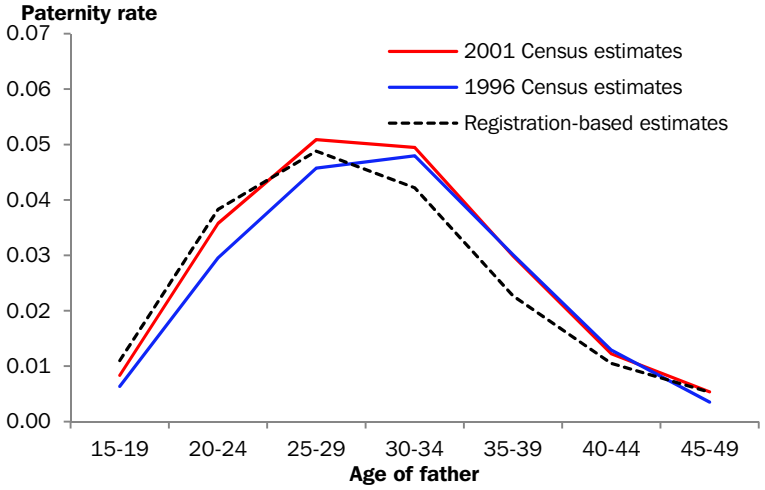
B.3 Age-specific fertility rates, 2006



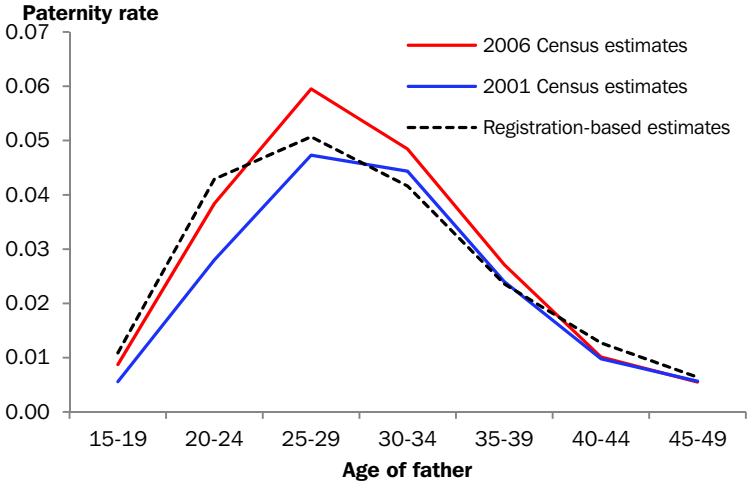
Source: ABS unpublished Census data.

C. COMPARISON OF AGE-SPECIFIC PATERNITY RATES BETWEEN CENSUS-BASED AND REGISTRATION-BASED ESTIMATES

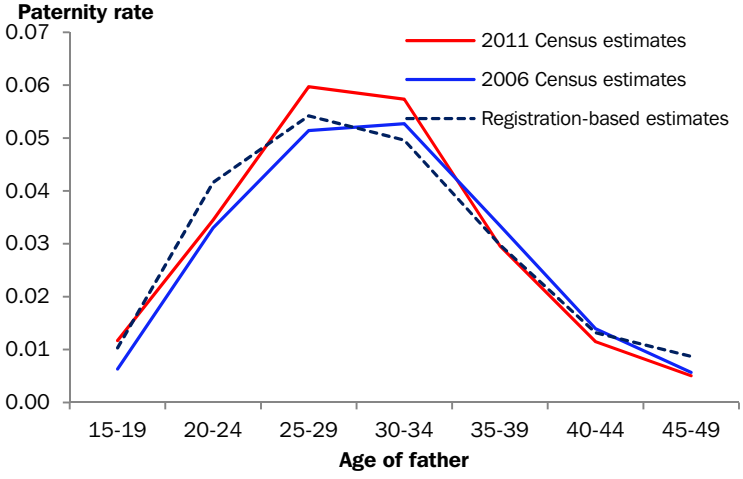
C.1 Age-specific paternity rates, 1996



C.2 Age-specific paternity rates, 2001



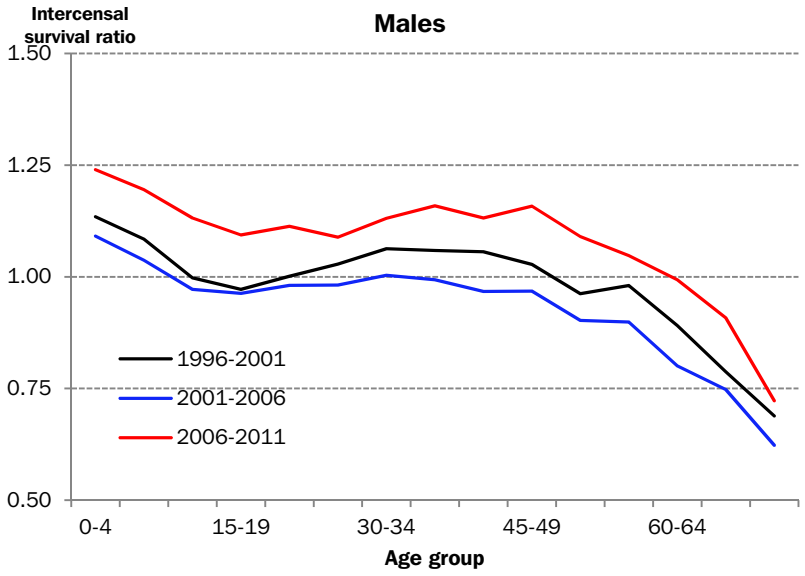
C.3 Age-specific paternity rates, 2006



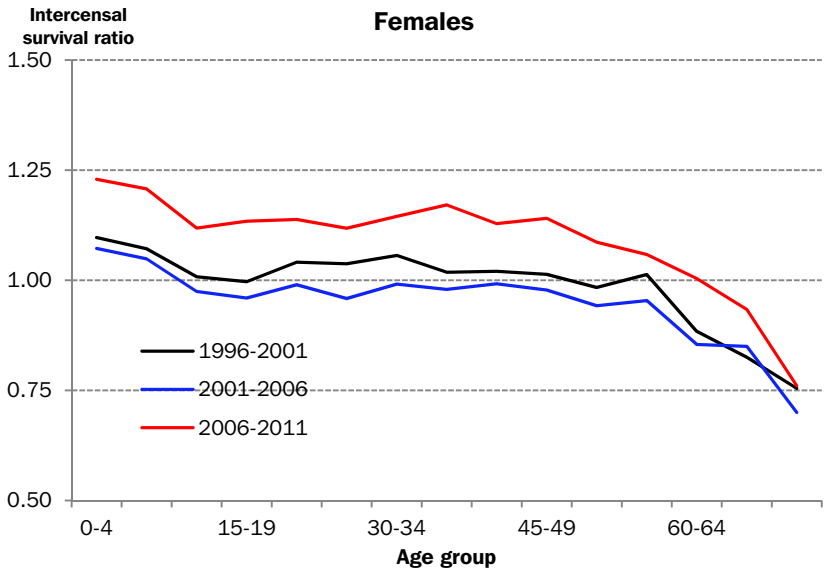
Source: ABS unpublished Census data.

D. AGE PATTERN OF INTERCENSAL INCREASE IN CENSUS-BASED ERP ESTIMATES OF ABORIGINAL AND TORRES STRAIT ISLANDER AUSTRALIANS, 1996–2011

D.1 Age structure of ERP estimates, males, 1996–2011



D.2 Age structure of ERP estimates, females, 1996–2011



Source: ABS (1998; 2004; 2009; 2013e).

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