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Analysis

Australia's Genuine Progress Indicator Revisited (1962–2013)

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A B S T R A C T

The Genuine Progress Indicator (GPI) has been proposed as an alternative to GDP as an indicator of national progress. GPI includes 26 components that adjust GDP for inequality, include household and volunteer work, and subtract a number of social and environmental costs best seen as negatives. The GPI has been estimated for over 20 countries and many states and territories. This paper updates Australia's GPI to determine whether Australia as a nation has progressed overall since the 1960s and compares two alternative approaches that differ in some important details. We find that despite these differing approaches, we find that GPI remained largely stagnant from the 1960s through to the 1990s, and only at the turn of the century has GPI started to increase, despite increasing negative environmental costs.

While GPI is well placed to serve as an improved Australian and global measure of national progress, further work is needed to measure national well-being and support its integration into political decision-making and to include the full range of subjective and objective indicators. Ultimately, this paper argues that while GPI is well placed to serve as a new Australian and global measure of well-being, we stress the need for an alternative indicator, like GPI, to supplement GDP and to better inform policy decisions.

1. Introduction

In 2014, the Australian Bureau of Statistics (ABS) discontinued its collection and measurement of a group of alternative indicators collectively known as the Measures of Australia's Progress (MAP) (ABS, 2014b). Significant budget cuts to the ABS forced the closure of the initiative, which collected and published data on environmental quality, population health, education levels, and community well-being to supplement Gross Domestic Product (GDP) (Martin, 2014). These cuts occurred despite a growing global recognition of the problems with GDP as a progress measure and widespread calls for alternatives (Costanza et al., 2014b; Shaw, 2015). The United Nation's Sustainable Development Goals (SDGs) process also emphasizes the need for more comprehensive measures of progress.

Gross Domestic Product has served as a proxy measure of national economic progress since WWII, when it was adopted as a macroeconomic guide at the national and global level (Fioramonti, 2017). Although never intended to be a measure of economic well-being, GDP has become the standard for economic health, and therefore societal well-being, based on the underlying assumption that increased marketed economic activity is linked to increased well-being, and that growth in GDP is equivalent to growth in 'progress' (Natoli and Zuhair, 2011; Costanza et al., 2014a). However, GDP has limited validity as a measurement of societal well-being or progress, and it may even be the case that GDP growth leads to negative societal outcomes (Natoli and Zuhair, 2011). Its antiquated accounting mechanisms neglect the social and environmental dimensions that underpin healthy societies and fails to recognize that marketed economic activity is a means to the end of societal well-being and progress, not the end itself (Costanza et al., 2014c). A broad range of other factors affects well-being and may be negatively affected by GDP (Natoli and Zuhair, 2011). For example the costs of crime, family breakdown, pollution, and climate change can increase GDP but do not improve social well-being (Kubiszewski et al., 2013). Fioramonti (2013) notes that for the United States,

> Indeed, between 1960 and 1990, American GDP nearly tripled and total social spending by all levels of government (measured in constant 1990 dollars) rose from $143.73 billion to $787 billion (a more than fivefold increase). Yet, during the same thirty-year period there was a 560 per cent increase in violent crime, a 419 per cent increase in illegitimate births, a quadrupling in divorce rates, a tripling of the percentage of children living in single-parent homes and more than a 200 per cent increase in the teenage suicide rate.
> (Fioramonti, 2013)

In recognition of shortcomings to GDP, alternative measures of sustainable progress have been proposed, which includes the Index of Sustainable Economic Welfare (ISEW) (Daly and Cobb, 1989), and its update, the Genuine Progress Indicator (GPI) (Talberth et al., 2007). Other alternative indices measure progress using objective and subjective measures of well-being, such as the Gross National Happiness Index that includes calculations of community, culture, and good governance; the Happy Planet Index that calculates the "ecological

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efficiency with which happy and healthy lives are supported" (Abdallah et al., 2009); and dozens of others (Smith et al., 2013; Costanza et al., 2014c). Even the World Bank has recognized the shortcomings of GDP, proposing an alternative measure of economic welfare, the Genuine Savings Index (GSI), also known as Adjusted National Savings (ANS). GSI came about in recognition that 'sustainability' is a vital concept in a worldwide extractive economy "reliant upon exhaustible resources" and so measures losses in natural capital against developments in human capital or infrastructure (Hamilton, 2000; The World Bank, 2013). Each of these alternative measures has strengths and weaknesses. The advantages of GPI include its ability to create historical time series directly comparable with GDP, its integration of natural and social capital components, and its widespread use at the national, regional and state scales. Previous estimates of GPI include Australia (Lawn, 2008), Belgium (Bleys, 2008), Brazil (Andrade and Garcia, 2015), Chile (Castañeda, 1999), China and several of its cities (Wen et al., 2007; Li et al., 2016), Japan (Hayashi, 2015), the Netherlands (Rosenberg et al., 1995), New Zealand (Forgie et al., 2008), Poland (Gil and Sleszynski, 2003), Sweden (Stymne and Jackson, 2000), Thailand (Clarke and Shaw, 2008), the United Kingdom (Jackson et al., 2008), the US and several of its states (Talberth et al., 2007; McGuire et al., 2012; Berik and Gaddis, 2014; Kubiszewski et al., 2015; Fox and Erickson, 2018), Vietnam (Hong et al., 2008), and global (Kubiszewski et al., 2013).

The GPI incorporates environmental and social costs into an economic measure of human well-being (Lawn, 2003). The GPI does not include subjective measures of well-being, rather it uses both market and non-market approximations of economic, social and environmental dimensions that contribute to well-being (Bagstad et al., 2014). GPI includes 26 indicators across three categories: economic, environmental and social. Within these categories four types of capital are represented: natural, built, human and social capital (Vemuri and Costanza, 2006; Costanza et al., 2007; Costanza et al., 2014b). For example, GPI subtracts the cost of crime and the costs of climate change (and the resulting degradation of natural capital) while GDP adds them as positive contributions. GPI attempts to standardize these measures across all studies so that direct comparisons can be made, but availability of data often means some indicators lack sufficient data and are either excluded or replaced by an alternative indicator. When GDP is growing, while GPI is not, this is considered to be 'uneconomic growth.' This is when the effects of growing inequality, the costs of environmental degradation, and other costs exceed the gains in GDP (Daly, 1999).

This paper updates Australia's GPI and compares alternative methods and assumptions to assess their impact on the results. We provide a background on GPI studies undertaken both in Australia and internationally, and discuss the various, and sometimes conflicting methods adopted in calculating the GPI. However, our measure of Australia's GPI is also intended to serve as a call for a better, more consistent measure of national well-being. Our discussion centers on how measuring GPI for Australia might be improved through more standardized data, a dynamic system of accounts, and through integration of human well-being into the fiber of politics at the local, national, and global scales. We do not delve too deep into the theoretical foundations of GPI, as much of that work has already been done (see Lawn, 2003). Ultimately, this paper argues that while GPI is well placed to serve as the Australian and global measure of national well-being to supplement GDP, we stress the need for additional research and consensus-building to better inform policy decisions.

2. Methods

GPI uses private consumption expenditures and then subtracts the costs and adds the benefits of economic, environmental, and social factors to arrive at a net annual welfare value for economic activity. In calculating the GPI, we are interested in *flows*; that is, the net annual change in four types of capital: built, natural, human and social. To determine the net annual change, we adjust private consumption expenditures for income inequality to arrive at Adjusted Personal Consumption Expenditures, from which the net benefit of social capital, contributions of human-made (built) capital and depletion of natural capital are subtracted or added (Lawn, 2003).

In Australia, extensive GPI studies were previously completed by Hamilton et al. (Hamilton and Saddler, 1997; Hamilton and Denniss, 2000) and Philip Lawn and Matthew Clarke (Lawn, 2003, 2008; Lawn and Clarke, 2006a, b). Our paper acknowledges these studies and has drawn on many of the data sources adopted within these projects. Publicly available statistical data was utilized and sourced from the Australian Bureau of Statistics (ABS) and other research or reporting agencies. We drew particularly on the Measures of Australia's Progress (MAP), a framework to assess well-being across a range of dimensions and regions that built on previous work initiated by the Organisation for Economic Co-Operation and Development (OECD) (ABS, 2014b). Surveys produced by the ABS started in 2002 and provided key sources of social and environmental data in our GPI study. However due to funding constraints and political tensions, the MAP was discontinued in 2013 (Shaw, 2015).

The selected indicators and their calculation that we used draw largely from the GPI methodology used in the USA for the state GPI studies of Oregon (Kubiszewski et al., 2015) and Maryland (McGuire et al., 2012) but we note changes made where necessary. Our calculation of the GPI was undertaken according to the approach described in Table 1.[1] The full methodology adopted for calculating each set of indicators is described in Appendix 1.

3. Results

3.1. Overall Trends

The overall trend for Australia's GPI reflected a modest but steady increase over time, however, the gap between GDP and GPI increases over time. Rates of growth differ between GDP and GPI, with GPI's rate of growth significantly behind that of GDP, until the turn of the millennium, where GPI began to just outpace growth in GDP, in larger part thanks to contributions of positive growth rates from the social indicators.

Time period	Rates of growth (%)				
	Total GDP	GPI estimates			
		Total GPI	Economic indicators	Environmental indicators	Social indicators
1962–1975	85.9	67.4	141.2	−46.0	25.8
1976–1990	58.1	27.2	53.3	−15.8	9.2
1991–2005	58.9	45.0	59.8	−19.0	−0.3
2002–2013	25.9	30.0	20.3	−15.9	34.4

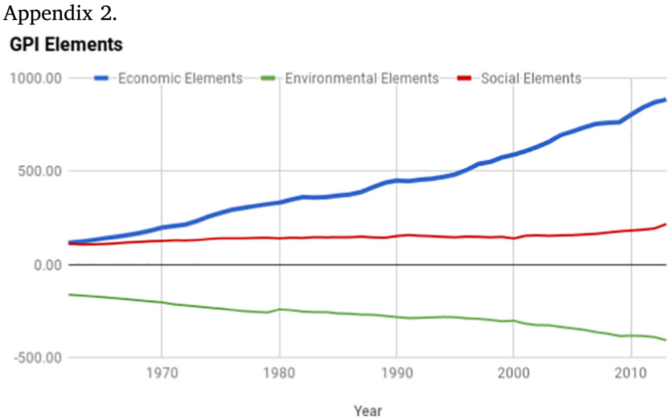
However, underlying the overall trend of GPI there are distinct variances in the directions of economic, environmental, and social indicators. Across the survey period, economic trends contributed significantly and positively to GPI, environmental trends contributed negatively, and social trends were a mix. Key indicators that have contributed increasing the GPI in recent years include rising personal consumption expenditure and capital investment, with an increased value attributable to the social indicators of volunteer work and higher

[1] Interpolation was undertaken across indicators where data collection occurred over irregular survey periods and extrapolation was undertaken using linear regression or growth functions, particularly for social and environmental indicators where data availability was limited (Kubiszewski et al., 2015). All values have been expressed in Australian dollars in real terms using a 2012 base year. Aggregation of state level data was further required for certain indicators.

Table 1
Indicators used in calculation of GPI.

Indicator	Method of calculation	Type of capital	Valuation approach & method	Operation
Personal consumption expenditure	Σ PCE	Built	Market	
Adjusted personal consumption	PCE × GINI coefficient	–	–	Add
Cost of consumer durables	Σ Expenditure on clothing/footwear, household appliances and vehicle purchases	Built	Market	Add
Services of consumer durables	Σ previous 5 years' consumer durables expenditure × 0.2	Built	Market	Add
Cost of unemployment and underemployment	Total unprovided hours (both unemployed and underemployed) × Median non-managerial adult wage ($/hr)	Social	Market	Add
Net capital investment	Net additions to capital stock + cost of maintaining existing capital ($pa)	Built	Market	Add
Cost of water pollution	Value of clean water × percentage of unclean freshwater	Natural	Damage function	Subtract
Cost of air pollution	Damage cost of air pollution (particulates 2.5) × amount of air pollution (particulates 2.5)	Natural	Damage function	Subtract
Cost of net farmland change	(Number of farmland acres lost) × value of farmland	Natural	Damage function	Subtract
Cost of net forest cover change	Number of forest cover acres lost × value of forest cover	Natural	Damage function	Subtract
Cost of climate change	CO_2 emissions from fossil fuel combustion × social Cost of Carbon ($/tonne)	Natural	Damage function	Subtract
Cost of ozone depletion	Cumulative CFC emissions × damage cost	Natural	Damage function	Subtract
Cost of nonrenewable energy resource depletion	Energy consumption × replacement cost	Natural	Non-market	Subtract
Value of unpaid household labour	Total hours of unpaid labour × average opportunity cost ($/hr)	Human	Non-market	Add
Cost of family changes	Cost of divorce + cost of sedentary TV time	Social	Damage function	Subtract
Cost of crime	Number of each crime × victim cost estimate for each crime	Social	Non-market	Subtract
Value of volunteer work	Total hours of volunteer work × average opportunity cost ($/hr)	Human	Non-market	Add
Cost of lost leisure time	Total hours of overtime × average opportunity cost ($/hr)	Human	Damage function	Subtract
Value of higher education	Number of persons 25+ with bachelor degree or higher education × social value of higher education	Social	Non-market	Add
Cost of commuting	Total hours spent commuting × average opportunity cost ($/hr) + direct costs for vehicle purchase and maintenance	Human	Non-market	Subtract
Cost of motor vehicle crashes	Number of crashes × average cost for injury or fatality ($/incident)	Social	Non-market	Subtract
Genuine Progress Indicator	**GDP – Σ all indicators**			

education. Indicators that have had the most significant downward influence on the GPI in recent years include the costs of non-renewable resource depletion, climate change and commuting. Charts illustrating Australia's GPI including individual indicators are provided in Appendix 2.



3.2. Economic Trends

The trend for economic indicators in general was consistently positive, with a significant increase in the rate of growth over the last two decades. Economic indicators represented the largest proportion of the GPI overall. The cost per capita of consumer durables has remained consistent over time, yet services from durables have increased. This is likely due to the cost of these goods falling over time due to improved technology and cheaper manufacturing costs; however, the data also shows an increase in the services these goods provide to individuals over time.

There has been a positive trend in net capital investment over the study period but this has been subject to increased volatility in recent years. Net capital investment strongly reflects underlying economic conditions and thus mirrors the financial troubles of the late 2000s, namely the Great Financial Crisis in 2008. The trend for underemployment reflects a small increase over time, indicating that the employment market has been expanding at a relatively slower pace than population growth.

3.3. Environmental Trends

All of the environmental indicators contributed negatively to GPI. The most noteworthy and substantial costs came from the cost of climate change and the cost of non-renewable resource depletion. The cost of ozone depletion was also significant but it has leveled off since the signing of the Montreal Protocol and the removal of chlorofluorocarbons (CFCs) from production in the 1980s. In fact, cost of ozone depletion is one of the factors being considered for removal from GPI (Bagstad et al., 2014; Talberth and Weisdorf, 2017); however, it may remain relevant in Australia due to the continued exposure to harmful UV rays (Department of the Environment and Energy, n.d.), leading to damaging health impacts (Norval et al., 2007). The other environmental indicators, such as the costs of water pollution, air pollution, and net farmland change all steadily and slowly increased but remained far lower than we had originally anticipated. It is possible these costs in particular have been underestimated, as the mechanisms to measure their costs are not particularly refined and the inconsistent availability of data limited our methodology and our findings.

3.4. Social Trends

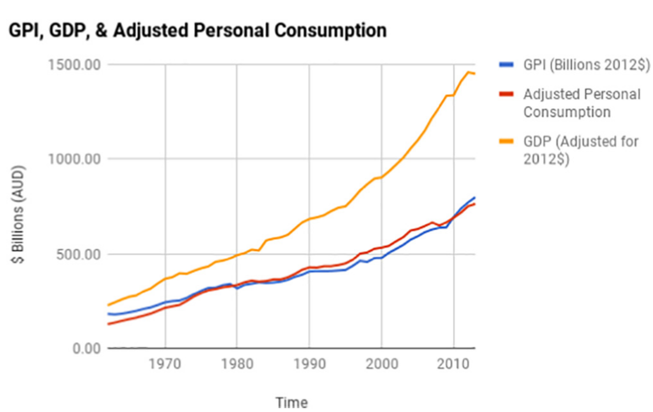
The social elements remained largely stable throughout the survey period (1962–2013). A key driver for the social aspects of the GPI is the cost of commuting. Given Australia's sparse urban geography and the related transport planning issues, average commuting time is high. The rapid increase in the number of private passenger vehicles has also driven up the cost of commuting, with the number of private cars increasing from two million in 1962 to 13 million in 2013. The increases in associated costs of private automobile ownership were partially offset by a decrease in public transport patronage from the early 1960s to the mid-1980s, generated by a fall in public transport revenues. Public transport patronage has since increased; in turn, a result of the reduced mobility brought about from urban traffic congestion and high vehicle ownership costs.

The value of housework was the largest contributor to the GPI after personal consumption expenditure, with a value of over $350 billion in 2013. The value of volunteer work was also a sizeable contributor, accounting for over $60 billion in 2013. The primary data sources for each were ABS time use surveys. Both indicators were heavily sensitive to the valuation method adopted. In each case, a market replacement figure would arguably provide the best proxy for the value of the goods produced or the services provided.

In the case of volunteer work, a net opportunity cost approach was adopted. This is likely conservative, and a gross opportunity cost approach has been used at a state level. For the purpose of comparability, the ABS provides estimates of each valuation method. The GPI would benefit from a finer understanding of the nature of volunteer work, its value and contribution to society. For household work, a housekeeper replacement wage rate was adopted. This might be a fair assumption in general, but misses or perhaps undervalues some of the finer aspects of household work, such as childcare. It led to a notably higher valuation for housework than the value for the United States, which has a much lower housekeeper wage. In a real sense, the value a country places on a service (or its minimum wage) determines the magnitude of its contribution to the GPI.

Leisure time increased in Australia from 2001 to 2013, mostly due to the impact of time-saving devices, reducing hours spent engaging in household work and saving 1% of household hours per year. The value of leisure time was calculated using the average wage rate of $33.35, for a total value in 2013 of over $38 billion.

3.5. Comparison to GDP



Our study found a continuous period of 'uneconomic' growth for the period of our study. This means at all points of our survey period, GDP, as a primary measure of economic productivity, exceeded GPI, a more comprehensive measure of well-being. This indicates that for every unit of economic 'growth' (as measured by GDP), this meant that matching growth in well-being (GPI) was either stagnant or negatively impacted (Daly, 1999).

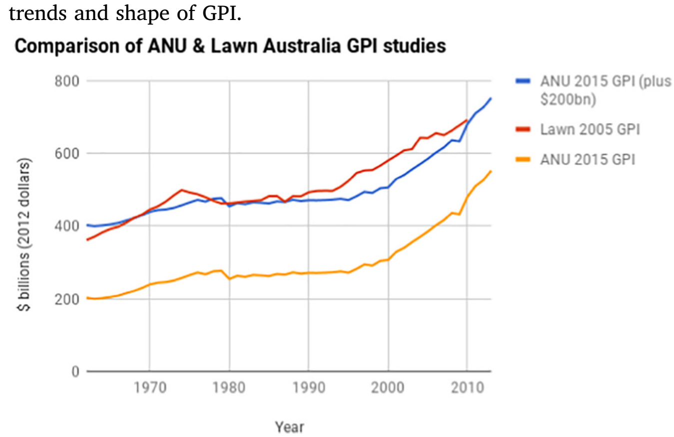
GDP steadily rose from the 1960s through to the mid 1990s, when it's growth rate accelerated through the 2000s. After the Global Financial Crisis of 2008, Australia's GDP slightly stagnated but did reasonably well in comparison to other Western nations, thanks to a mining boom which contributed 8.4% of Australia's GDP in 2009–2010 (ABS, 2012). However, this growth would have come at the expense of natural capital, which is part of why GPI is much lower than GDP throughout the study period. The costs of nonrenewable resource extraction and climate change in particular would not be captured by GDP, but they are accounted for as indicators in GPI.

3.6. Comparison to Other GPI Studies

The methods we used originated from Maryland and Oregon, and we thus sought to compare our findings both with those US states, and with the previous studies of Australia. We found both cultural differences in the calculation of the indicators as well as differences in data collection methods. First, there is a greater availability of environmental data for regions of the United States than in Australia, enhancing the rigour of calculations for these indicators in US studies and making calculation of GPI in Australia more difficult. The US Environmental Protection Agency collects data at both a national and state scale, the majority of which is widely accessible. In Australia, data in recent years was often available, but usually at the state level which then had to be consolidated into one national figure, and often with limited or no data for the earlier decades of this study. Indicators such as the cost of noise pollution and personal pollution abatement, for which Australian data is not directly available, meant our 'costs' for the environmental indicators are likely to be underestimated.

Furthermore, comparing the results of our study against Lawn's (2008) Australian GPI study, following an adjustment of our study figures to enable a direct comparison, there are differences both in the selection of indicators and their calculation. Lawn's study indicated that GPI exceeded GDP until the mid 1960s, with GDP outstripping GPI thereafter (Lawn, 2008). In our study, however, GDP exceeds GPI throughout the study period indicating a continuous period of uneconomic growth in Australia.

The trend for GPI over the study period was consistent between the two studies; however, there was a disparity of approximately AUD 200 billion per year between the calculated GPI values. This study produced a much lower estimate of GPI than did Lawn (2008), and the primary driver of this difference was the calculation of Unpaid Household Labour. As a consequence of adopting the Maryland and Oregon approach in our study, we accounted for the cost of Unpaid Household Labour whereas the Lawn study did not include this cost. The chart below shoes our GPI compared with Lawn's (2008) study, largely mirroring the trends and shape of GPI.



3.7. Data Constraints

We encountered certain constraints in the collection of our data, particularly for the environmental indicators. For example, the calculation of air pollution utilized measures of particulates in each state of Australia, drawing from data provided by the National Pollutant Inventory (Department of Environment, 2014). However, data was only available from 2007 onwards, so extrapolations were made to account for improvements in air pollution technology over time. The sources of data were also quite varied for our environmental and social indicators, as opposed to the economic indicators where most data seemed to be available directly through the Australian government. On a number of occasions, we needed to locate state data and compile it state by state to create a national figure. This can be a useful exercise, particularly if we wanted to follow up with a state GPI study, but it also assumes that state calculation for each of the indicators is identical.

While the issues of data constraints were not limited to the environmental indicators, it was the most consistent in the difficulty of locating the data, which in turn was often incomplete. Despite more accessible and more thorough data, similar problems in missing or inconsistent data, particularly for environmental indicators, were also encountered in a number of the US studies (Bagstad et al., 2014).

Omissions of particular components are likely if they are not problematic in a domestic context. In our local sensitivity analysis, we unsurprisingly found that adjusted personal consumption was a significant contributor to the GPI outcome, as was the value of housework. However, indicators such as the cost of family changes and the cost of air pollution bore little impact on the final GPI, even when zeroed out. This suggests an agreement with the literature, which argue for eliminating such indicators, both for their lack of impact and to streamline GPI calculations (Talberth and Weisdorf, 2017; Fox and Erickson, 2018). (See the supplementary spreadsheet to see our sensitivity experiments). A lack of data might also occur for other reasons, such as lack of government funding or institutional capacity. As such, steps should be taken to standardize the collection of environmental data going forward, in part to assist with future studies of GPI, but also to provide policymakers with the information necessary to make informed, environmentally sustainable, and scientifically sound decisions.

Differences in the prominence of social and environmental effects are expected across countries. This raises the question of whether a standard GPI across all indicators is both necessary and practical, and how substitutability of indicators is to be handled (Fox and Erickson, 2018). One option might be to require GPI between countries to cost the primary indicators within a national context, with further indicators optional, for example, a minimum requirement to cost the top six environmental indicators. The indicators could be substitutable depending on the local environment, geography, and resource use. This study omitted three environmental indicators included in studies in the Unites States due to lack of data: the cost of net wetland loss, of net forest cover change and of noise pollution.

Data constraints were also found in the calculation of social indicators mainly to find the social value of some indicators. For instance, research papers were consulted to get the human capital value of higher education, which has been calculated for Australia in different years. Although having some estimates of human capital is very valuable, more time series data is essential to achieve more realistic trends over time. The lack of data required us to extrapolate values and assume, for example, that a 25-year-old person and a 50-year-old person with the same education would have the same income.

4. Discussion

Is Australia heading in the right direction? Our findings and previous studies (Lawn, 2003, 2008; Lawn and Clarke, 2006b) suggest there is much to be done to improve Australia's 'societal well-being'. Although both our study and Lawn's (2008) have found that GPI has been slightly increasing in recent years, closer analysis reveals this is largely due to economic growth, at the expense of increasing environmental damages over time and relatively flat social progress. This suggests Australia's rising GDP is due to a conversion of natural capital into built and/or economic capital, with no consideration given for thresholds and a finite supply of resources in the natural world (Rockström et al., 2009). While GPI also struggles to account for and to incorporate these ecological thresholds (Lawn, 2003), it begins the process by recognizing that the conversion of natural capital puts an increasing strain on Australia's ecosystem services, threatening the well-being of both current and future generations. Such an outcome can arise from a lack of regard for environmental (and other) externalities, or by embracing a perspective of weak sustainability, which argues that types of capital are interchangeable (a hospital is equal in worth to a forest) (Beckerman, 1994), as seen in the Global Savings Index proposed by the World Bank (Hamilton, 2000). Previous GPI studies have pointed out the issues with this approach (Andrade and Garcia, 2015; Kubiszewski et al., 2015) and warn against assuming stocks of natural capital can be anything but 'quantitatively and qualitatively intact' in the long-term (Andrade and Garcia, 2015). These studies also advocate, as we do, for supplementing GPI with 'satellite accounts' or alternative models of natural capital to determine what is and what is not 'ecologically sustainable' in regards to societal welfare (Lawn, 2003).

Despite these similar trends between our study and Lawn's, there were also notable differences. Our study measured GPI using different datasets to calculate the limited environmental indicators, for example air pollution, as Lawn used nitrous oxide and sulphur dioxide to calculate the damage cost, while we used particulates (NSW EPA, 2013). We also differed in our accounting for government expenditure. As a consequence of adopting the Maryland and Oregon approach for the purposes of comparison, we omitted this from the GPI as calculated in the earlier approach of Lawn. Adding in government expenditure and its effect strengthens the Australian GPI. In accounting for expenditure, Lawn and Clarke discount government spending significantly to adjust for defensive and rehabilitation expenditures (Lawn and Clarke, 2006b). That some expenditure should be discounted is not controversial, but setting the size of the discount rate is both important and requires careful consideration.

4.1. GPI Going Forward

As both our methodology (drawing from Maryland and Oregon) and Lawn's studies are accepted measures of GPI, this points to several key issues with the structure, data, and calculation of the GPI, at all scales.

First, these differences demonstrate that we need ways to compensate for missing or inadequate data, a problem not limited to developing nations. In Australia, we found little to no information on several measures and were forced to either eliminate them, or settle for proxy measures that are likely to be less accurate. Even with the assistance of the ABS in identifying data sources, there were still multiple instances where sources did not neatly line up with data catalogues. This resulted in lengthy searching for data sources from local and state governments and matching between data sets was often required.

However, even though our method calculates GPI using 27 indicators, not every country, region, state, or culture has access to all of the necessary data. There are alternatives to address this issue, such as using replacement proxy measures (particulates instead of ozone for cost of air pollution) but perhaps a larger issue is that these selected indicators are not necessarily the things that contribute most to well-being. In short, GPI takes a more holistic measure of well-being than the sole focus on economic productivity as measured by GDP. As previously discussed, the problems of equating growing GDP with a nation's progress is problematic because all the externalities it devalues, including natural capital, social capital, human capital, health, unpaid work, etc. (Cobb et al., 1999; Grootaert, 2001; Natoli and Zuhair, 2011). GPI distinguishes itself with its efforts to include social and environmental externalities and yet, significant problems still remain. Several studies (Graham, 2012; Kubiszewski et al., 2013; Chuluun et al., 2014) suggest that indicators such as exercise, marriage, and neighbors significantly contribute to well-being. None of these indicators were directly captured in any GPI studies (McGuire et al., 2012; Kubiszewski et al., 2015). Other studies suggest that certain indicators, such as the cost of ozone depletion, are no longer relevant, thanks to international progress on phasing out CFC's since the 1987 Montreal Protocol (Bagstad et al., 2014; Talberth and Weisdorf, 2017). Various formats have been proposed to address these issues, from expansion of GPI to include more relevant indicators (Bagstad et al., 2014; Kubiszewski et al., 2015), to the creation of a new hybrid framework that includes the economic, environmental, and social elements of both GPI and the SDG's, but also draws from a dynamic and non-linear model of the human-economy in-society in-nature (Costanza et al., 2016a). No model has been accepted as a universal standard yet.

This leads to the second issue, that the lack of consistent data availability, and differing methods of GPI calculation (out of necessity or choice) mean that there is no universal 'standard' for GPI, making comparison between various countries, regions, or states extremely difficult. As one of the foremost difficulties in this study was the collection of data, a first step in working towards mainstreaming the GPI as a global standard would be to standardize the methodology and data collection for the economic, social, and environmental indicators. An oft-cited critique of GPI is the inconsistency of the data used between different studies (Lawn, 2003; Costanza et al., 2004; Kubiszewski et al., 2013), which is often the result of the inconsistent availability of similar datasets between countries, regions, or states (Bagstad et al., 2014). In a GPI study for all 50 states of the US, Fox & Erickson were often forced to use national level data scaled down to the state, which can distort or dilute the real 'impact' of that indicator on the calculation of GPI (Fox and Erickson, 2018). The authors stress, as do we, the need for state level, or at least regional data, as this allows for a more direct comparison and assessment of how differing state or regional policies can lead to different outcomes in wellbeing (Fox and Erickson, 2018). In short, the finer tuned the data is, the more precise the insights can be into the impact of policy. However, this will need to be assessed against the tradeoffs of the cost of collection and compilation of such data.

Two separate studies on the same country (ours and Lawn's on Australia) arrive at different numbers, but find similar trends in the nation's GPI. It is comforting to know our different methodologies trace roughly the same trend in a relatively stagnant GPI for Australia, but through our experience, it is also easy to envision the complexities of accurately comparing GPI between different nations. In contrast, GDP, as the standard of economic well-being for the past several decades, is calculated in similar ways for every nation, which allows for easy comparison. The GPI does not currently reach that level of uniformity. There certainly needs to be more similarity, perhaps through the creation of essential 'core' components of GPI, which can be supplemented by additional indicators if available or desired. The United Nations Sustainable Development Goals (SDG's) (Costanza et al., 2016b), the OECD World Forum (Shaw, 2015) and studies on happiness, well-being, and GPI 2.0 (Graham, 2012; Bagstad et al., 2014; Chuluun et al., 2014; Talberth and Weisdorf, 2017) have begun conversations to that effect, moving towards a more comparable and comprehensive measure of national well-being.

In terms of potential, there is much to be drawn from the creation and adoption of the System of Environmental-Economic Accounting (SEEA) in 2012, an initiative which began with the United Nations (UN) Statistical Division in 1993, but was not officially adopted until 2012, with the framework finalized and released in 2014 (United Nations, 2014). SEEA is an accounting framework, based on the System of National Accounts (SNA), also developed by the UN. Similar to GPI, it provides a series of indicators for economic and environmental indices, in an attempt to better capture the complex relationship between the environment and the various 'stocks and flows' of capital assets, both economic and natural. The system was designed to apply to all nations, no matter the stage of development of their statistic and accounting systems (United Nations, 2014). However, the limited inclusion of social indicators (such as income inequality, the cost of commuting, or the cost of crime), and a continuing debate on ways to best account for the health of the environment, means that a holistic picture of societal well-being is still out of reach if we were to solely rely on SEEA. However, a UN led partnership between GPI and SEEA to create a hybrid framework, particularly given the holistic focus of the UN's Sustainable Development Goals, could very well be the platform needed to form an ideal global standard (Costanza et al., 2016b).

The final issue with GPI, and other measures of well-being, is a reliance on an antiquated accounting system. Current 'accounts' of any sort (financial, natural, social, etc.) are, largely, based in a system of measurements that have not been updated in decades in their methods; they do not take advantage of our updated capabilities to more accurately measure our indicators (Kubiszewski et al., 2015; Costanza et al., 2016a). For example, 'citizen science' efforts and the prevalence of mobile phones allows for decentralized measurement of a number of indicators. This approach was used to great effect in Australia through the WaterWatch program, where farmers, land managers, and community activists took part in water quality measurements and then sent the data in by text message, which was then collated into state databases (Waterwatch Australian Capital Territory, 2016). Other examples could include the Household, Income, and Labour Dynamics in Australia (HILDA) survey, the British Household Panel Survey (BHPS) in the UK, or the World Values Survey, which collect well-being and life satisfaction information at regular time intervals. This effort should also draw upon the increasing number of modeling tools that employ spatially explicit methods to calculate the benefits of social and ecosystem services (Daily et al., 2009; Bagstad et al., 2014; Kenny, 2017). These models operate at various scales and could either replace or supplement national data in calculating a measure of well-being. For example, models exist that calculate the value of natural capital and ecosystem services at the global level, like the Global Unified Metamodel of the Biosphere (GUMBO) (Boumans et al., 2002), the national scale, such as the Multiscale Integrated Model of Ecosystem Services (MIMES) (Boumans et al., 2015), and local scales, such as the Artificial Intelligence for Ecosystem Services (ARIES) (Bagstad et al., 2013). Recognizing the value of advancements like these means our 'accounts' can draw from real-time data and models at multiple scales, leading to a more accurate measurement.

One suggestion for improvement and efficiency in generating GPI data would be for specific data sets to be generated by relevant government agencies, primarily the ABS, drawing upon their experience calculating the Measures of Australia's Progress (ABS, 2014a). Models that collect data and calculate individual indicators could be of great use in this effort, as there is no holistic GPI system in place at the moment. Moving forward, efforts should seek to incorporate these more dynamic accounting systems so as to create a more streamlined, more consistent, and more accurate measure of the various indicators that contribute to well-being.

It is important to note here that a number of the problems associated with GPI come from its role as a composite indicator (Hoskins and Mascherini, 2009). Composite indicators form a single metric based on multiple indicators, as GPI does for societal well-being based on a series of economic, environmental, and social indicators. GDP does the same, providing a single measure based on a series of individual indicators, as this one number is easier to track and analyze as opposed to tracking the trends and patterns of a myriad of economic indicators. Extensive discussion on the pros and cons of composite indicators has been covered in the literature (OECD, 2008), but we think it important to mention for two essential reasons. The first of which is that we view GPI as a tool for discussion about how our society progresses; it is not the goal in and of itself. GPI, or a similar alternative indicator, provides a starting point for discussing where our society can progress and the type of future we as a society want to build. This does not negate the value of such a measure; it just means the context, assumptions, and desired outcomes are important to keep in mind when discussing any GPI. On a related note, the second reason is that discussion and debate around the indicators that form the composite indicator will always be contentious, and it should be because societal well-being is incredibly important and holds significant potential to determine political outcomes. However, we do not believe this should exclude GPI from being used, or from a universal standard being adopted, as the purpose is to improve societal well-being. GDP is widely (and inappropriately) used as the marker for well-being (Lequiller and Blades, 2004; Graham, 2012; Stiglitz, 2012; Fioramonti, 2013, 2017; Kubiszewski et al., 2015; Costanza et al., 2016b), and thus moving forward with even an imperfect alternative measure that includes social and environmental considerations, such as GPI, is a vast improvement.

4.2. GPI 2.0

Despite the various issues with GPI, it remains a necessary and leading alternative measure of well-being, particularly given increasing recognition of GDP to be inadequate as the primary standard of human well-being (Lequiller and Blades, 2004; Graham, 2012; Stiglitz, 2012; Fioramonti, 2013, 2017; Kubiszewski et al., 2015; Costanza et al., 2016b). The rise in studies seeking to calculate GPI and other objective or subjective measures of well-being is a positive sign that academia, policymakers, and the general public are increasingly aware that more contributes to the public well-being than economic productivity. We are encouraged by this development.

In our hopes for a universal standard for well-being, our purpose in calculating Australia's GPI was not to produce a number, but to serve as a call for better measurement and management of our nation's well-being (Dean, 2014). While proposals for GPI reform are not new (Bagstad et al., 2014; Talberth and Weisdorf, 2017), these studies (including our own) can serve as starting points for a new measure of the nation's well-being. Based on those findings, we believe that regardless of what name is given to the nation's new measure, the following should be essential components of the new universal indicator:

- All types of capital (human, built, social, and natural) should be accounted for in this new measure. Past measures, namely GDP, have focused almost exclusively on the flows of marketed goods and services. While they may include some costs of maintaining, replacing, and building built capital, there is very little direct accounting of social, human, and natural capital, leading to poor management. GPI includes measures for social capital, such as costs of crime or the benefit costs of volunteer work, and for natural capital, like the cost of climate change.
- Using and adapting to the 'best' data that actually measures well-being. The field of well-being and happiness is ever changing and evolving with new findings, and the national measure should seek to accommodate this knowledge to ensure the most vital indicators of well-being are included (Graham, 2012; Chuluun et al., 2014; Bleys and Whitby, 2015). For example, an analysis of HILDA surveys by Kubiszewski et al. (2018), suggest that 'life satisfaction' is more indicated by an individual's amount of exercise in a week than income. This finding is supported in the literature (Fox, 1999; Alfermann and Stoll, 2000; Penedo and Dahn, 2005; Pretty et al., 2007) but it means that a national account of well-being should accommodate this information, and find a way to measure it.
- Updated systems of accounting are integrated into the measure, so as to utilize the most accurate data available but also to take advantage of the new technologies available. This could include drawing from 'big data' that has become increasingly widespread and available, or it could include more grassroots like efforts, drawing upon the popularity of mobile phones to engage in 'citizen science' efforts, similar to WaterWatch in Australia. Social network analysis, employing tools to examine Facebook, Twitter, LinkedIn and others, could be incredibly useful in assessing the mental state of a population (Ellison et al., 2007; Steinfield et al., 2008; Burke et al., 2010). Fitness devices and mobile phones track amounts of exercise and may be able to create a picture of national physical fitness (Chen et al., 2015). There are undoubtedly significant ethical questions to be raised in this collection and use of such personal data, questions deserving a paper of their own. We simply wish to point out the existence and potential for this data, as it is something we have not had access to until the recent decade.
- Select 'core' components to allow for international comparison. As discussed earlier, one of the main criticisms of measures like GPI is that the availability of data means each GPI study is often unique (Bagstad et al., 2014; Kubiszewski et al., 2015; Talberth and Weisdorf, 2017). Even if most studies have the same 'core' of indicators, those indicators may be calculated differently, making comparison between nations very difficult. As such, we suggest the adoption of international 'core' components of GPI, perhaps drawing upon larger efforts such as the United Nation's Sustainable Development Goals (SDGs) (Costanza et al., 2016b). This is likely to be the most difficult to accomplish, as the debate around what contributes to well-being is fierce (Graham, 2012; Bleys and Whitby, 2015), but even starting with measurements of an imperfect 'core' could lead to valuable insights about global development efforts. Based on previous studies on a 'GPI 2.0', the value of non-renewable resources and the value of ecosystem services are crucial components for the environmental indicators (Bagstad et al., 2014; Bleys and Whitby, 2015; Talberth and Weisdorf, 2017; Fox and Erickson, 2018), and the value of employment (or costs of underemployment) (Lawn and Clarke, 2006b), the value of housework, personal expenditure, government spending, and the costs of income inequality together form the biggest economic and social components (Bagstad et al., 2014; Talberth and Weisdorf, 2017; Fox and Erickson, 2018). The fewer the components selected, the easier it is to calculate GPI, and so priority should be given to those components that are easy to find and significantly contribute to GPI outcomes (OECD, 2008; Fox and Erickson, 2018). Whatever components are selected, it should be done with transparency as to why those indicators were selected (and why others were excluded) and to be clear about the ultimate purpose and place of using such indicators in policy decision-making (Bleys and Whitby, 2015; Fox and Erickson, 2018). This could be complemented with the addition of 'periphery' components, more relevant and specific to the nations being studied (Olafsson et al., 2014). Using this 'core' and 'periphery' approach would allow for comparability between nations, while recognizing the flexibility needed to account for important national specificities. These additional components could be developed directly with participatory input from those nations, particularly policymakers so as to increase GPI's relevance to political decision-making. As previously mentioned, drawing from SEEA and the SDG's could be the ideal platform for these discussions at the international level (United Nations, 2014; Costanza et al., 2016b).
- On that note, integrate these measures of well-being into national government accounts so as to inform policymakers and policy decisions and be clear about the role of such measures in decision-making (Bleys and Whitby, 2015). The measurement of these indicators is a first step, but it must be followed by action. Measurement for measurement's sake serves no purpose, so integrating these measures into an actionable policy forum, such as the Measures of Australia's Progress (MAP), can help our national governments maximize limited resources to improve citizen well-being (Graham, 2012; Bagstad et al., 2014; Bleys and Whitby, 2015). Measurements of well-being are resource intensive, both in time and money, and there is pressure on governments to cut down on waste, but by measuring these indicators, governments can manage prosperity for long-term sustainability.

4.3. Policy Implications

There is an increasing political and public awareness of social and environmental externalities, in Australia and globally. This creates a positive space for alternative methods of measuring these factors and their impacts on well-being (Dean, 2014). As a result, the GPI is one path forward as a possible alternative to GDP. Fortunately, much of the groundwork has been laid in Australia by previous studies (Lawn, 2008) this study, and past government efforts towards social and environmental accounting (ABS, 2014b). While there remains much to debate in terms of measuring well-being (see Graham, 2012 for the implications of well-being and happiness in politics), if a nation knows overall trends in indicators that are "acceptable, understandable and measurable", such as those provided by GPI, policymakers can tackle the 'lowest hanging fruit' that contribute to (or damage) human well-being the most (Graham, 2012; Bleys and Whitby, 2015).

The results of the study provide starting points for a range of policy initiatives. Our findings suggests that while economic growth is a factor in some countries' national well-being, governments should seek policies that seek to minimize environmental damage, but also actively maintain and build the benefits of natural capital so as to improve societal and inter-generational well-being (Bleys and Whitby, 2015). In terms of specific solutions, costs of climate change and non-renewable resource depletion, for example, could be addressed through the introduction of tradable resource permits and tax incentives for resource conservation. Commuting, which has social, environmental and economic impacts, could be addressed through improved public transport and city planning policies (Kelly and Donegan, 2015). For social costs, policymakers considering cuts to education funding would have a better understanding of the value of an educated public and their contributions to the nation's well-being (Graham, 2012). However, without a sense of that value, or a way to measure it, policymakers could be making a significant decision based more on rhetoric than an informed conclusion.

According to GPI, policy should also seek to deliver more equitable distributions of income, particularly given the divergence of economic growth, as measured by GDP, and well-being indicators (Bleys and Whitby, 2015). Addressing income inequality would have a significant impact on economic well-being, and significantly improve Australia's GPI (Wilkinson and Pickett, 2009; Stiglitz, 2012).

In seeking to create a tool directly applicable to policy, efforts should be made to build on the work of GPI and other alternative indicators of well-being and to combine them with the efforts in dynamic modeling, (i.e. simplifying and adapting something like the GUMBO model (Boumans et al., 2002) to focus on the indicators provided by GPI). Such a model, developed with the assistance of policymakers (for example, in Australia, those previously involved with the Measures of Australia's Progress (MAP)), could provide a system capable of highlighting holistic trade-offs between various policy decisions and their effects on the key capital classes captured by GPI (natural, human, social, built). This might reduce the need for extensive data gathering and analysis, and if driven by the new 'core' and 'periphery' approach, could allow for international comparison, and still provide insight specific to Australia's national context and be directly usable by policymakers.

These options and others are all on the table. A national measure of GPI and its associated indicators can give our politicians a more comprehensive system of accounts (economic, environmental, and social). With these metrics in hand, policymakers can prioritize those indicators that represent the best investment of limited public resources for maximum development of human well-being (Graham, 2012). In terms of policy, our message is a simple one: what gets measured gets managed, and it has become increasingly clear we need to measure and act on more than just GDP.

5. Conclusion

The Genuine Progress Indicator has the potential to change our thinking about the future direction of our world beyond measuring progress purely through growth of marketed goods and services. GPI has undergone considerable methodological improvement since its initial development 20 years ago, and its expanding presence within a number of jurisdictions means the GPI is continuing its journey towards becoming a mainstream – rather than an alternative – measure of progress.

While this study is neither the first to measure GPI, nor the first to measure GPI for Australia, it highlights a number of potential issues to address, and presents an opportunity for further research efforts. This study reveals differences between the Australian studies, and suggests the need for consistent methodology in the calculation of the GPI. The differences between our study and Lawn's in calculating the GPI for Australia does create a more holistic picture of societal well-being by providing varying perspectives and methodologies. With that said, if GPI is to reach international prominence as the standard supplement to GDP, consistency is needed.

The selection and calculation of indicators should be addressed through further research to ensure that the GPI can be replicated and meaningfully interpreted into political decision-making. Greater advocacy is needed in Australia to mainstream the GPI into policy debate, and this could be achieved through the introduction of a government driven pilot study within a new Australian state or territory. Some of this work is already completed or underway with the past efforts of MAP, past GPI state studies (Lawn and Clarke, 2006a) and the current work to create a System of National Environmental Accounts, which is being led by a coalition of experts from Commonwealth and State agencies, NRM Regions Australia and the Wentworth Group (Wentworth Group, 2016).

This study has highlighted a clear need for further work on developing Australia's GPI, and supports a need to develop more detailed national surveys of social and environmental indicators; and in the case of state level data, greater consistency and transparency in data collection approaches. In particular, a focus on improving environmental accounting will improve the valuation of natural capital. This study found significant differences in social and environmental attitudes between the US and Australia, reflected in both the calculation methodology and results. Furthermore, there are many opportunities for intra-country and intra-state comparisons. For example, a new national indigenous survey is currently underway, to compare progress of indigenous Australians to the rest of Australia (Biddle, 2014).

Australia could work to identify strategies to overcome these issues through the undertaking of a pilot study on a particular Australian state or territory, to complement work like Lawn's study on Victoria (Lawn and Clarke, 2006a) or recent study on South Australia (Lawn, 2017). Past studies like those, including this one, provide possible frameworks to follow, and the experience of those studies reveal that such a project could be implemented at a relatively low cost by the national government. Indeed, some of this work is already underway, with the ACT undertaking a system of Environmental Accounts as part of its State of the Environment Report (Wentworth Group, 2016). Current research at the Australian National University did an analysis of HILDA data (a nationwide survey on well-being), which could be supplemented by information from regional/rural well-being surveys undertaken at the University of Canberra by Jacki Schirmer (University of Canberra, 2017; Kubiszewski et al., 2018). In short, there are already studies in progress, but it may take coordination at a national level to establish a consistent System of National Well-Being Accounts for all of Australia. The valuable guidance gained through this study could help create a standardized model for the states and territories of Australia, thus providing a remarkably useful and consistent tool for our policymakers.

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Appendix A. Supplementary Data

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Appendices

Appendix 1

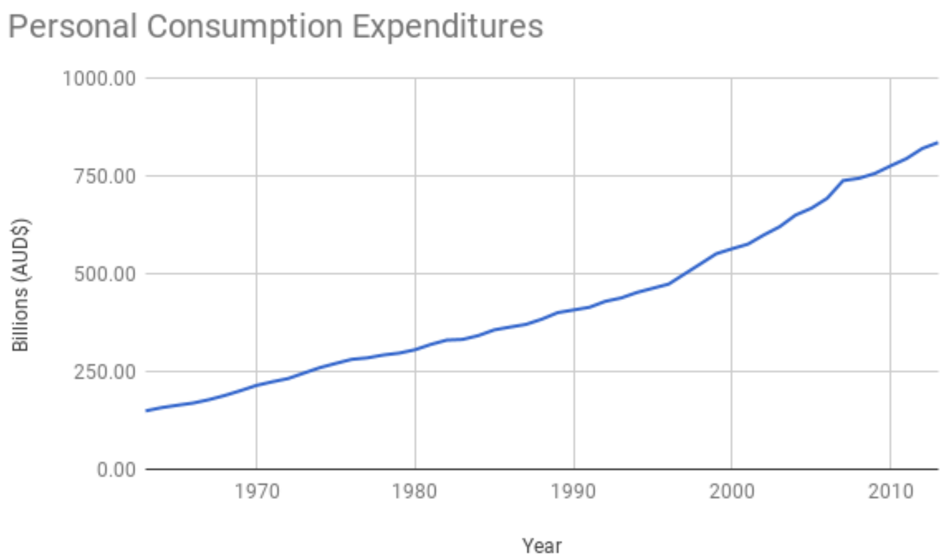
1.1 Economic indicators

Due to its importance in the calculation of GDP, time series data for economic indicators was readily available throughout the study period. Consumption expenditure, capital investment and unemployment are ongoing survey items for the ABS, and data is available at both the national and state/territory level (ABS 2014).

1.1.1 Personal Consumption Expenditure

Personal Consumption Expenditure information were taken from ABS Catalogue 5206.A2302236T and adjusted to the value of money in the year 2012 by dividing the Consumer Price Index estimate for each year in the time series by the Consumer Price Index estimate for the 2012 year. Data was available for all years.

There was a steady rise in consumption throughout the time period indicating Australia increased its consumption each year. There was a significant acceleration in consumption in the mid-90s that was sustained for the remainder of the time series. While PCE contributes substantially to well-being in the GPI it does not reflect the distribution of this consumption among the population. The Income Inequality indicator is used to measure these disparities and is subsequently used to adjust consumption information.

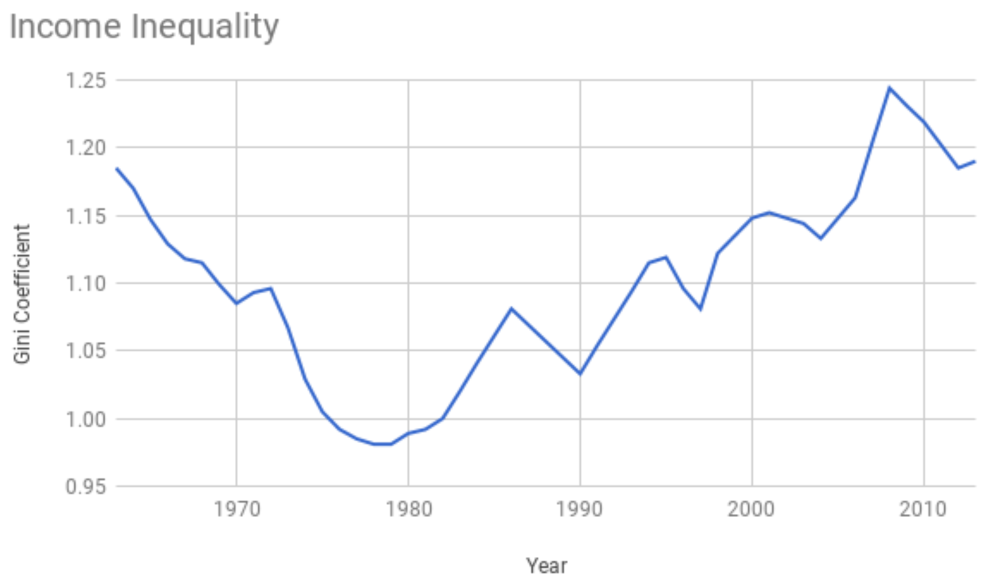


1.1.2 Income Inequality

Income inequality indicator was constructed using Gini coefficients for Australia and the share of income of the top 10% of Australians. Values for Gini coefficients calculated by the ABS (2013) and Johnson and Wilkins (2004) were merged for the 1982-2012 period as per the approach in Whiteford (2013). Values that are missing within the time period are interpolated using a linear function.

Estimating longer run trends of income distribution within Australia is often difficult because of the unavailability or poor quality of data (Saunders 1993) with the income shares of the top 10% in Australia used to construct the indicator from 1962-1982. Atkinson and Leigh (2007) find that top 10% income shares perform well as a proxy for the Gini coefficient relative to other commonly used measures of income distribution. Moreover the data contains trends that match cross-sectional studies of inequality that estimate the distribution of individual income is similar in 1942/43 compared to the 1989/90 year (Saunders 1993) and a rise income distribution in 1968/69 relative to 1932/33 (Jones 1975) that continues in 1978/79 (McLean and Richardson 1986). An index was used to normalise values from the two datasets so they could be joined together to construct the indicator.

The indicator shows decrease in inequality from 1962 to the mid-1970s and a trend of increasing inequality from the early-1980s to 2013. A fall in inequality is seen following the Global Financial Crisis in 2008.



1.1.3 Adjusted Personal Consumption

The adjustment to personal consumption expenditures accounts for the distribution of incomes represented by the income inequality indicator. The inequality indicator was normalised to 1970 by dividing the value of each year by the 1970 value. Adjusted Personal Consumption was estimated by dividing the personal consumption expenditure values by the normalised inequality values calculated in indicator 2.

Adjusted Personal Consumption Expenditures are similar to values without adjustment until about 1990. However the gap between adjusted and unadjusted values widens considerably from 1991 to 2013. This fall in adjusted consumption expenditure is as a result of increasing inequality over that time.

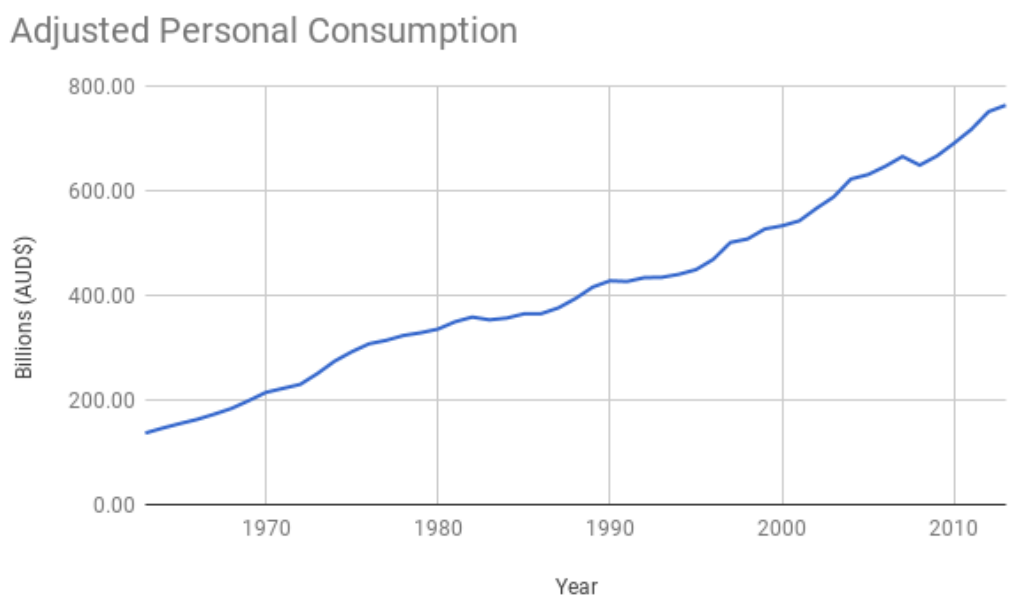
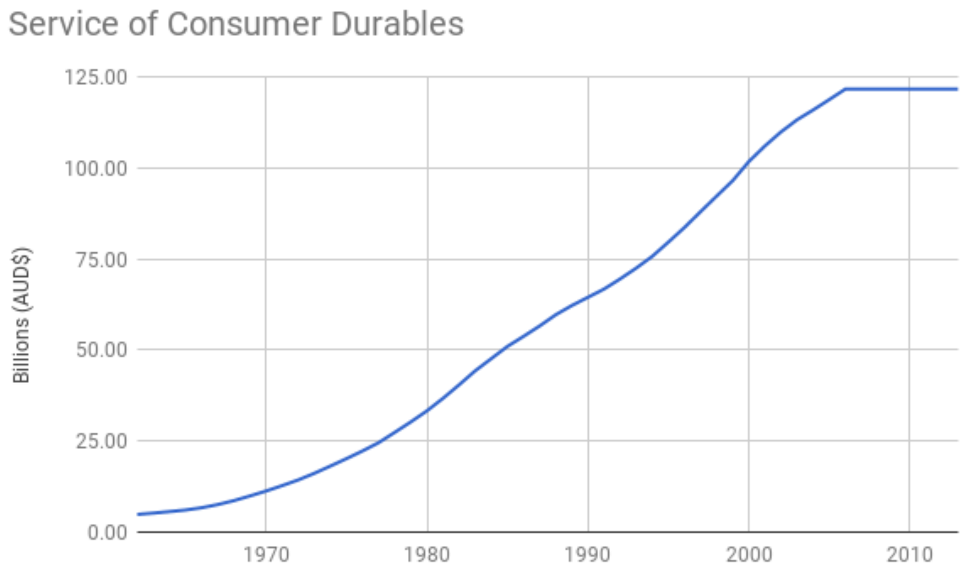


Figure: Adjusted Personal Consumption Indicator (constant, 2011/12 dollars)

1.1.4 Services from Consumer Durables

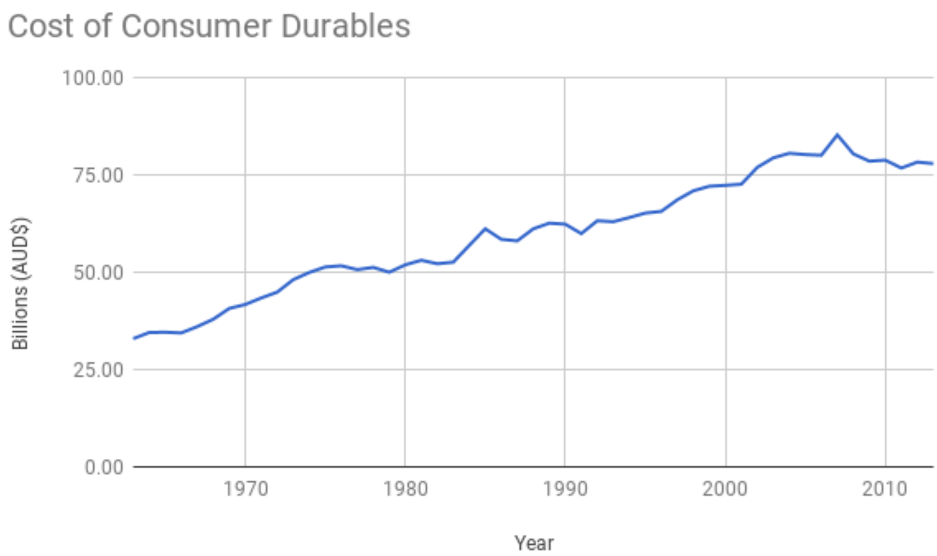
The services from above expenditure are depreciated over time (8 years based on the Oregon methodology) to accurately capture their ongoing contribution to welfare in each year of the study period. The only adjustment made is in the final 8 years of the data, where the stock of consumer durables remains constant to adjust for the fact that utility of durables are maintained until goods are replaced.



1.1.5 Cost of Consumer Durables

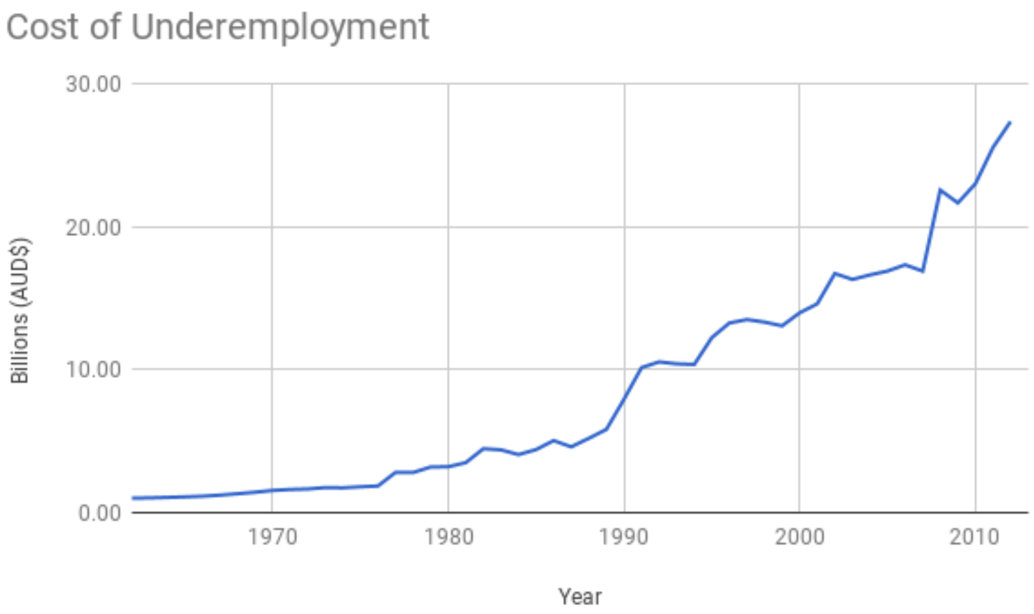
Consumer durables are goods that are purchased infrequently and whose consumption benefits are enjoyed over a longer period of time. Unlike personal consumption expenditure whose value is captured only in the period the cost is incurred, consumer durables behave like stocks and flows- that is, they have an immediate and ongoing value. Consequently, their benefits are both captured in the GPI at the time their cost is incurred, as well as through the ongoing services goods purchased in previous periods provide.

Consumer durables include the expenditure categories of clothing and footwear, household appliances and private vehicle purchases. This data was readily available from the Household Expenditure Survey.



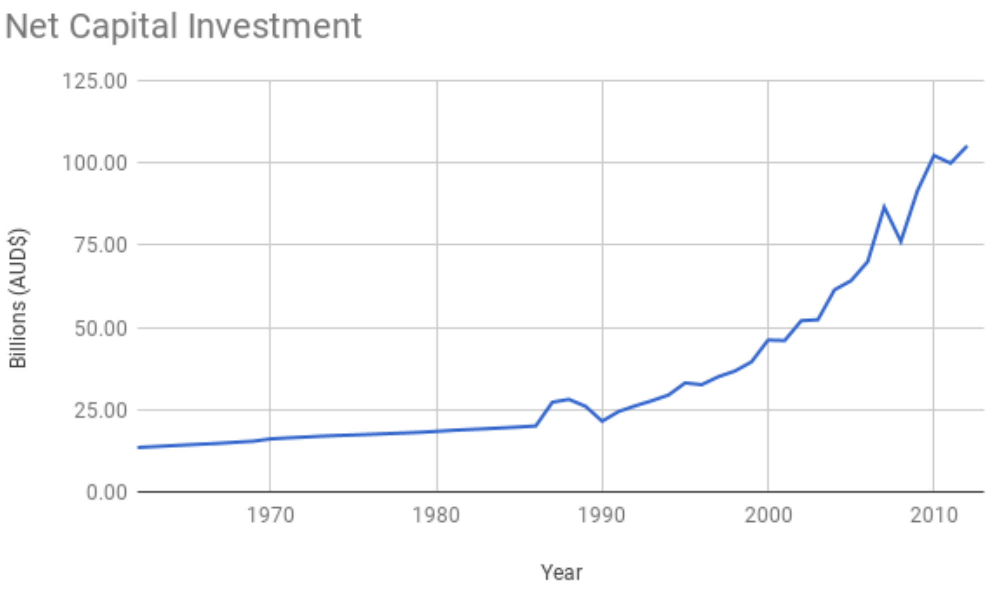
1.1.6 Costs of Unemployment and Underemployment

The costs of labour shortfalls have been calculated by determining the total rate of unemployment and underemployment, using both ABS data and extrapolation prior to 1978. The cost of unprovided work hours was calculated by adopting the median adult non-managerial full-time wage and determining an hourly wage rate, and multiplying by total annual unprovided work hours. This is considered to better reflect the unprovided earning potential of both the unemployed and underemployed than the minimum wage rate.



1.1.7 - Net Capital Investment

Net capital investment comprises fixed capital formation during a given period and was taken from the National Income Account. The Oregon calculation method does not differentiate private and government fixed capital formation.



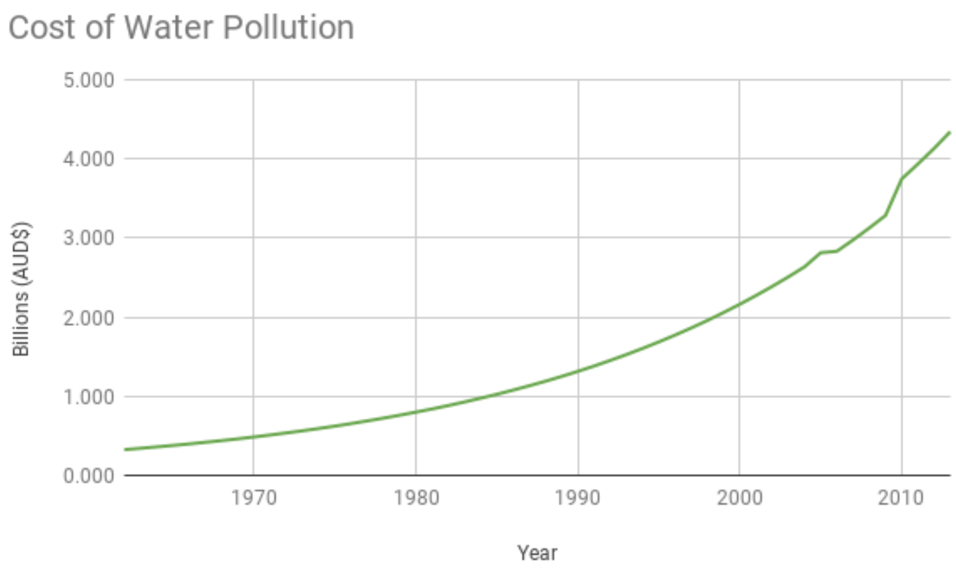
1.2 Environmental indicators

There was challenge in finding the data for environmental indicators due to partial data availability as some information is only available at the state level and some of the data is available at national level only for certain time periods. A further difficulty was due to significant data gaps for environmental indicators overall. Data utilised in our research was acquired through the ABS and other governmental departments. Unlike economic data, most environmental data are incomplete and are not collected systematically. Estimates on the socio-economic costs of environmental degradation are also limited.

1.2.1 Cost of Water Pollution

Drawing from previous studies of GPI for Maryland and Oregon (McGuire et al. 2012; Kubiszewski et al.), the formula for determining the costs of water pollution is the value of clean water multiplied by the percentage of the water that is unclean or polluted. This percentage was obtained from a study by AUSRIVAS (Australian River Assessment System) under the Australian State of the Environment program (2011). Reports had been produced for 2011, 2006, and 2001 and the percentage of impaired sites totalled the percentages of “significantly impaired” and “severely impaired” sites found in the report. For the intervening and previous years, an interpolated rate of 2 per cent increase was assumed for the impairment of the river systems, based on the trends noted in the reports.

For the value of the water, this was derived from the numbers provided under the Environmental Expenditure Account for Australia, using values for wastewater management and water management from the Australian Bureau of Statistics (ABS 2014). ABS provides expenditures on these two areas for the years 2009 and 2010, dividing them by industry use. While this data is undoubtedly limited, we believed they provided the best accounting of the value of water as a resource in Australia. The growth rate from 2009 to 2010 is roughly 10 per cent for both wastewater management and water management, but we assume a much more conservative growth rate of 3 per cent for the value of water for the years preceding and following the data provided by ABS.



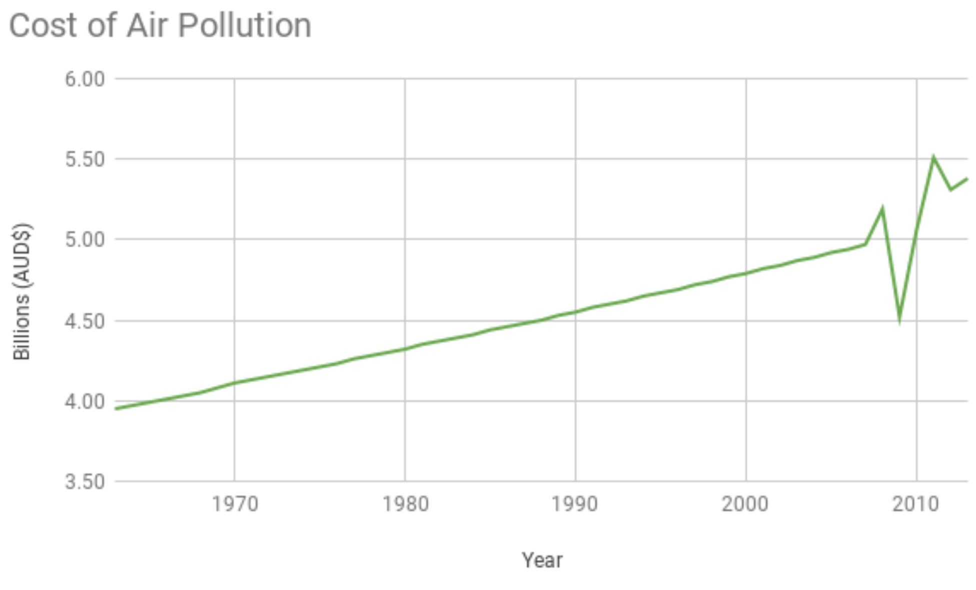
1.2.2 Cost of Air Pollution

The cost of air pollution is determined by the value of the damage costs of air pollution (as indicated by the proxy of particulates 2.5) multiplied by the volume of emissions of air pollution (represented again by volume of particulates 2.5) (McGuire et al. 2012; Kubiszewski et al.). Data on the emissions of particulates was obtained from the Australian Department of Environment's National Pollutant Inventory (NPI), for the years 2007-2013 (Department of Environment 2015). Data from the NPI was provided in kilograms (kg), and this was converted to metric tonnes to maintain unit consistency. For years prior to 2007, it was assumed that technological advances reduced the amount of particulate emissions by 1 per cent each year.

The value of the damage costs was generated from a study completed by a partnership between the Environmental Protection Authority (EPA) of New South Wales and PAE Holmes, an environmental consulting firm (NSW EPA 2013). In their report, they identify particulates 2.5 as the most suitable mechanism by which to estimate the health costs of air pollution, as well as provide a formula for determining the value of these costs per tonne of emissions, as the damage may increase or decrease in accordance with population density. This formula is: the Unit Damage Cost (in AUD $ per tonne of PM2.5) is equivalent to 280 multiplied by the Population Density (people/km2). The value of 280 is the constant derived from a linear regression analysis of previous case studies done in the UK, the US, and Australia.

Population density was determined using the 2011 population density of the capital cities of each state/territory of Australia, as found in the NSW EPA report. It was assumed that population density would grow by 1.5 per cent a year in these capital cities. It should be noted that this calculation assigns the particulate emissions of the respective state/territory to the capital city, which may not necessarily be the case. However, to determine the population density of every area in which particulates are emitted is beyond the scope of this study, and we were unable to find more localized data for air pollution. While this method may inflate the total cost of air pollution in some areas, we believe it does not negate the value of this estimation.

The report from the New South Wales EPA used 2011 Australian dollars, which was used for the calculation of air pollution costs, before converting these values to 2012 Australian dollars using the Consumer Price Index Inflation Calculator provided by the Australian Bureau of Statistics (ABS 2015).



1.2.3 Cost of Noise Pollution

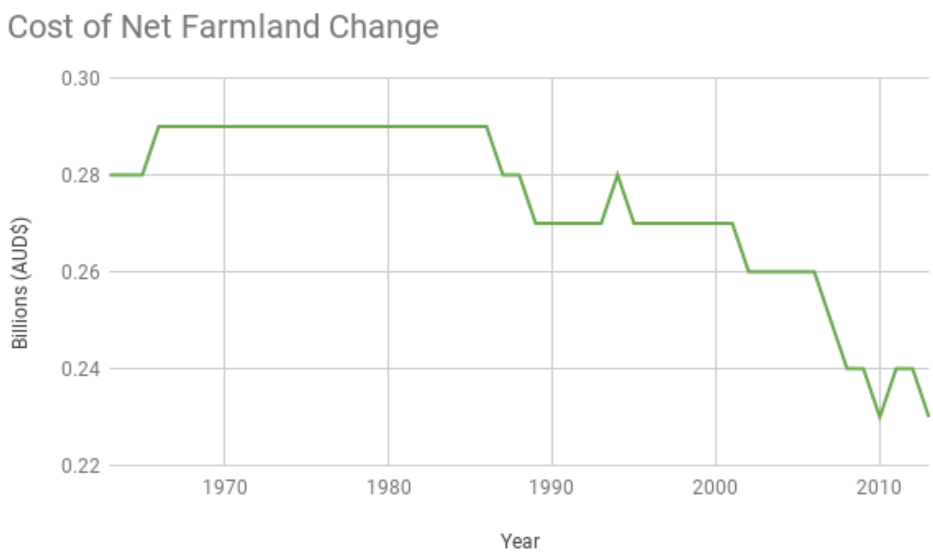
This was not included due to insufficient data.

1.2.4 Value of Lost Wetlands.

This was not included due to insufficient data.

1.2.5 Value of Lost Agricultural Land

Valuation for lost agricultural land is based on the data of land management and farming in Australia, provided by the ABS. Farming once accounted to 80 per cent of Australia's export (ABS 2012), therefore fertile agricultural land is a primary requirement. Agricultural land also functioned as renewable resource for replacing non-renewable resource, and as a provider of psychological benefit from aesthetic and historical value. Hence, the value is non replaceable (Lawn 2005). Between 1961 to 1976, the use of agricultural increase from 468 million hectare to 500 million hectare before gradually decreasing to 396 million hectare in 2013. The calculation for the cost of agricultural land is based on the Oregon GPI Calculation, which is adjusted from Maryland GPI calculation. The Maryland farmland value is adjusted per acre baseline data from product sales per acre. Oregon adopted this calculation, but added productivity at the rate of 2.9 compared to Maryland's 2.8. The value for Oregon is USD 3,280 per acre. Maryland's equation is numbers of farmland acres lost multiplied by value. Calculation for Australia is made by following Maryland's equation with converting the value to Australian dollars then converting the price from per acre to per hectare. Australia's agricultural land value is AUD 5979 (2012 dollars).



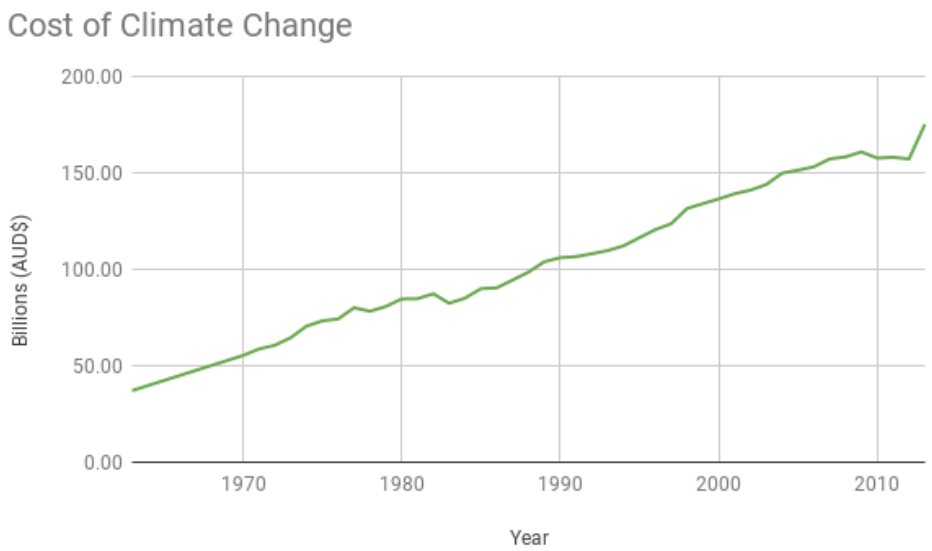
Indicator 13 – Net Forest Cover Change

This was not included due to insufficient data.

Indicator 14 - Cost of Climate Change

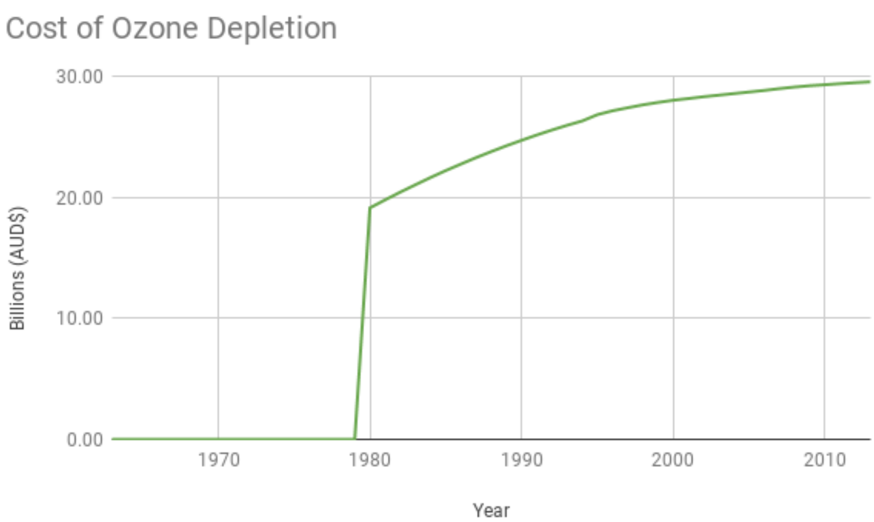
The cost of climate change was estimated using the equation below. Carbon dioxide (CO_2) emissions data from fossil fuel combustion was obtained from the International Energy Agency (IEA). Since data was only available from 1971 to 2012, emissions outside this period were estimated by extrapolation. For the social cost of carbon (SCC), alternative SCC estimates have been derived at different pure rates of time preference of between US$33 and US$270 per tonne

(Arent et al 2014). This study has adopted the estimate of the Intergovernmental Panel for Climate Change (IPCC) which assume a zero pure rate of time preference, yielding a social cost of US$270 per tonne of CO_2.



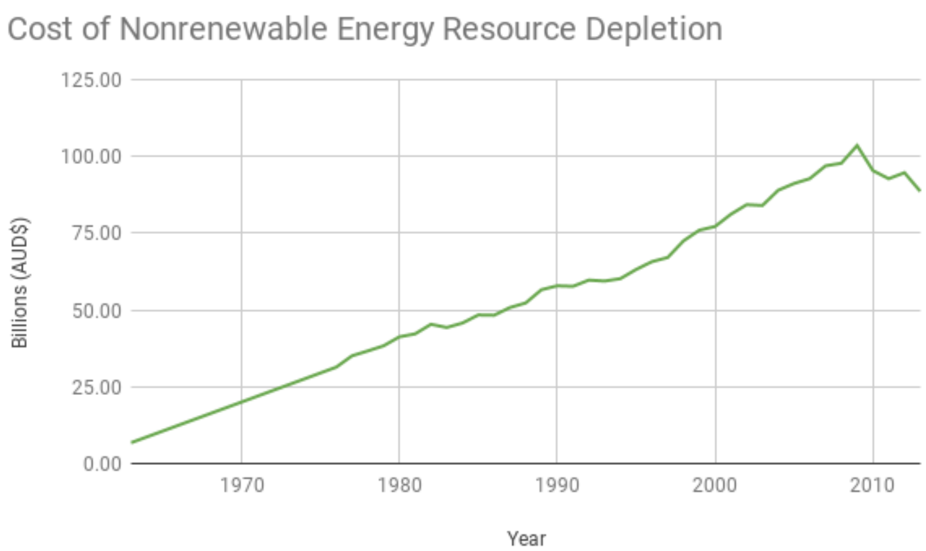
Indicator 15 - Cost of Ozone Depletion

The cost of ozone depletion was calculated using the equation below. Cumulative Chlorofluorocarbon (CFC) emissions were used because CFCs have long atmospheric lifetimes and damages persist long after they were emitted. CFC emissions data from 1995 to 2013 was obtained from Fraser et al (2013). Prior to 1995, emissions were estimated by extrapolating data from 1995 to when the emissions peaked at 2007 backwards. Because damage cost estimates per unit of CFC emitted are unavailable for Australia, it was assumed to be similar to that of the United States at AU$ 91,967 per tonne of CFC in 2012 dollars (Talberth et al 2007). Prior to 1980, the damage cost was assumed to be zero because substantial ozone layer depletion only began afterwards (US EPA 2015).



Indicator 16 - Cost of Nonrenewable Energy Resource Depletion

The sectoral energy consumption data from the Australian Bureau of Energy Economics (BREE 2014) is not disaggregated per fuel type. For this reason, it was assumed that the energy generated from renewable sources was exclusively used for electricity generation. Since energy consumption data was only available from 1977 to 2013, data outside this period were derived by extrapolation. The cost of replacement was used as a proxy for the cost of nonrenewable energy resource depletion. Equal proportions of wind and solar energy were assumed to replace fossil fuel consumption for electricity generation and biofuel for other uses. It is further assumed that such replacement employed the lowest cost options. The cheapest estimates for wind and solar energy generation were obtained from Hearps & McConnell (2011) and biofuel generation from Warden & Haritos (2008) at AU$54/MwH, 289/MwH, and 40/boe in 2012 dollars, respectively.



1.3 Social indicators

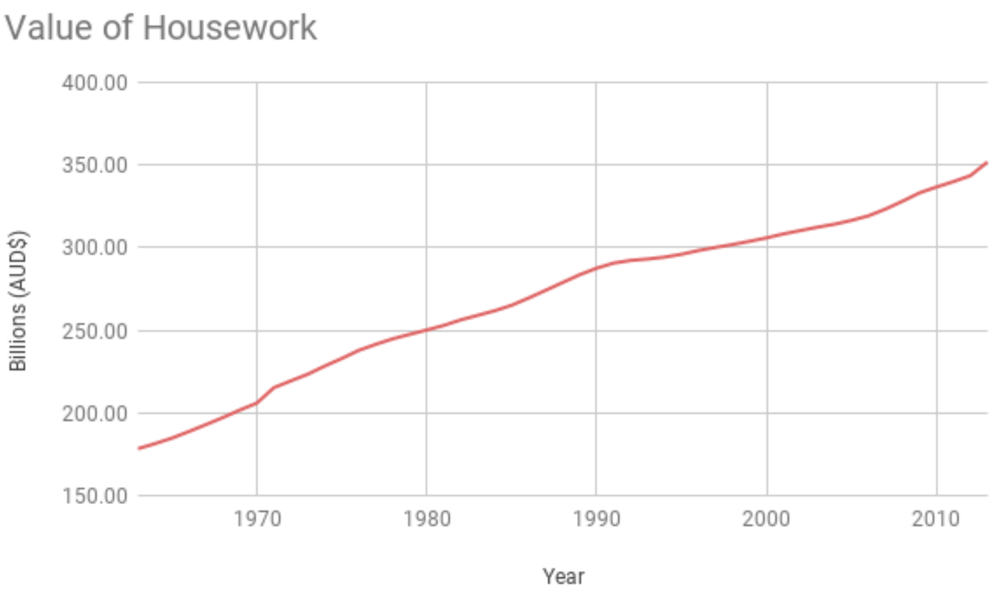
Data availability for social indicators was difficult to obtain. Some social indicators such as the value of higher education have not been previously included as part of Australian GPI studies, and therefore information for these indicators was collated from multiple sources.

1.3.1 Value of Housework

The value of household work is one of the biggest contributors to the GPI, with a value of approximately $352 billion in 2013. It includes: child care, housework, household activities, hours spent caring for and helping family members, household activities and family care. It is a significant addition to the GPI, and values non-market work that is excluded from traditional GDP calculations.

The value of housework is calculated as the number of hours per year of household labour, multiplied by the housekeeper replacement cost person wage rate. Hours of household labour per person per year was taken from ABS time use surveys, (the 1997 ABS survey (Cat. no. 5240), and the 2006 ABS Time Use Survey). We followed the approach of Lawn and Clarke in assuming that labour-reducing technological progress embodied in household appliances increased at a rate of 1 per cent per annum. We therefore adjusted the hours of unpaid work per Australian household upwards by 1 per cent per annum in the years prior to 1997. This value was then multiplied by the population aged 15 and over, found in the ABS Australian Historical Population Statistics 2014.

The household replacement cost person wage rate of $17.59 was taken from the ABS, cat. no. 5202. It was then indexed to 2012 values, and this figure of $20.56 used as the multiplier throughout all years (ABS Cat 5202).



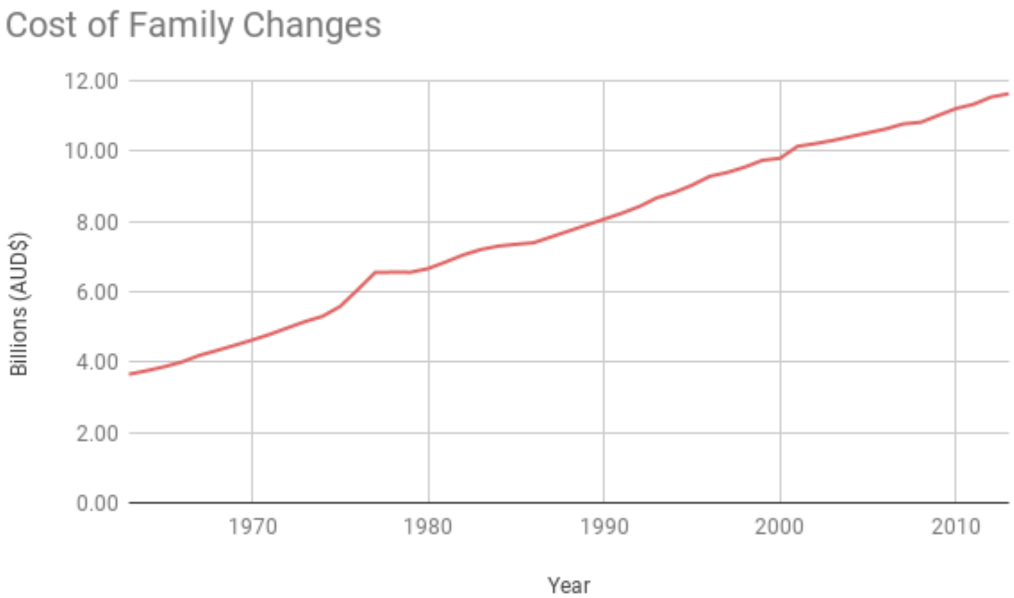
1.3.2 Cost of Family Changes

The cost of family changes metric quantifies costs of social disruption from divorce, and detrimental effects from television watching in households with children. Divorce is often accompanied by legal fees, counselling costs, disruption to children and psychological impacts. These costs, of $35,166 (indexed to 2012 dollars) were taken from a 1998 Report of the House of Representatives Standing Committee of Legal Affairs are multiplied by the number of divorces per year.

The GPI costs the number of hours of television watched per household with children, at a rate of $1.04 per person. The main driver of this cost is the impact of sedentary activity on health outcomes, and greater rates of obesity.

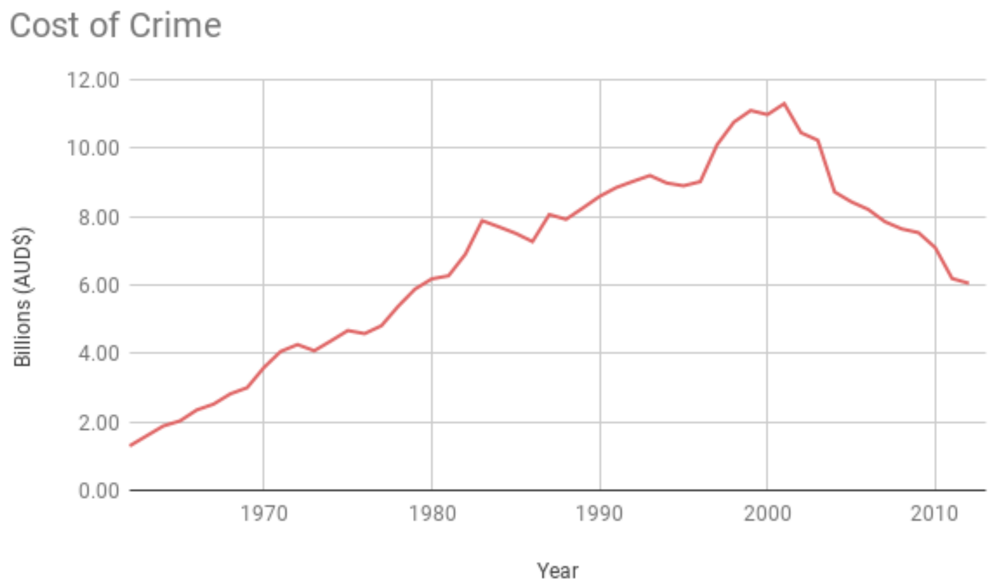
The data for this indicator relied upon ABS Time Use Surveys, the last of which was in 2006. An update to this survey would improve the indicator's accuracy. Technology continues to change the composition of screen use by Australians - smart phones use, tablets, and the ubiquity of streaming and on-demand multimedia have developed significantly since the last survey.

While sedentary effects may stay equal from participating in 'screen time', the nature of the screen activity can differ from educational, to cultural, to less socially desirable or 'mindless' television or screen participation. Future studies might look more deeply at research on the impacts of screen use in its various forms.



1.3.3 Cost of Crime

The cost of crime was calculated based on Lawn's study. The different types of crime include: homicides, assaults, sexual assaults, robbery, break and entry, motor vehicle theft and other theft. Each type of crime was multiplied by the estimate victim cost of each crime and all the values were summed. The data was collected from the ABS cat. 5410 and also from the Australian Institute of Criminology report in crime (2013). The estimate costs were extrapolated from three years.



1.3.4 Cost of Personal Pollution Abatement

This was not included due to insufficient data.

1.3.5 Value of Volunteer Work

Volunteer work provides a valuable service to Australian society. Volunteer work includes the physical care of adults, helping and doing favours, unpaid voluntary work, and all communication and travel associated with volunteer and community work activities (see ABS for a complete definition)

Volunteer work adds approximately $60 billion dollars to the GPI in 2013.

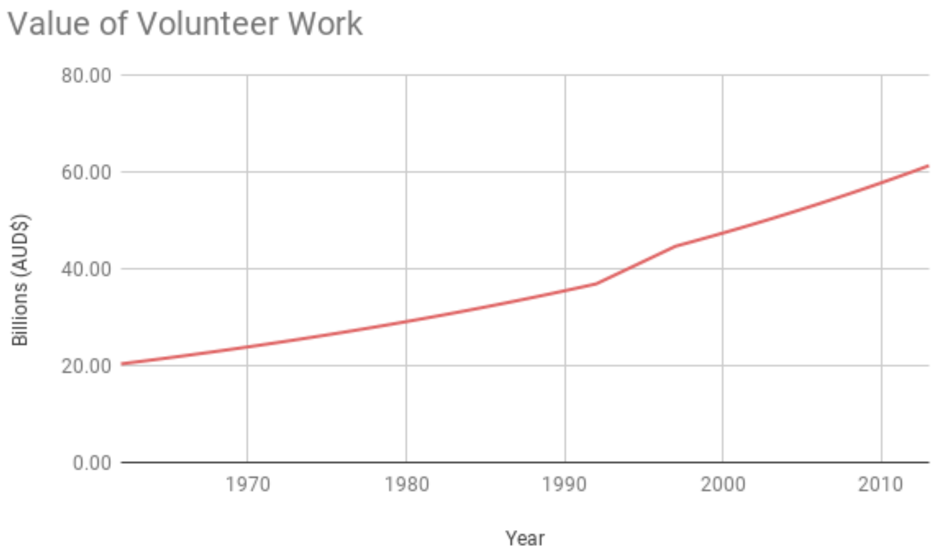
The value of volunteer work is calculated as the total number of hours of volunteer work per year, multiplied by the value of that work.

The primary source of data for number of hours volunteered is the ABS, in its 1997 and 2006 Time Use Surveys. Data has been interpolated between these years and extrapolated, indexed to changes in population.

There are a number of methods of valuing volunteer work. The best and most demanding to calculate, is accurately costing the value of volunteer work provided, across the range of volunteering environments. This study did not locate any comprehensive costing or survey of volunteer work based upon the actual volunteering activity, precluding that as a valuation measure. GPI studies in Oregon have used an average wage rate to value work, while Australian state level studies have used a gross opportunity cost approach (Kubiszewski et al. 2013).

In Australia, we decided that a direct average wage rate valuation approach was likely to overstate the actual value of the volunteer work, especially given that 44% of male and 32% of female volunteering was in sport and physical recreation organisations — contexts likely to be at the lower end of the work valuation spectrum.

The ABS, in its time use survey papers provides a number of different valuations, particularly to emphasise how the overall value attributed to volunteer work varies depending on the adopted valuation method. This study has adopted the net opportunity cost valuation rather than a gross opportunity cost method as a more conservative estimate of the value of volunteer work.



1.3.6 Lost Leisure Time

Leisure time grew, on average, in Australia over the reference period, mostly due to the impact of time-saving devices reducing hours spent engaging in household work.

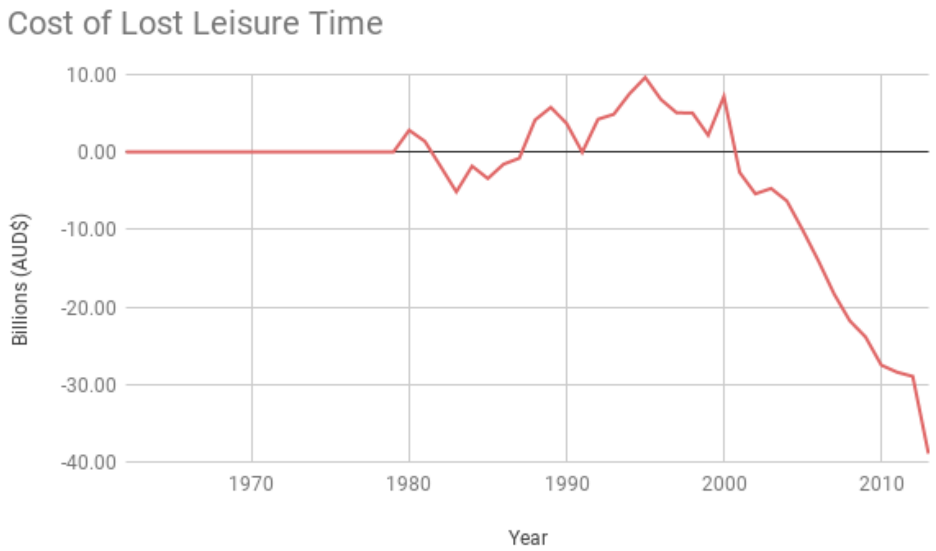
Leisure time, and its value is sometimes cast aside in discussions about workforce participation or the conventional drivers of economic growth in an economy, overlooked as residual time between other 'productive' activities, or as the rest component required for people to prepare themselves to keep working (or other socially beneficial activities such as child rearing, housework or volunteering). While leisure time might have restorative benefits, its value is worth measuring in its own right, for workers less enthusiastic about committing to increasing work hours, at home or in the workforce who might appreciate more time to spend as they choose. Its value could be accentuated when considered in the overall sustainability context, as a circuit-breaker to lifestyles centred on material goods. Organisations such as the New Economics Foundation are increasingly examining whether leisure time can be increased in the context of a reduced work week, as a matter of good public policy that may help better balance natural resource usage, human resources, and relationships.

Leisure time may be lost (or gained) through changes in work hours, and other activities such as housework or volunteering. While volunteering in particular might be seen as desirable and, by definition, voluntary, it still reduces leisure time (of which an increase is calculated as benefit), and its value is measured through the value of volunteer work indicator. The cost of underemployed is already captured under the Cost of Employment indicator. Both market and non-market work are counted (respectively measured in other indicators through income and the counting of household labour)

This study would ideally follow the approach of Leete-Guy and Schor, who use only data on unconstrained workers (workers in full-time employment, for the entire calendar year), as it is only likely those workers that would be experiencing overwork. However, the most complete data available from the ABS provides figures on an average full-time hours worked basis, which does not distinguish between workers who have just transitioned or begun (or finished) working full-time in that month, and those that have been working consistently throughout the year.

The result of lost leisure time is highly dependent on the base year chosen. In the Oregon state GPI study, the highest year of leisure time was chosen as the base year. In the Australian GPI, choosing the year with the most leisure time would result in a base year of 2013. As this would show earlier increases in leisure time as a cost, we have chosen the base year of the current study instead. The leisure time measure runs from 1978 reflecting ABS data availability.

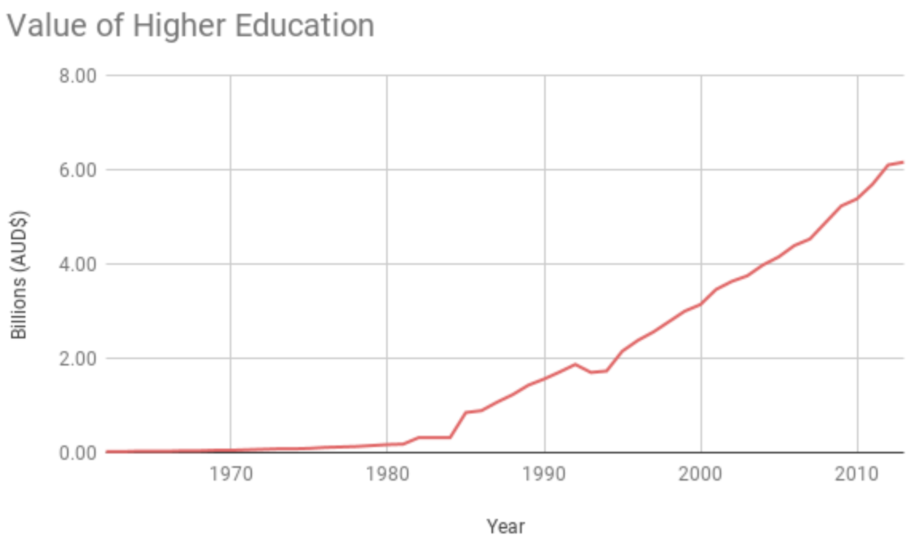
A notable component of the increase in leisure time is an adjustment made to household work time. Following Lawn’s approach, we reduce household work time by 1 per cent per year due to increased home efficiency from technological improvements.



1.3.7 Value of Higher Education

This was the first time the value of higher education was calculated for Australia. The indicator was calculated by multiplying the number of persons 25 years or older with bachelor degree or higher education by the social value of higher education. Data were found in the ABS cat. 6227 where the number of educated people were available starting in 1980. The previous years were extrapolated. The number of educated people from 1985 onwards increases in a drastic way in Australia.

One of the crucial parts was how to calculate the social value of higher education. We found a research report from the ABS that measures human capital flows for Australia (number 1351.0.55.023) and calculated the labour income per capita for educated 25 year olds. However, we assumed that for different ages the income per capita was the same. In the Vermont and Oregon studies the social value of higher was constant during time. A standard methodology is needed to calculate the social value for future calculations.



1.3.8 Services of Highways & Streets: not used due to insufficient data

This was not included due to insufficient data.

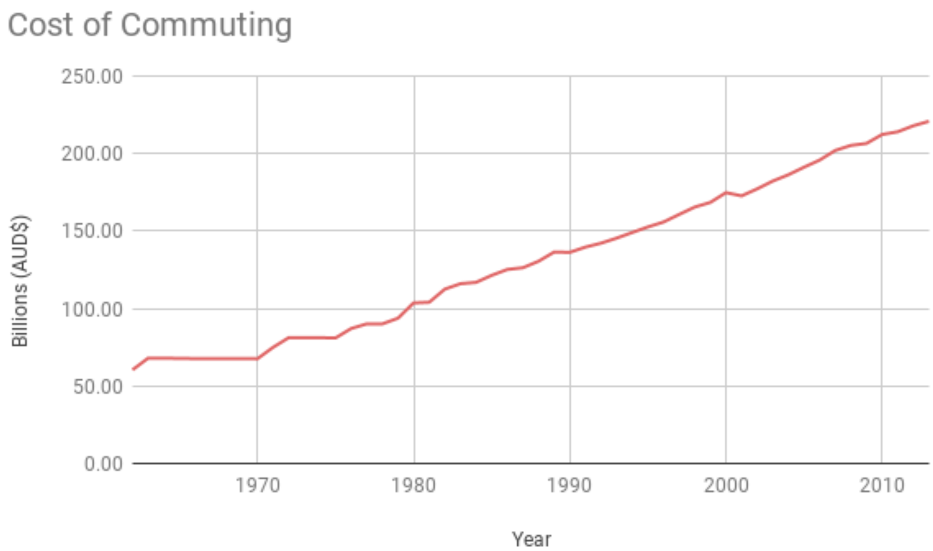
1.3.9 Cost of Commuting

The cost of commuting was a significant driver for the social components of the GPI. The cost of commuting was not included in Lawn's previous calculation of GPI for Australia. However, it was included in GPI calculations for Vermont and Oregon. The methodology used in this study is based on that of GPI studies in Vermont and Oregon (Costanza et al 2004). There are three key components to the cost of commuting indicator: direct costs for vehicle purchase and maintenance, public transport fare revenue, and the indirect cost for lost time due to travel. Combined, these components are used as a proxy for the cost of commuting over the study period.

The direct costs for vehicle purchase and maintenance consisted of the average annual national maintenance cost for private passenger vehicles, and the average cost of new vehicle purchases. Due to data limitations it was not possible to include purchase of used vehicles. The cost of a new passenger vehicle was calculated by taking the average of 2014 sales prices from a Royal Automobile Club of Queensland database. This figure was converted to 2012 dollars, producing a price of $32,986 for new vehicle purchases. The price was multiplied by the number of new vehicle purchases each year, based on data available in ABS catalogue number 9314.0 Sales of New Motor Vehicles. As this data series is only available between 2000 and 2013, vehicle purchase rates for previous years were calculated using the ratio of new vehicle purchases to existing private passenger vehicles for the period 2000 to 2013. Data for the number of private passenger vehicles was taken from ABS catalogue number 9309.0 Motor Vehicle Census.

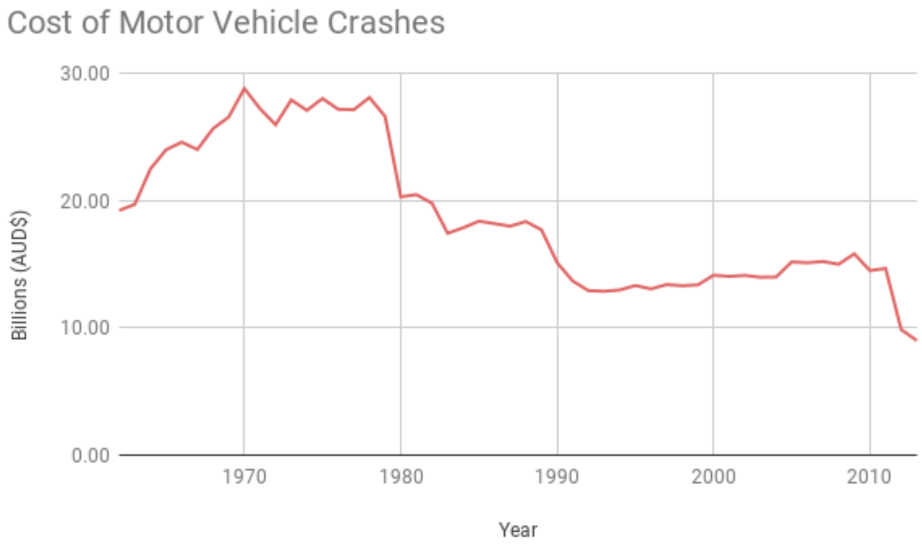
Public transport fare revenue was calculated by multiplying the average cost of a public transport journey by the number of trips. The public transport journey cost of $3.28 in 2012 dollars was calculated by averaging the cost of a single trip ticket in Melbourne, Canberra, Sydney, Adelaide, Perth and Hobart. Annual passenger trip data was obtained from the Bureau of Infrastructure, Transport and Regional Economics (BITRE 2014).

The indirect cost for lost time due to commuting was calculated by multiplying average commuting time, average hourly wage, working days per year, and labour force data. An average commuting time of three hours and 37 minutes per week was adopted, based on journeys to and from paid employment (Flood and Barbato 2005). A constant average commuting time was used for this study due to limitations in obtaining reliable data; a more rigorous approach would vary commuting time, which would change over time due to urban planning policies, advancements in traffic management, changes in mobility, and private transport affordability. The average hourly wage of $29.63 in 2012 dollars was taken from ABS catalogue number 6306.0 Employee Earnings and Hours. The calculations assumed 231 working days per year based on previous studies (Wang 2013). Labour force data was taken from ABS catalogue number 6202.0 Labor Force.



1.3.10 Cost of Motor Vehicle Crashes

The cost of motor vehicle crashes included two key components: cost of fatalities resulting from motor vehicle crashes, and the cost of injuries resulting from motor vehicle crashes. Each component was calculated by multiplying the number of deaths or fatalities by the respective unit cost. The unit cost for fatalities from motor vehicle crashes was estimated at $3.137 million per death in 2012 dollars (BITRE 2009). The unit cost for injuries from motor vehicle crashes was $0.313 million in 2012 dollars (BITRE 2009). The number of fatalities was taken from the Australian Road Deaths Database (BITRE 2015). Data for injuries from motor vehicle crashes was taken from data held by the Australian Transport Safety Bureau (ATSB 2007).



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