DEAKIN BUSINESS SCHOOL
Centre for Energy, the Environment and Natural Disasters

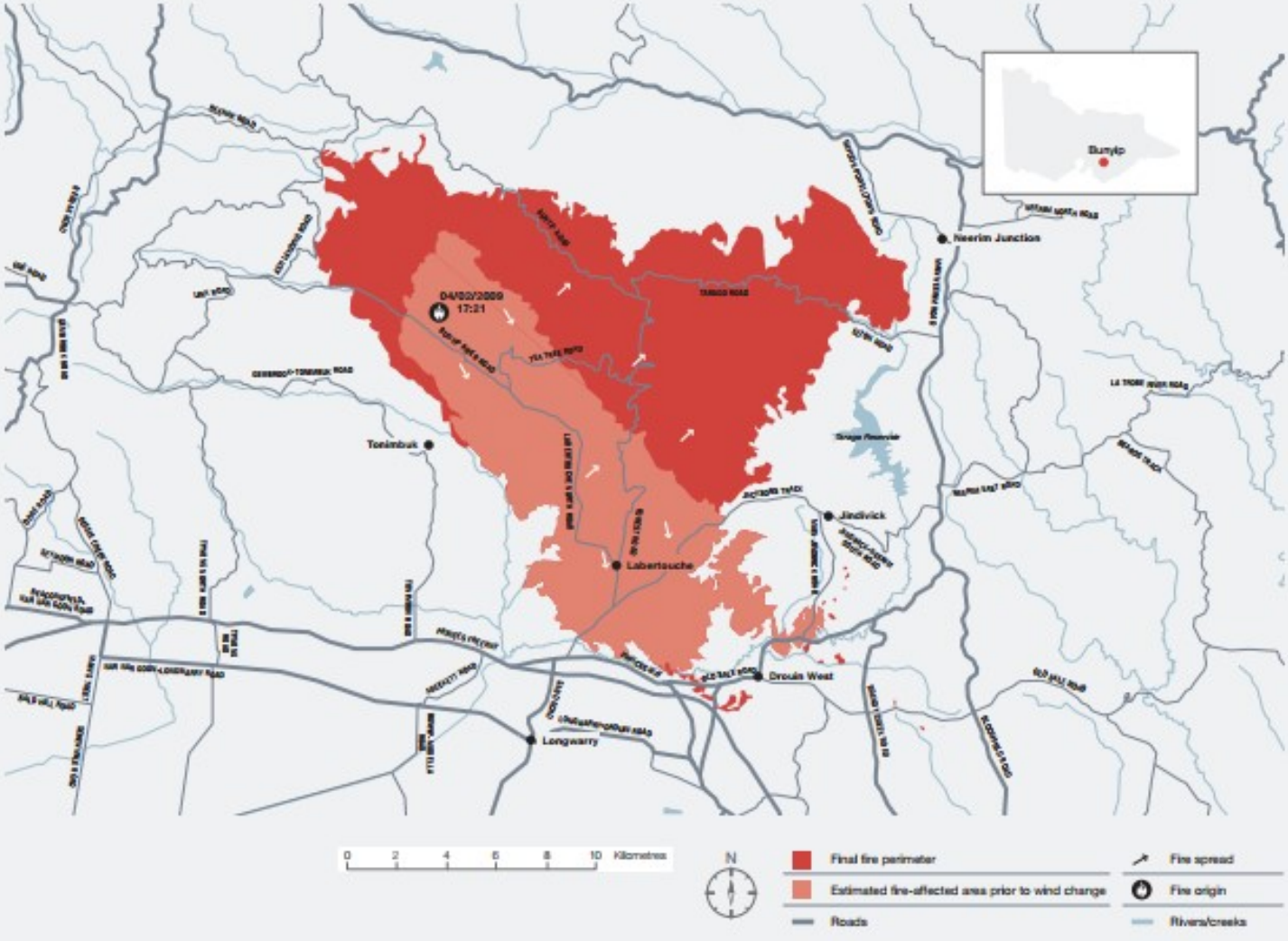
bushfire&natural HAZARDSCRC

bnhcrc.com.au

DISASTERS AND ECONOMIC RESILIENCE: THE EFFECTS OF THE BLACK SATURDAY BUSHFIRES ON INDIVIDUAL INCOME

A case study

Mehmet Ulubasoglu, Yasin Kürşat Önder
Deakin University



Version	Release history	Date
1.0	Initial release of document	15/06/2020

Australian Government
Department of Industry, Innovation and Science

Business Cooperative Research Centres Programme

Publisher:
Bushfire and Natural Hazards CRC

June 2020

Citation: Ulubasoglu M & Onder YK, *Disasters and economic resilience: the effects of Black Saturday bushfires on individual income,* Bushfire and Natural Hazards CRC, Melbourne.

Cover: The extent of fires for Delburn. Source: Black Saturday Royal Commission (2009)

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

As academic researchers, our primary focus is on producing high-quality research and rigorously examining the effects that disasters have on communities and economies.

To deliver socially meaningful and impactful research, we need to work closely with our government and research counterparts so that our research is holistic, directly answers the questions that policymakers are grappling with, and makes our Australian communities safer and more resilient to natural disasters.

Our partnership with the Bushfire and Natural Hazards Cooperative Research Centre (BNHCRC) has been a fantastic avenue for doing just that. We are grateful to the BNHCRC not only for generously funding this project, but also for their dedication and passionate support, which has facilitated conversations and pushed for greater utilisation of our research among end-users and beyond. For this report, we particularly thank Dr Michael Rumsewicz, Dr John Bates, Dr Desiree Beekharry and Dr Matthew Hayne for their commitment to identifying utilisation opportunities and fostering collaborative relationships with end-users.

We thank Ed Pikusa, our lead end-user from the Department for Environment and Water (SA), who has steadfastly promoted the value of our research. We are also grateful to Julie Hoy for ongoing support, guidance and suggestions for this particular case study. We also warmly thank all end-users who have at various stages collaborated on research design and informed the utilisation direction of the *Optimising Post-Disaster Recovery Interventions in Australia* research program. These organisations in alphabetical order are: Department for Environment and Water (SA), Department of Environment, Land, Water and Planning (VIC), Department of Fire and Emergency Services (WA), Emergency Management Australia, Emergency Management Victoria, IGEM South Australia, IGEM Victoria and Queensland Reconstruction Authority.

We are also thankful to fellow BNHCRC research project leads Professor Lisa Gibbs, Dr Melissa Parsons and Dr Veronique Florec for their support. Melissa and Veronique kindly provided information regarding their BNHCRC research projects (*Factors Affecting Long Term Community Recovery*, *Australian Natural Disaster Resilience Index,* and *Economics of Natural Hazards,* respectively). This information has strengthened the evidence base for our own research and provided opportunities for broader research utilisation.

We also thank the Australian Bureau of Statistics' DataLab team, especially Barry Tynan, for patiently uploading our program files and clearing outputs following countless sessions. We are also grateful to Talei Parker, Kim McCosker, and Salma Mujagic-Horvat from the same team, who provided significant support in different ways and on different occasions.

Finally, we would like to acknowledge the valuable contributions and tireless efforts of several researchers who supported or contributed to this project in its various stages: Ms Farah Beaini, Dr Muhammad Habibur Rahman, Dr Lan Anh Tong, Ms Merve Kucuk, Ms Trang Tran, and Professor Mevlude Akbulut-Yuksel. Farah skilfully managed end-user relations and contributed to the broader interpretation of results over and above her required role in the project.

END USER STATEMENT

Marcin Pius, Emergency Management Australia, ACT

Emergency Management Australia (EMA), as the national emergency management coordinating body, including national recovery policy, may have an opportunity to use findings from these reports at various national recovery fora, encouraging the recovery community to consider the findings in the design of future recovery policy and programs. EMA is often involved in reviewing national recovery handbooks, development of guidelines and frameworks and could use the report findings to guide the content of the resources being developed. Finally, in respect of sharing the results of this research, EMA will include these reports in its knowledge management repositories making it available to recovery communities across all jurisdictions.

KEY TERMS USED IN THIS REPORT

TABLE 1 ACRONYMS USED IN REPORT

Acronym	Explanation
ABS	Australian Bureau of Statistics
ACLD	Australian Census Longitudinal Dataset
ANZSIC	Australian and New Zealand Standard Industrial Classification. This provides a basis for the standardised collection, analysis and dissemination of economic data on an industry basis for Australia and New Zealand
BSB	Black Saturday Bushfires
GDP	Gross Domestic Product
GSP	Gross State Product
LGA	Local Government Area
SA2	Statistical Areas Level 2. Under the Australian Statistical Geography Standard framework used by the Australian Bureau of Statistics, SA2 are medium-sized general purpose areas built up from whole Statistical Areas Level 1. Their purpose is to represent a community that interacts together socially and economically.
VBAF	Victoria Bushfire Appeal Fund

TABLE 2 DEFINITIONS OF KEY TERMS USED IN REPORT

Term	Definition	Definition Source
Impact	The broadest term, includes both market-based (i.e. tangible) and non-market (i.e. intangible) effects. Individual impacts can be either negative or positive.	Stephenson, 2010
Difference-in-differences modelling	Difference-in-differences modelling is a quasi-experimental method that allows for evaluating the impact of a "treatment" on a group of interest. It is a natural experiment, in which one group has experienced the treatment, whereas another comparable group has not. The impact of the treatment is estimated by looking at the difference between the changes experienced by the two groups before and after the treatment.	Kennedy, 2003
Disaster risk	The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity. Annotation: The definition of disaster risk reflects the concept of hazardous events and disasters as the outcome of continuously present conditions of risk. Disaster risk comprises different types of potential losses, which are often difficult to quantify. Nevertheless, with knowledge of the prevailing hazards and the patterns of population and socioeconomic development, disaster risks can be assessed and mapped, in broad terms at least. It is important to consider the social and economic contexts in which disaster risks occur and that people do not necessarily share the same perceptions of risk and their underlying risk factors.	UNISDR, 2018
Economic resilience	At the macrolevel, static economic resilience refers to the ability or capacity of a system to maintain function (continue production) when shocked, while dynamic economic resilience is the ability and speed of a system to recover from a shock.	Xi et al., 2018

	At an individual level, this study considers an individual's income stream as effectively representing their economic resilience to external shocks.	Author
Natural disaster	Disasters caused by natural hazards. Natural hazards only lead to 'disaster' if they intersect with an exposed and vulnerable society (interrupting these systems) and when the consequences exceed people's capacity to cope.	Commonwealth of Australia, 2018a
Natural hazard	A natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation.	UNISDR, 2018
Tangible impact	Impacts on items that are normally bought or sold and that are therefore easy to assess in monetary terms.	Stephenson, 2010
Intangible impact	Impacts on items that are not normally bought or sold. Social and environmental impacts are considered to be intangible.	Stephenson, 2010
Resilience	The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and function through risk management.	UNISDR, 2018
Vulnerability	The conditions determined by physical, social, economic and environmental factors or processes that increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards.	UNISDR, 2018

1. EXECUTIVE SUMMARY

In an era when the reality of climate change is creating an uncertain future, it is imperative to consider the lasting impact this will have on Australia, which is historically prone to natural disasters. The increased possibility of more frequent and intense natural disasters present a number of issues for Australians, ranging from the impact on vulnerable communities to broader economic consequences.

In an effort to tackle this global phenomenon at a local level, we must turn our attention towards not only the actions required to support our businesses and communities but also to ensuring Australia is ready to adapt and become more economically disaster resilient in an ever changing environment. The urgency and delicacy of the matter is exacerbated when we consider that the average annual total economic cost of natural disasters in Australia is forecast to reach $39 billion per year by 2050 (Deloitte Access Economics, 2017) and that fiscal constraints will be imposed on government disaster expenditure due to Australia's aging population.

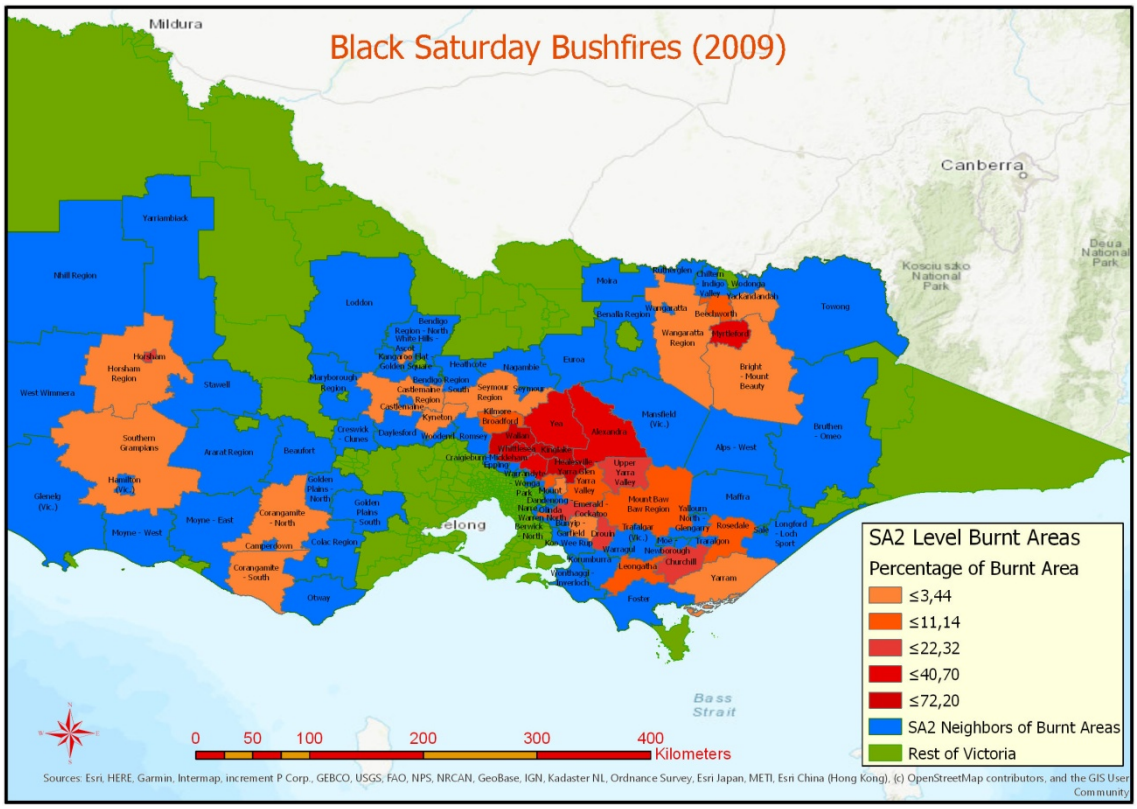
When a natural disaster strikes, the damages incurred are readily assessable in the immediate aftermath of the disaster. While this information is vital to the economic dimension of disaster resilience policy, it provides little integrity to analysing the direct impact such disasters have on the Australian people and, more specifically, communities and workforces that are more vulnerable to disaster.

To that end, the *Disasters and Economic Resilience: The Effects of the Black Saturday Bushfires on Individual Income – A Case Study* explores the impact of the Black Saturday bushfires (BSBs) on the income trajectory of individuals in the labour force and residents of the disaster-hit Statistical Area-2s (SA2s). These areas are depicted in red and orange in FIGURE 1.

The 2009 Victorian Black Saturday bushfires were some of the worst bushfire conditions ever recorded globally; equivalent to 1500 of the atom bombs dropped on Hiroshima going off (SMH, 2009). One hundred and seventy-three people died; over 2,100 houses and 3,500 structures were destroyed, and thousands more suffered damage (Parliament of Victoria, 2010). The total area destroyed was around 400,000 hectares (CFA, 2009). The toll was estimated to be $3.1 billion in tangible damages and $3.9 billion in intangible costs (Deloitte Access Economics, 2016). To the best of our knowledge, this study is the first in the economics literature to examine the impact of a bushfire on individual income, considering demographic and sectoral heterogeneities at very fine units.

The report makes a unique assessment of economic resilience at an individual level (measured through changes in the income stream), and explores the effects of disaster-induced economic shocks transmitted to individuals through income-earning channels. In turn, this provides a deeper understanding of how income costs of disasters are borne by different areas of the workforce and assists policymakers in understanding the socioeconomics of natural disasters to better formulate public policies.

FIGURE 1 IN-SCOPE BLACK SATURDAY BUSHFIRE-HIT SA2S AND THEIR NEIGHBOURS



SOURCE: OWN CALCULATIONS.

In an effort to assist policymakers contextualise our assessment at a broader social and economic level, this report amplifies the socioeconomic and disaster-resilience profiles of the disaster hit SA2s.

The findings of the report provide a distinctive variation from research to date by focusing on the way disasters such as the BSB affect individuals within a particular workforce and community, as well as their ability to economically cope with the ongoing effects of the disaster.

The report attempts to pinpoint the income effects observed in the BSB by using a difference-in-differences modelling approach. This approach compares the income changes of individuals living in the disaster-hit SA2s (treatment group) with those neighbouring SA2s that were not directly hit by the bushfires (control group). Because of their comparability, it is the control group that provides us with the income path that would have occurred for disaster-hit residents that were reported to be in the labour force in 2006, had the bushfires *not* happened, and thus enables us to compute any income deviations (losses or gains) arising from the bushfires.

The report utilises the Australian Census Longitudinal Dataset (ACLD)[1], which provides a unique opportunity to robustly examine the bushfire's impacts across a longer timeframe (across 2006, 2011 and 2016) and across multiple dimensions (demographic and economic). All results we report are net results, post any disaster relief and recovery efforts; are relative to our baseline year (2006); and are compared to our control group. We define short-term results as changes over 2006–11, and medium-term results as changes over 2006–16.

[1] Available through the ABS DataLab.

Our framework was developed to capture income effects following the bushfires. Data limitations impede our ability to confirm some of the assumptions of our modelling approach, but we have taken a number of steps to alleviate the likely impact of these limitations on the reliability of our findings.

Nevertheless, to the best of our knowledge, our report is the first one utilizing three ABS Censuses to explore income effects of bushfires more comprehensively. Our findings offer compelling insights on how disasters like the BSB affect local economies, individuals within the community, and in turn their ability to economically cope with the ongoing effects of the disaster.

1.1 KEY INSIGHTS

1. **The 2009 Black Saturday Bushfires were associated with significant income losses within the disaster-hit communities.**

Geo-referencing of the BSB map and the SA2 boundaries in the State of Victoria reveals that the share of burnt area in the total SA2 surface area of the 37 SA2s hit by the bushfires was between 0.1% and 72.2%, with the mean share in our estimation sample being 12.5%. Our subsequent modelling documents that, in this mean group of SA2s, bushfires were associated with losses in average annual individual income of 5.1%, which corresponds to about $2,000 AUD.

Our results also imply that every additional 10 percentage point increase in the share of burnt area in an SA2 (e.g. an increase from 12.5% to 22.5%) is associated with additional reduction in average annual individual income by 5.5%.

These estimates are economically meaningful and statistically significant.

2. **We must also look beyond overall impacts to understand our socioeconomic vulnerability to disasters.**

Aggregate figures may mask important information we observed between individuals with different demographic attributes and employment characteristics. Thus, we enrich our analysis by investigating the economic resilience of individuals in relation to their sectors of employment and demographic background.

To illustrate, the BSBs were associated with annual income losses among low-income earners (loss of 8.6%; A$2,240) and women (loss of 9.7%; A$2,961) residing in disaster-hit SA2s. Some of these differences are explained by the concentration of these groups' employment in certain vulnerable sectors. There is also evidence that the losses of the low-income earners might have persisted in the medium-run, so we observe continued reduction in their incomes even in 2016. The evidence for the medium-term adverse effects for female residents is much stronger.

Out of all sectors explored, the heaviest income losses were for individuals employed in two key sectors: the agriculture sector (-23.4%, A$8,057) and accommodation and food services (-16%, $4,600). These acute individual-level losses highlight the scale of the devastation in the disaster-hit SA2s and the extent of their economic exposure to the disaster-sensitive industries like agriculture and tourism.

3. Economic sectors represent a significant channel through which disaster-induced economic shocks can be transmitted to individuals.

Our results demonstrate the likely channels through which disaster-induced economic shocks are transmitted to individuals in the labour force.

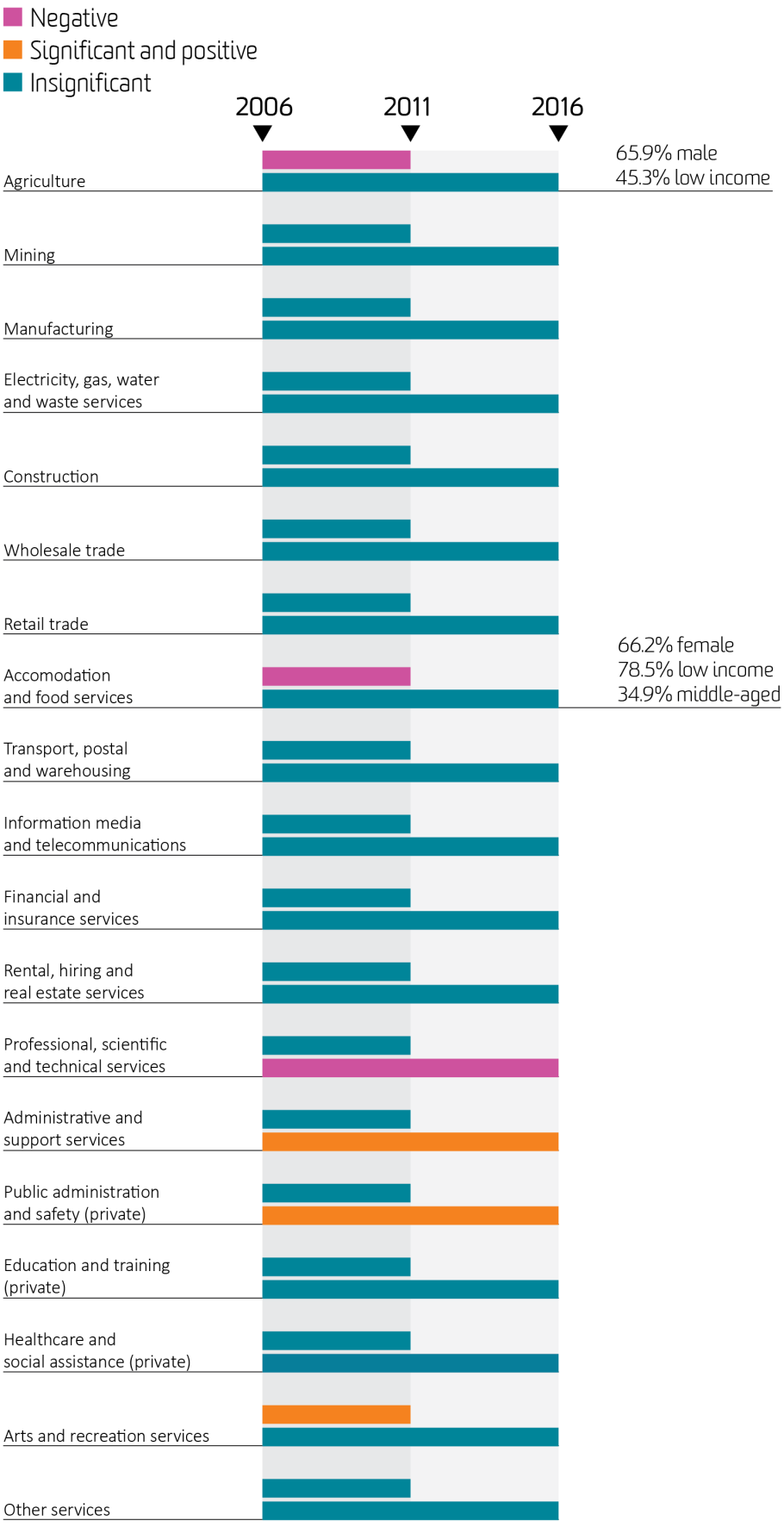
Sectors vulnerable to a disaster are one such a channel. We find that two sectors were particularly vulnerable to bushfires; agriculture, forestry and fishing, and accommodation and food services. The adverse effects on agriculture, forestry and fishing can be explained by the extent and severity of the BSBs. Given the size of the bushfires, it is plausible to assume that some crops were lost or left unattended during the fires. In addition, livestock losses amounted to 11,000 during the BSBs and would have contributed to the overall decline in the sector (see Stephenson, 2010). Moreover, severe bushfires would inhibit resources of an enterprise operating in the forestry industry as the sector highly relies on logging.

Turning to accommodation and food services, part of the tourism sector, the local communities were unavoidably affected by the BSB. There is significant anecdotal evidence that the bushfires afflicted rural enterprises, such as bed and breakfasts and short-period rental properties, with reduced tourism and business. This would also mean that individuals who were employed in service jobs in these businesses, including a number of part-time employees, lost either employment or work hours until the economic activity resumed fully.

It must be noted that the 2.5 years of time between the BSBs and the 2011 Census might have affected our results. During this time, some demographic groups or sectors may have recovered. Thus, effects we pick up here are likely to be for those *who were severely affected*. For instance, economic theory suggests that construction may initially experience a boom following a disaster as reconstruction efforts are undertaken. This would boost income for individuals employed in this sector. In BSB-affected areas, however, we observe relatively limited evidence on increased income in the construction sector. Even though our point estimate is positive, implying a 6% increase in individuals' income in the sector, it is not statistically significant. It might have been the case that the construction sector boomed immediately as a result of the recovery efforts, and then levelled off until the 2011 Census. Supporting this interpretation is the evidence that our medium-run estimate (i.e. 2016) implies no difference in construction income compared to that in the control group.

All of this underscores the need to go beyond the overall results to understand how disaster-induced shocks interact with social and economic dimensions that influence an individual's economic resilience to disasters.

FIGURE 2 OVERLAYING SECTORAL AND DEMOGRAPHIC RESULTS



NOTE: PERCENTAGES REFLECT BASELINE YEAR (2006) SECTOR COMPOSITIONS. SEE SECTION 5.4.3 FOR DISCUSSION ON CROSS-SECTOR TRANSITIONS DURING STUDY PERIOD.

4. **Socioeconomic vulnerabilities are concentrated in particular demographic groups and sectors of the economy.**

Our sectoral results are useful to illustrate where some of the socioeconomic vulnerabilities to disasters lie. In a visual representation, FIGURE 2 overlays some of the demographic groups and employment sectors. The income losses accrued by the agriculture and accommodation sectors seem to explain the losses we estimated for females and low-income individuals. It is particularly evident that the accommodation and food services sector employs a significant number of low-income earners and females. This sector is characterised by a high level of casual employment and lower earnings potential than other sectors. Such losses seem disproportionate to the financial capacity of the workforce employed in this sector to absorb.

A useful contrasting finding is related to high-income earners. Our findings highlight that high-income earners also experienced significant income losses as of the 2011 Census (-7.3%, A$4,382). However, they were able to return to their pre-disaster income levels as of the 2016 Census. By contrast, low-income earners exhibited persistent income losses in the 2016 Census. This finding suggests that the high-income earners are likely to be more economically resilient than low-income earners in terms of ability to return to their pre-disaster income trajectory. The key implication of our findings is that certain demographic groups present acute socioeconomic vulnerabilities to disasters.

5. **Government disaster relief and recovery programs have a role to play in supporting individual economic resilience to, and recovery from, disasters.**

While other market-based recovery means such as insurance payments are available, sovereign interventions are generally the first available and are essential for alleviating the disasters' financial and cognitive burdens and expediting the economic recovery. To ensure a successful rebound, well-designed recovery and relief programs, targeted at both public domain and individual economic wellbeing, are the principal way forward.

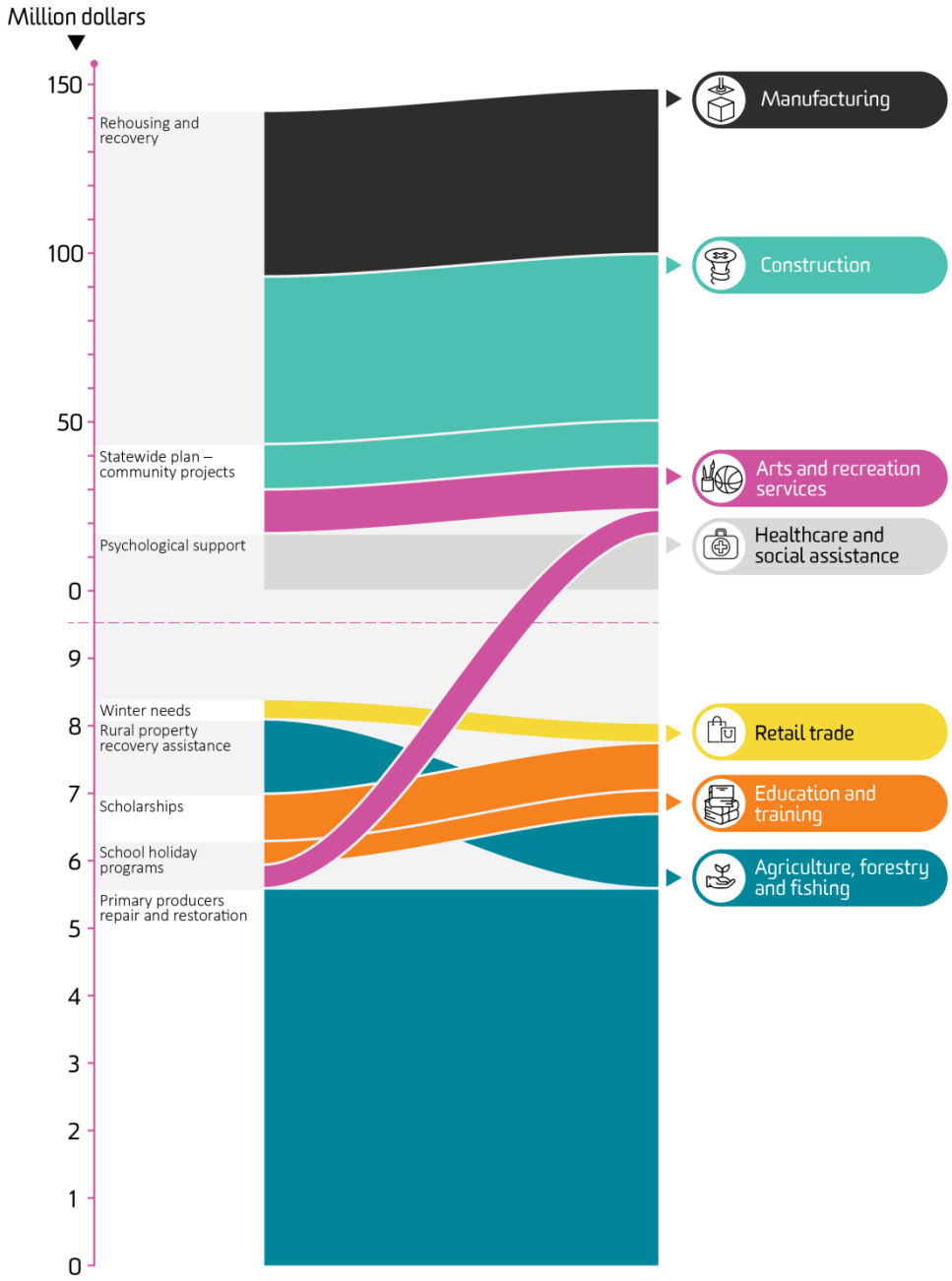
Due to data limitations, we were unable to directly assess in our economic modelling whether the substantial government relief and recovery programs played a role in mitigating or reducing the effects of the BSB.

However, FIGURE 3 attempts to establish some links between government disaster recovery efforts and subsequent economic activity in different sectors. These recovery programs include, among others, rehousing and recovery, state-wide community projects, psychological support, scholarship, school holiday programs, and primary producer repair and restoration. Mapping these programs onto economic sectors reveal the beneficiary sectors as: manufacturing, construction, arts and recreation, health care and social assistance, retail trade, education and training, and agriculture, forestry and fishing.

Our estimated income results indicate that the recovery programs may not have been sufficient for the agricultural sector given that our economic modelling still identifies persisting negative income effects for this sector. We also infer that the

programs may have muted otherwise negative effects accruing to manufacturing and retail trade sectors given that we estimate insignificant income changes for these sectors. Finally, with some positive income effects identified, there is some evidence that the construction and arts and recreation sectors may have benefitted from the relief and recovery efforts.

FIGURE 3 GOVERNMENT DISASTER RECOVERY PACKAGES THAT STIMULATE ECONOMIC ACTIVITY IN INDUSTRY SECTORS



1.2 WHERE TO FROM HERE?

While interpreting the results cautiously, due to data limitations, our report provides an appropriate framework to guide and inform future economic investigations of disasters arising from natural hazards.

We have demonstrated the value of systematically examining the potential effects of disasters across and between multiple economic and social dimensions. Importantly, our report highlights the criticality of examining employment sectors and known social vulnerabilities concurrently, within the social and economic context of the disaster-hit regions, so that results are interpreted correctly and programs formulated and targeted accordingly.

Such an approach aids in better understanding our vulnerabilities to disasters, as recommended by the A National Monitoring and Evaluation Framework for Disaster Recovery Programs; and in informing evaluations of disaster recovery programs, as under the National Impact Assessment Framework. Notwithstanding certain limitations, rich and publicly available datasets like the ACLD provide a path for doing so in a robust and rigorous way, before and after disasters.

Looking ahead, the completion of other case studies under the broader *Optimising Post-Disaster Recovery Intervention Program* will further consolidate our understanding of income costs of disasters arising from natural hazards, and provide significant input into a policy brief note on post-disaster recovery interventions in Australia. This note will be an input into the development of a guideline for optimising budget allocation across economic sectors in both pre-disaster mitigation and post-disaster recovery phases.

Extensions to this research are warranted, particularly to further understand differences between income groups, and unpack the impacts of natural disasters on business activity and on those who migrate out of disaster zones.

With many government disaster relief and recovery programs focused on community outcomes, it is worthwhile examining how economic programs help communities recover in the longer term. Here, the extension of previously implemented wage assistance programs, such as the Cyclone Yasi program, to include part-time employees is likely to help individuals better cope with disasters when they strike. Likewise, targeting disaster-sensitive sectors where socioeconomic vulnerabilities are concentrated may provide a helpful buffer to the most sensitive workforces, particularly those already living on the margin.

2. INTRODUCTION

Disasters and Economic Resilience: The Effects of the Black Saturday Bushfires on Individual Income – A Case Study examines the impact of the Black Saturday Bushfires (BSB) of February 2009 on the incomes of individuals who were in the labour force and residents of the disaster-hit areas in 2006, the last census year before the fires.[2]

The BSBs present a unique setting to explore the income effects of bushfires on individuals. The BSBs killed almost 200 people, destroyed 3,500 buildings and burnt 450,000 hectares of land. Deloitte Access (2016) estimated the toll of the BSBs to be A$7 billion, A$3.1 billion being tangible and A$3.9 billion being intangible costs.

This report aims to contribute to a greater understanding of the income effects by analysing the income changes of individuals who reported to be in the labour force in 2006 in BSB-hit SA2s. It utilises the nationally representative longitudinal census data obtained from the ACLD, for the years 2006, 2011 and 2016.

To estimate the short- and medium-term effects of the BSB, we first geo-reference the bushfire-hit areas at the SA2 level to identify the treatment group. In order to assess the impact of the bushfires on our treatment group, we need to identify a control group which would help deduce the income changes in the BSB-hit areas had there been no bushfires. We consider the control group to be the immediate neighbours of bushfire-hit SA2s that had no exposure to the fires (hence providing a benchmark for income changes in the treatment group had there been no disaster). We anticipate this group to have similar characteristics to that of directly-hit areas so that we can form comparable groups. With these treatment and control groups determined, we next undertake difference-in-differences modelling.[3] With the use of end-user knowledge, we can, as much as possible, pinpoint and isolate the bushfires' effects from other shocks that hit our study area during our study period. In this vein, the ACLD provides a unique opportunity to apply a longer-term examination of such impacts, and ensures we have a representative, robust and large enough sample to undertake the empirical analysis.

Not all Australian communities have the same capacity for disaster resilience (Parsons et al., 2019). Recognising this, the report disaggregates the overall income effects of the BSBs by social and economic dimensions. This is done to provide policymakers with a nuanced understanding of such effects to better target and evaluate the contributions that disaster recovery support initiatives can make to the longer-term economic recovery of disaster-hit communities.

The rest of the report is organised as follows. The project background defines our project scope and research rationale. We follow this with a socioeconomic and disaster-resilience profiling of the disaster-hit SA2s, and summarise the known social and economic impacts of the bushfires on the region. We then outline the research approach we have taken to estimate the bushfires' impacts,

[2] There are 37 SA2s that are hit by the BSB. See Figure 1.
[3] See definition in TABLE 2.

highlighting the implications of key assumptions and limitations, before turning to reporting and discussing the implications of our results.

3. PROJECT BACKGROUND

Disasters and Economic Resilience: The Effects of the Black Saturday Bushfires on Individual Income – A Case Study is one of four natural disaster case studies explored within our *Optimising Post-Disaster Recovery Interventions in Australia* research program:

- The Victorian Black Saturday Bushfires 2009 (this study)
- The Western Australian Toodyay Bushfires 2009
- The Queensland Floods 2010-11
- Cyclone Oswald 2013.

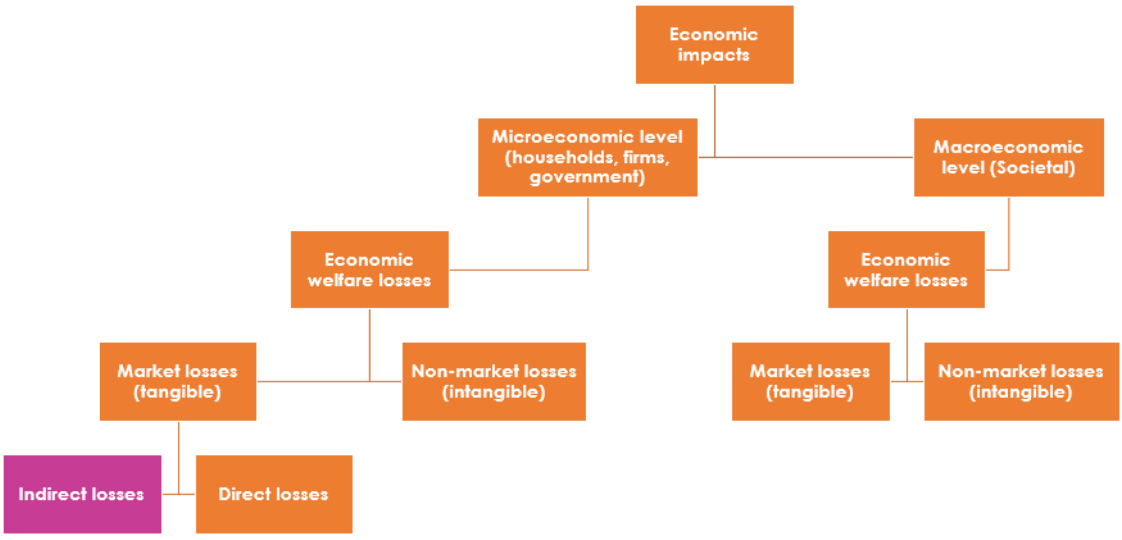
The case studies were chosen to unpack the economic effects that disasters of different types and scales can have on metropolitan and regional communities in Australia.

The research program is generously funded by the BNHCRC and informed by consultations with several government emergency management agencies as end-users.

3.1 PROJECT SCOPE

Depending on the research motivation, the economic impacts of natural disasters can be assessed at either a macro level (i.e. impacts across the whole economy), or micro level (i.e. impacts on households, firms/industry sectors or government). Within each categorisation, we can also explore market and non-market economic welfare losses (FIGURE 3).

FIGURE 4 WHERE OUR PROJECT SITS WITHIN THE BROADER ECONOMIC IMPACTS ASSESSMENT OF NATURAL DISASTERS



As we are looking at income changes (losses or gains) at an individual level, such changes are microeconomic in nature. In this report, we try to shed light on some of the potential channels through which these shocks propagate.

3.1.1 In scope

This report measures the income changes for employed individuals who were living within the boundaries of the 37 directly hit SA2 areas in 2006.

We use difference-in-differences modelling to assess the effects the BSBs had on individuals' income streams in both the short term (August 2011) and medium term (August 2016), disaggregated by demographic and sectoral attributes. The Australian Census Longitudinal Dataset (ACLD) is our primary dataset for our quantitative exploration.

3.1.2 Out of scope

The project does not examine any other costs or any other economic effects described in FIGURE 3. We acknowledge that the BSB caused profound and long-lasting psychosocial impacts and[4] intangible costs. Recognising this, we provide additional information to contextualise our assessment so policymakers can interpret our findings holistically, within the broader social and economic conditions arising from the fires.

We also do not compute the effect of income changes on individual expenditure. We acknowledge that this is likely to significantly influence the coping and adaptive capacity of individuals, and the scope by which individuals can respond to future shocks. We discuss this further in our analysis section and take this into account when formulating our key insights and conclusions.

The project does not assess the role insurance could have played in reducing or mitigating the effects of the fires, which we consider to play, at best, a stimulatory role in the medium-term. As noted in our limitations section (5.5.2), this is predominantly because of the dearth of insurance data at the SA2 level. To this end, the estimates we provide here are likely to be an underestimate of the true costs.

3.2 RESEARCH RATIONALE

Disasters arising from natural hazards ("natural disasters") are very costly in Australia, and often have profound physical, psychological and economic consequences on impacted communities. Recent devastating examples include the Victorian Black Saturday bushfires 2009, the Queensland floods 2010–11 and Cyclone Debbie (2017), all of which caused loss of life, damage to countless homes and properties, and significant losses across multiple sectors.

With the severity and frequency of natural hazards in Australia expected to increase (Kitching et al., 2014), there is growing academic and policy effort to better understand the risks that disasters arising from natural hazards pose to Australian communities; the impacts they have on different sections of the economy and community; and the role that disaster risk reduction can play in minimising such impacts and building disaster resilience.

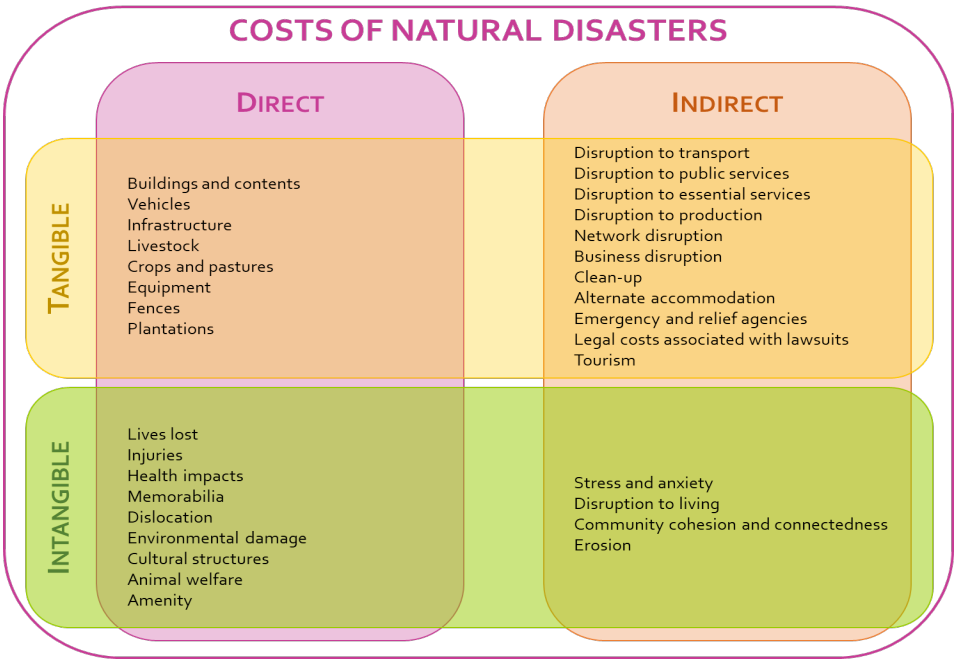
1. **By estimating income effects, our research contributes to a greater understanding of the income effects of natural disasters.**

[4] Gibbs et al., 2016, explores how individual trajectories of mental health, wellbeing and social connectedness respond after the BSB.

Until recently, a large majority of empirical economic literature has focused on investigating the economic effects of natural disasters at a macro level, with typical instruments used in the analysis being GDP and aggregate consumption.

While such broader examinations are useful, aggregate indicators like GDP or GDP equivalents miss the impacts of disasters on government transfer payments (Deryugina, 2017). They can also mask very large distributive impacts, and thus, are misleading measures of actual welfare changes (Hallegatte, 2014). The poorest, Hallegatte argues (2014), would have little to lose in a disaster and so the impact on their welfare is "invisible". Rather, to measure welfare, recent OECD reports like the *Commission on the Measurement of Economic Performance and Social Progress* recommend focusing on income, as we do, and consumption instead of GDP (OECD, 2009).

FIGURE 5 ECONOMIC COSTS OF NATURAL DISASTERS



SOURCE: PENMAN ET AL. (2019)

2. Investigating income effects helps us understand the underlying vulnerability to disasters and likely flow-on effects on disaster resilience.

Socioeconomic inequality is widely recognised as one of the root causes of vulnerability to disasters (Wisner et al., 2004). A lower socioeconomic status has been consistently associated with greater post-disaster hardship, with the poor suffering significant disaster effects due to lower financial capacity and limited access to public and private (e.g. insurance) recovery assets (Gladwin and Peacock, 2000; Fothergill and Peek, 2004).

While it is one of many potential measures of an individual's economic resilience, income is a significant socioeconomic indicator that determines status in both absolute and relative terms (i.e. income inequality) and determines inter-generational transmission of skills (e.g. investment into children's education).

Income is also at the core of household finance, and determines the levels of indebtedness, borrowing and wealth accumulation. Unlike other possible measures, it is also the most readily assessable and accessible measure of economic resilience, particularly to correlate with other demographic and employment attributes we are interested in exploring. Moreover, income is a

stream, something that can change in the short term and therefore offers a critical "pulse" through which we can measure the effects of disasters.[5]

Finally, recognising the broader intangible effects of disasters we noted earlier, there are also strong links between income disruptions during disasters and mental health outcomes. In the case of bushfires, the longevity of disruptions to income post-disaster has been shown to materially affect the mental health of those affected by bushfires. Following the Victorian BSBs in 2009, people who experienced major life stressors after the fires (change in relationship, income, or accommodation) were more likely to have poor mental health outcomes three to five years after the fires (Gibbs et al., 2016).

3. **Our analysis investigates the disaster effects across fine geographic locations.**

To the best of our knowledge, the present study is the first in the economics literature to examine the impact of bushfires on individual income at finer units of geographic locations (i.e., SA2s). It also considers demographic and sectoral heterogeneities.

The gap in the literature in evaluating the effect of a disaster and determining the particular vulnerable socio-demographic groups and industrial sectors is partly there because the rich datasets that enable this type of analyses have been made available only recently. For example, the ACLD 2006 and 2011 linking was released by the ABS in 2013 and ACLD 2006-11-16-linked dataset was released in 2018.

International studies show the value of using individual-level panel datasets to investigate the income effects of disasters. At the forefront of this literature is the Deryugina, Kawano and Levitt (2018) study, which examines tax return data from the USA to look at the long-term economic impacts of Hurricane Katrina on its victims. The authors find that "Hurricane Katrina had large and persistent impacts on where people live, but small and surprisingly transitory effects on their employment and income. Within just a few years, Katrina victims' incomes actually surpassed that of controls from similar unaffected cities. The strong economic performance of Hurricane Katrina victims is particularly remarkable given that the hurricane struck with essentially no warning." However, their study is at state level whereas we undertake our analysis at SA2 level. An analysis at such a large scale is likely to bring in noise, as a researcher would be more likely to include individuals that were not affected by the disaster in question.

Another study by Deryugina (2017) does look at the fiscal costs of disasters, but uses county-level data, rather than individual-level data, from the USA. Examining all hurricanes that landed on the USA during the period 1979–2002, Deryugina (2017) shows that "US hurricanes lead to substantial increases in non-disaster government transfers, such as unemployment insurance and public medical payments, in affected counties in the decade after a hurricane. The present value of this increase significantly exceeds that of direct disaster aid. This implies, among other things, that the fiscal costs of natural disasters have been significantly underestimated and that victims in developed countries are better

[5] In contrast, wealth is a stock and so doesn't change as easily, which makes it difficult to detect these effects.

insured against them than previously thought". In contrast, our study uses individual-level data from Australia to examine the income effects following a single disaster, the BSB.

4. **Exploring the effects of bushfires offers important lessons for other bushfire-prone areas. The literature typically focuses on floods.**

To the best of our knowledge, this is one of the very few studies analysing the economic impacts of bushfires both in the short- and medium-term.

Globally, many areas are prone to bushfires. With the recent bushfires in NSW and QLD and all over the world (e.g., Greece, California), the toll of bushfires have skyrocketed. Bushfires threaten not only human life and social order, but also economic activity, with extended risks across the economic and political sphere.

4. PROFILE OF THE BUSHFIRE-HIT AREAS

Our research aims to estimate the changes in the income trajectory of individuals residing in 12 non-contiguous bushfire pockets in Victoria during the Black Saturday Bushfires 2009.

The Kilmore East–Murrindindi fires by far had the most devastating impacts, not only in sheer numbers of fatalities and houses destroyed, but also the number of SA2s that were exposed to the fires, which are known to have had adverse effects on the mental health of residents (Gibbs et al, 2016).

TABLE 3 BLACK SATURDAY BUSHFIRES COMMUNITY IMPACT AND EXPOSURE

Fires	Fatalities (A)	Casualties (A)	Houses destroyed (A)	No. houses within fire perimeter (B)	Burnt area sqkm (C)	Exposed SA2s (C)	Exposed SA2 population (D)
Beechworth–Mudgegonga	2	12	38	–	388	5	32,386
Bendigo	1	41	58	172	39	4	36,611
Bunyip	–	2	31	240	244	4	40,642
Churchill	11	35	145	359	340	3	13,914
Coleraine	–	1	1	–	9	1	5,523
Delburn	–	–	44	–	178	2	15,734
Horsham	–	–	13	–	16	2	10,156
Kilmore East–Murrindindi	123	305	1790	4604	1364	12	113,684
Narre Warren–Upper Ferntree Gully	–	–	7	–	15	1	15,554
Pomborneit–Weerite	–	–	–	–	2	1	7,567
Redesdale	–	1	14	–	1030	3	14,976

SOURCE: (A) PARLIAMENT OF VICTORIA (2010). NOTE, THE 'HOUSES DESTROYED' FIGURES DO NOT INCLUDE DAMAGED HOUSES, WHICH WOULD INCREASE THE TOTAL FIGURE TO OVER 4,600. (B) CHANG-RICHARDS ET AL. (2013), C) AUTHOR CALCULATIONS, TOTALS REPORTED WILL NOT MATCH AS SOME SA2S WERE EXPOSED TO MULTIPLE FIRES. PLEASE REFER TO APPENDIX, (D) 2008 ABS ESTIMATED RESIDENT POPULATION.

To set the context for our results, we first provide an overview of the in-scope areas' socioeconomic and disaster-resilience profiles, then discuss the known social and economic impacts of the BSBs on the region.

4.1 SOCIAL AND ECONOMIC PROFILE[6]

Based on the ABS 2007–08 estimated residential population, over 302,000 people, or 6% of Victoria's population would have been residing within the bushfire-hit areas at the time of the fires, with varied levels of exposure based on factors like the area's population density, bushfire severity and residence proximity to the fires' perimeter. On the latter, based on the available fire perimeter information, 38% of houses within fire perimeters were destroyed (min=13%, max=51%). Notably, the bushfire-affected areas contributed 4.6% of state employment in the agriculture, forestry and fishing sector, and 2% of state's employment in electricity, gas and water services. The latter is explained by the presence of important infrastructural assets and water supply in bushfire-affected areas,

[6] Unless otherwise stated, all data presented in this section has been sourced from the: Australian Bureau of Statistics (2017a), 2024.0 – Census of Population and Housing; Australian Bureau of Statistics (2017b), 8165.0 – Counts of Australian Businesses, including Entries and Exits; Australian Bureau of Statistics (2017c), 3218.0 Regional Population Growth, Australia.

including: (i) Morwell's open-cut mine and power station and the main high-tension power line servicing Melbourne and (ii) the O'Shannassy and Maroondah catchments in Melbourne's Yarra Ranges. Five of Melbourne's nine major dams had their forest catchments affected by the bushfires, and 30% of Melbourne Water's water catchments were burnt (Parliament of Victoria, 2016).

In the period between the 2006 and 2011 Census, employees in 2 of the 19 industry sectors in the bushfire-affected areas experienced income declines. As not all of these sectoral declines are causally linked to the fires, only significant study results are reported in TABLE 4. The bushfires particularly adversely affected the incomes of the agriculture sector and tourism-related industries (e.g. accommodation and food services).

The BSBs affected the overall economic composition of bushfire-hit areas. In 2006, the top eight industries across the bushfire-affected areas were manufacturing; retail trade; construction; health care and social assistance; agriculture, forestry and fishing; education and training; public administration and safety; and accommodation and food services. In 2011 and 2016, industries involved in individual assistance, recovery and rebuild efforts (e.g. health care and social assistance; construction) increased their percentage share of total employment, while the top two sectors (manufacturing and retail trade) declined. Here, it is important to remember that we construct this table by excluding the individuals who were not in the labour force in 2006, reported non-positive income and were not in the working-age group. If one includes them, the sectoral composition in 2011 and 2016 would change as some of these individuals who were not part of the labour force may have joined the labour force. To make sure that we complete employment sector details and provide a full picture, we also include TABLE 5, which reports the universe of all individuals in the census years grouped by treatment and control groups. We present the raw numbers of employment for each sector and year that are in our treatment and control groups in the Appendix (TABLE 30).

TABLE 4 SUMMARY OF BUSHFIRE-AFFECTED AREAS' INDUSTRIES OF EMPLOYMENT (BY RANK, AVERAGE SA2 % OF EMPLOYMENT, AND % INCOME CHANGES ATTRIBUTABLE TO THE FIRES)

Employment industry	Study results		2006		2011		2016	
			Rank	%	Rank	%	Rank	%
Manufacturing	-	-	1	*13.0%*	2	*11.2%*	4	*8.6%*
Retail trade	-	-	2	*10.0%*	5	*8.8%*	6	*8.1%*
Construction	-	-	3	*7.8%*	3	*11.2%*	2	*11.9%*
Health care and social assistance	-	-	4	*9.6%*	1	*11.6%*	1	*13.8%*
Agriculture, forestry and fishing	▼	23.4%	5	*13.9%*	4	*9.1%*	5	*8.0%*
Education and training	-	-	6	*7.6%*	6	*8.7%*	3	*10.4%*
Public administration and safety	-	-	7	*4.6%*	7	*6.2%*	7	*6.7%*
Accommodation and food services	▼	16.6%	8	*5.6%*	12	*4.1%*	11	*3.3%*
Transport, postal and warehousing	-	-	9	*4.3%*	9	*4.6%*	9	*4.6%*
Other services	-	-	10	*4.2%*	11	*4.1%*	10	*4.3%*
Wholesale trade	-	-	11	*4.1%*	10	*4.4%*	12	*3.3%*
Professional, scientific and technical services	-	-	12	*3.8%*	8	*4.8%*	8	*4.2%*

Administrative and support services	-	-	13	2.8%	13	3.1%	13	3.3%
Financial and insurance services	-	-	14	2.0%	14	1.9%	15	1.9%
Information media and telecommunications	-	-	15	1.6%	17	1.2%	18	1.2%
Arts and recreation services	▲	12.4%	16	1.5%	16	1.6%	16	1.4%
Electricity, gas, water and waste services	-	-	17	1.3%	15	1.7%	14	2.0%
Rental, hiring and real estate services	-	-	18	1.2%	18	0.9%	17	1.2%
Mining	-	-	19	0.5%	19	0.7%	19	0.8%
Information media and telecommunications	-	-	15	1.6%	17	1.2%	18	1.2%

SOURCE: ABS CENSUS 2006, 2011, 2016

TABLE 5 TOP INDUSTRIES OF EMPLOYMENT FOR TREATMENT AND CONTROL GROUPS

					2001–2016
	2001	2006	2011	2016	Annualized change
Treatment group					
Accommodation and food services	5.84%	5.51%	5.79%	6.18%	1.51%
Agriculture, forestry and fishing	11.69%	9.81%	8.27%	8.04%	-1.38%
Construction	7.91%	9.91%	11.19%	11.44%	3.67%
Education and training	7.78%	7.61%	7.66%	8.04%	1.36%
Health care and social assistance	9.57%	10.33%	11.49%	12.27%	2.83%
Manufacturing	13.40%	11.95%	10.73%	8.35%	-2.03%
Public administration and safety	4.25%	5.33%	5.53%	5.68%	3.10%
Retail trade	10.52%	11.05%	10.53%	9.54%	0.47%
Control group					
Accommodation and food services	5.60%	5.55%	5.89%	6.13%	1.15%
Agriculture, forestry and fishing	9.25%	8.67%	7.20%	7.00%	-1.31%
Construction	7.34%	9.05%	10.00%	10.04%	2.68%
Education and training	7.32%	7.51%	7.83%	8.23%	1.34%
Health care and social assistance	9.66%	10.87%	12.14%	13.22%	2.68%
Manufacturing	14.43%	11.79%	10.47%	8.26%	-3.14%
Public administration and safety	4.42%	5.60%	6.01%	5.98%	2.59%
Retail trade	11.71%	12.02%	11.13%	10.27%	-0.34%

SOURCE: AUTHORS' CALCULATION FROM ABS CENSUS DATA.

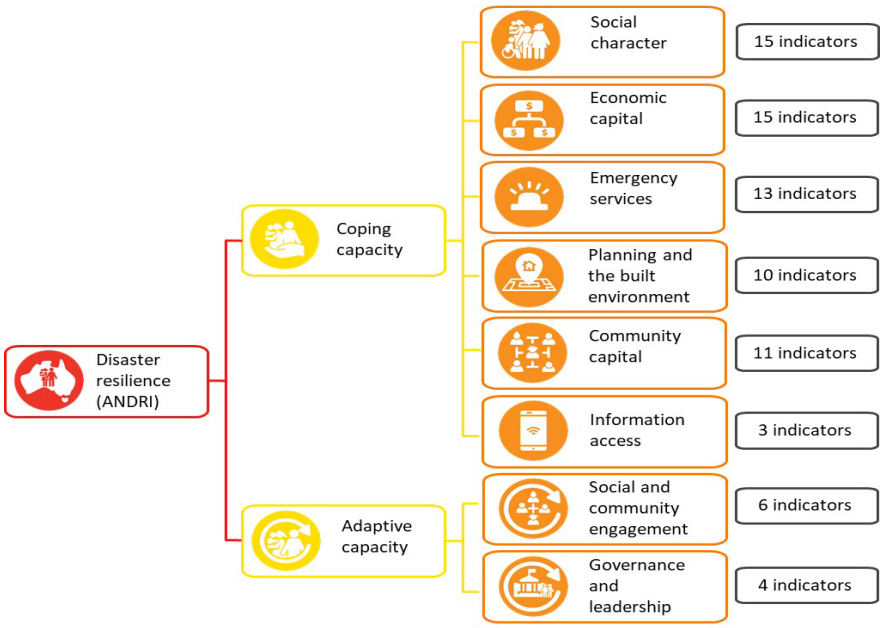
4.2 DISASTER RESILIENCE PROFILE

Not all Australian communities have the same capacity for disaster resilience (Parsons et al., 2019), with flow-on consequences on the speed with which they can socially and economically recover. This is especially true for regional communities, with some reported to take up to 25 years to recover (Regional Australia Institute, 2013).

The Australian Natural Disaster Resilience Index (ANDRI) is a national scale composite index that provides an evidence-based snapshot of the disaster resilience of SA2s across Australia. It defines resilience to disasters arising from natural hazards as: "the capacity of communities to prepare for, absorb and recover from natural hazard events and to learn, adapt and transform in ways that enhance these capacities in the face of future events." (Parsons et al., 2019).

Overall resilience to disasters arising from natural hazards (i.e. the ANDRI overall score) is viewed as a composite of coping and adaptive capacities (FIGURE 5). The coping and adaptive capacities for disaster resilience are captured using eight themes that encompass various known dimensions of disaster resilience. The index ranges from 0 (lowest capacity for disaster resilience) to 1 (highest capacity for disaster resilience).[7]

FIGURE 6 ANDRI STRUCTURE



SOURCE: PARSONS ET AL, (2019)

ANDRI scores are available for SA2s corresponding with our in-scope SA2s. For the entire BSB-hit SA2s as a whole (n=37), the majority of SA2s (71.1%, n=27) were assessed as having moderate capacity for disaster resilience. Typically, such SA2s have moderate levels of economic capital, moderate access to services, moderate community cohesion and variable encouragement for adaptive learning and problem solving. Typically, they score better on coping capacity than adaptive capacity.

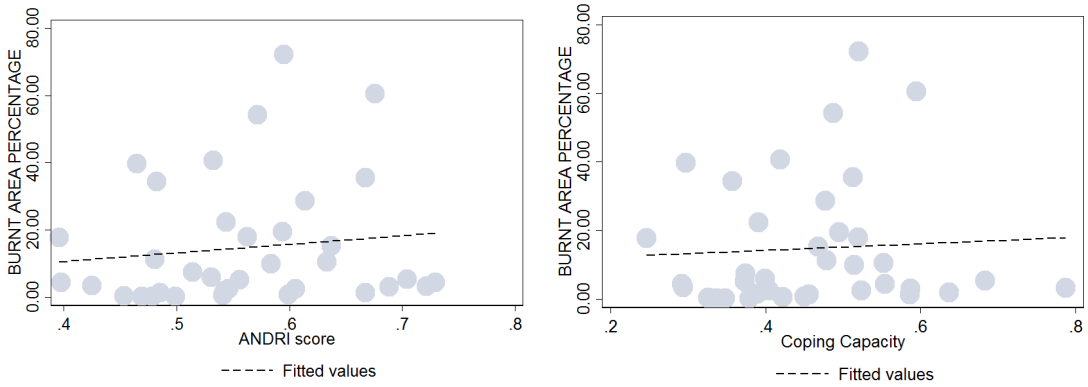
The left panel of FIGURE 6 plots ANDRI scores with respect to the SA2s' burnt percentage area while the right panel plots burnt percentage with respect to coping capacity. The following observations stand out. First, it does not appear that there is a strong relationship between a disaster-hit area's burnt area percentage and ANDRI score or coping capacity. This is important because one may have though that disaster-prone areas are likely to have better coping mechanisms. Our figure reveals that this is not really the case.

Factors contributing to the areas' high disaster resilience typically included socioeconomic characteristics, outlined earlier (e.g. employment, education

[7] See Appendix 12.1 for further information on the ANDRI scoring.

and income); good access to or provision of resources and services; strong community cohesion and ample opportunities for adaptive learning and problem solving.

FIGURE 7 BRISBANE RIVER CATCHMENT AREA (BRCA) ANDRI SCORES, BY BRCA REGION



SOURCE: PARSONS ET AL. (2019)

In reviewing the measures used to score each theme, it is evident that the relatively lower economic diversity, higher unemployment rates and lower educational attainment levels of the SA2 areas we discussed earlier detracted from the social engagement and economic capital that enable communities within these SA2s to cope and adapt to disasters. For this reason, undertaking a separate analysis of the income effects in the BSB-hit areas warrants further investigation.

4.3 EFFECTS OF THE BLACK SATURDAY BUSHFIRES

4.3.1 Overall Impacts

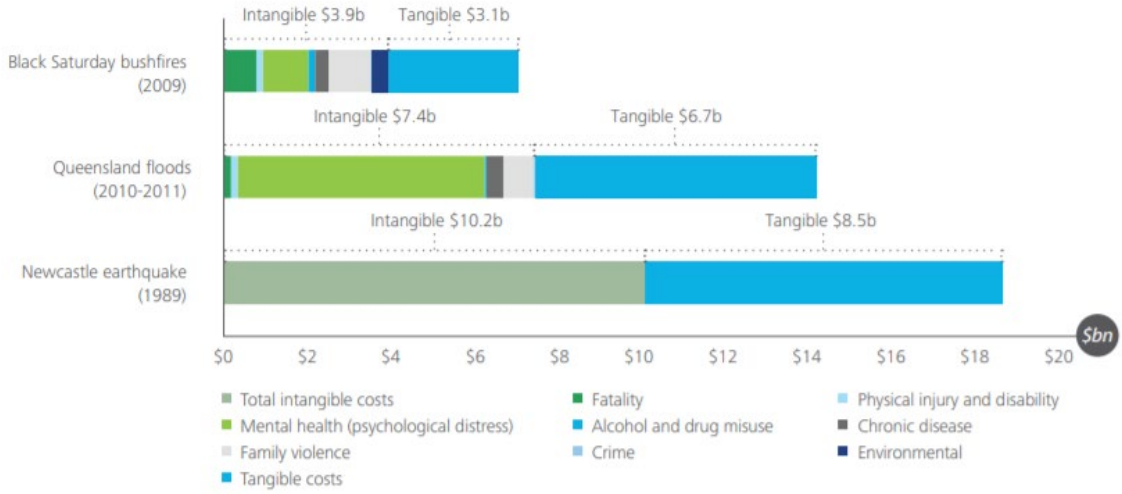
The BSBs were the most destructive bushfires recorded in Australia. One hundred and seventy-three people died, over 2,100 houses and 3,500 structures were destroyed, 4,500km^2 of land in Victoria was burnt, with thousands more suffering damage (Parliament of Victoria, 2010). The bushfires caused an estimated A$3.1 billion in tangible damages, with an overall cost of A$7 billion (Deloitte Access Economics, 2016, see FIGURE 7).

The bushfires caused significant losses in sectors that form key drivers of Victoria's economic growth (TABLE 6). Consistent with our empirical findings, agriculture and accommodation-related sectors took the hardest hit.

Local businesses operating in retail, manufacturing and transportation sectors are anticipated to be affected by a severe fire even though these sectors are not directly hit. Unavoidably, severe fires would cost local businesses lost revenue and customer.

There is also some evidence that the bushfires had long-lasting community impacts on mental health, alcohol misuse and family violence, exacerbating already-existing chronic diseases (Deloitte Access Economics, 2016). While it's never easy to quantify these intangible impacts, a Deloitte Access Economics report (2016) estimated the lifetime cost of bushfires-related mental health issues alone at around A$1 billion (net value in 2015 A$) (TABLE 7).

FIGURE 8 TOTAL ECONOMIC COST OF QUEENSLAND FLOODS, BLACK SATURDAY BUSHFIRES AND NEWCASTLE EARTHQUAKE



SOURCE: DELOITTE ACCESS ECONOMICS (2016)

TABLE 6 ESTIMATED ECONOMIC SECTOR DAMAGE AND LOSSES FROM THE BLACK SATURDAY BUSHFIRES

Sector	Estimated losses (2008 A$)
Agriculture	720,102,519
Commercial and industrial buildings and contents	37,223,605
Emergency response operations	337,850,738
Park buildings, contents and infrastructure	33,392,225
Public infrastructure	6,885,000
Residential buildings and contents	611,842,500
Timber	78,900,464
Total Economic Losses	**1,826,197,051**

SOURCES: STEPHONSON (2010)

TABLE 7 ESTIMATES OF INTANGIBLE COSTS OF THE BLACK SATURDAY BUSHFIRES

Intangible cost	Net present value in 2015 dollars
Deaths and injuries	Almost $930 million
Mental health issues	More than $1 billion
Risky substance use (alcohol and smoking)	About $190 million
Exacerbation of chronic and non-communicable diseases	Around $320 million
Family violence	Around $990 million
Environmental damage	Approximately $410 million

SOURCE: DELOITTE ACCESS ECONOMICS (2016)

5. RESEARCH APPROACH

5.1 MEASUREMENT

5.1.1 Model

As with other shocks, severe disasters can alter the income path for individuals residing in disaster-hit areas. In this report, we seek to find out how the 2009 Black Saturday Bushfires affected the incomes of individuals who were in the labour force and were residing in disaster-hit SA2s at the time of the 2006 Census. We therefore need to know what the income path would have been had the bushfires *not* happened, and compare it to the observed income path post the bushfires.

To achieve this, we use a difference-in-differences model,[8] formally defined as:

$$\boldsymbol{Y_{ist} = \beta_1 Intensity_i + \beta_2 Post_t + \beta_3 Intensity_i \times Post_t + \alpha_i + S_s + \varepsilon_{ist}}$$

where:

$\boldsymbol{Y_{ist}}$ = Log of income
$\boldsymbol{i}$ = Individuals
$\boldsymbol{s}$ = Indicates the SA2 in which an individual lived in 2006
$\boldsymbol{t}$ = Census dates for 2006, 2011, 2016
$\boldsymbol{Intensity}$ = Intensity indicator, representing the share of burnt area in total surface area of a given SA2 that individual *i* resided at the time of the BSB.
$\boldsymbol{Post}$ = Post BSB indicator that equals 1 if the time period is 2011 or 2016.
$\boldsymbol{\alpha}$ = Individual fixed effect
$\boldsymbol{S}$ = SA2 fixed effect
$\boldsymbol{\beta_3}$ = Vector of coefficients of interest
$\boldsymbol{\varepsilon}$ = Disturbance term

This model estimates the effect of a treatment (i.e. the bushfires) on an outcome (i.e. individual income) by comparing the differences in average changes over time between the treatment group (individuals living in the disaster-hit area) and a control group (comparable individuals in a comparable area). We consider the control group to be the immediate neighbours of bushfire-hit SA2s that had no exposure to the fires. These SA2s are chosen to closely resemble the treatment group, hence provide a benchmark for income changes in the treatment group had there been no disaster.

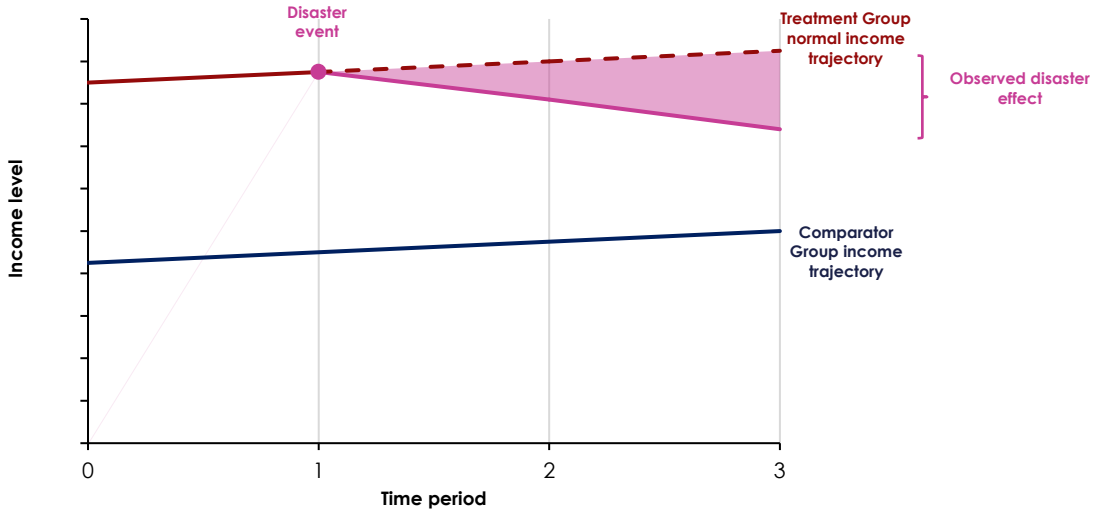
We use an intensity indicator to measure the bushfire exposure of individuals, which is the share of burnt area in total surface area of their residential SA2s. This measure has significant advantages over a binary indicator (a simple 0 or 1 indicator representing "burnt" and "unburnt", respectively). A binary measure makes no distinction regarding how households might have reacted to the severity of the bushfires.

FIGURE 8 illustrates a hypothetical case of negative disaster effect on income, whereby the pink solid line portrays the income trajectory in the treatment group

[8] See TABLE 2 for definition.

and dashed pink line represents the counterfactual income in the treatment group had the disaster not occurred at point 1. This counterfactual income trajectory is provided by the control group. The fully realised income effect of the disaster in this hypothetical case is the difference between the pink dashed line and solid line at point 3 (with point 2 representing the effect in the shorter term).

FIGURE 9 ILLUSTRATIVE DIFFERENCE-IN-DIFFERENCES MODEL SHOWING A HYPOTHETICAL NEGATIVE DISASTER EFFECT



Our modelling examines both the average income effect on all individuals within our benchmark sample, and the disaggregated effects by demographic and sectoral characteristics.

5.1.2 Data

We utilise the rich, anonymised, individual-level ACLD. This dataset includes a nationally representative 5% sample from each of the 2006, 2011 and 2016 censuses, and links the individual records in these censuses. In other words, an individual can be tracked over time, including the changes in their economic, demographic, and other characteristics.

The collection timing of the censuses (August) provides "baseline" (2006) and two "end-line" (2011, 2016) surveys for our difference-in-differences design. This allows us to measure the individual income effects of the bushfires by observing the treatment and control groups before and after the disaster. We refer to the 2006–11 results as "short-term" results, and 2006–16 as "medium-term" results.

While there are several limitations of using this dataset (see section 5.5), compared to alternative sources, the ACLD has the largest sample size available for empirical research; enables decomposition of the population into different demographic and sectoral groups and collects information on the location of individuals, allowing us to isolate and track individuals who likely lived in the BSB-hit SA2s at the time of the bushfires.

The income variable is provided by the census question: "What is the total of all wages/salaries, government benefits, pensions, allowances and other income the person usually receives?"

Because respondents tick a box that corresponds with an income range (e.g. $1–$7,799), this provides interval-based annual income data.[9] We take the mid-point of the respective interval class as the actual income of individuals. We then adjust this income measure for inflation using the Consumer Price Index provided for each capital city. We confirm that changes in income are not driven by changes in prices over this period.

Other questions in the census allow us to investigate social and economic dimensions. We choose attributes (TABLE 8) based on economic literature and end-user feedback. Our baseline is 2006 and so all demographic and sectoral results are based on the attributes in 2006.[10]

TABLE 8 INDIVIDUAL DATA COLLECTED, BY DIMENSION

Dimension	Attribute
Demographic	
Gender	Male, female
Age	Less than 25, between 25 and 45, Older than 45
Home ownership status	Owner, owner (outright), owner (mortgage), renter
Disability	Has disability
English language	Other language than English spoken at home
Economic	
Income level	Low (lower 33rd percentile), middle (middle 33rd percentile), high income (upper 33rd percentile)
Employment Status	Employed, unemployed, labour force
Hours worked	Full time, part time
Business ownership	Does not own business, owner of incorporated business, owner of unincorporated business, owner of small business, owner of medium or large business
Employment Sector	19 sectors based on ANZSIC classification: A- Agriculture, B- Mining, C- Manufacturing, D- Electricity, gas, water and waste services, E- Construction, F- Wholesale trade, G- Retail trade, H- Accommodation and food services, I- Transport, postal and warehousing, J- Information media and telecommunications, K- Financial and insurance services, L- Rental, hiring and real estate services, M- Professional, scientific and technical services, N- Administrative and support services, O- Public administration and safety (private), P- Education and training (private), Q- Health care and social assistance (private), R- Arts and recreation services, S- Other services.

[9] $0, $1–$7,799; $7,800–$12,999; $13,000–$20,799; $20,800–$31,199; $31,200–$41,599; $41,600–$51,999; $52,000–$67,599; $67,600–$83,199; $83,200–$103,999; and $104000 or more.

[10] For example, if an individual was recorded to be in the agriculture sector in 2006 in the treatment group, we explore their income change in 2011 compared to the groups of individuals who were in the agriculture sector in the control group regardless of their sectoral movement or change in employment status in 2011. As a demographic example, for low (high) income group, we compare the individuals whose income belongs to bottom (upper) 33rd percentile both in the treatment and control groups in 2006. So we track these individuals' income changes within these groups and report the differential impact of the disaster on this group.

5.2 SAMPLE CONSTRUCTION

5.2.1 Sample refinement

As we are interested in individual income, we refine our sample to incorporate only individuals who were in the labour force. [11] We construct our panel data by excluding the following individuals from our sample in the following order:

(i) individuals that are not within the working age;
(ii) individuals who were not in the labour force in 2006; and
(iii) individuals who reported to have negative income or chose not to report any sort of income.

The rationale behind this sample construction is as follows. It is a common practice in the literature on the economic effects of disasters caused by natural disasters to focus on individuals who are between 15 to 65 years of age, so that children and retired people do not pull the focus of attention. From a policy perspective, we wish to know how to allocate the scarce relief and recovery assistance for a sample of those who are part of market dynamics, and hence, those whose economic resilience may need to be supported by the government. For practical purposes, individuals who are not in the labour force are mostly those aged 15–20. These individuals could be subject to a separate analysis, and/or their relief and recovery assistance could be set on other grounds (i.e. youth allowance) than supporting their economic resilience.

We exclude those who reported negative income as the ABS census data report "-1" for these individuals' income. This information is practically unusable from the analysis perspective. This is a limitation of the ABS census data. We note that these individuals constitute only a small portion of the sample, so we consider that their exclusion is unlikely to impact our results.

5.2.2 Treatment and control group construction

To identify the immediate effect of the BSBs, individuals living within the borders of bushfire-hit SA2s form our treatment group. For our control group, we identify the SA2s that share a border with any of the burnt SA2s but were not burnt by the fires.

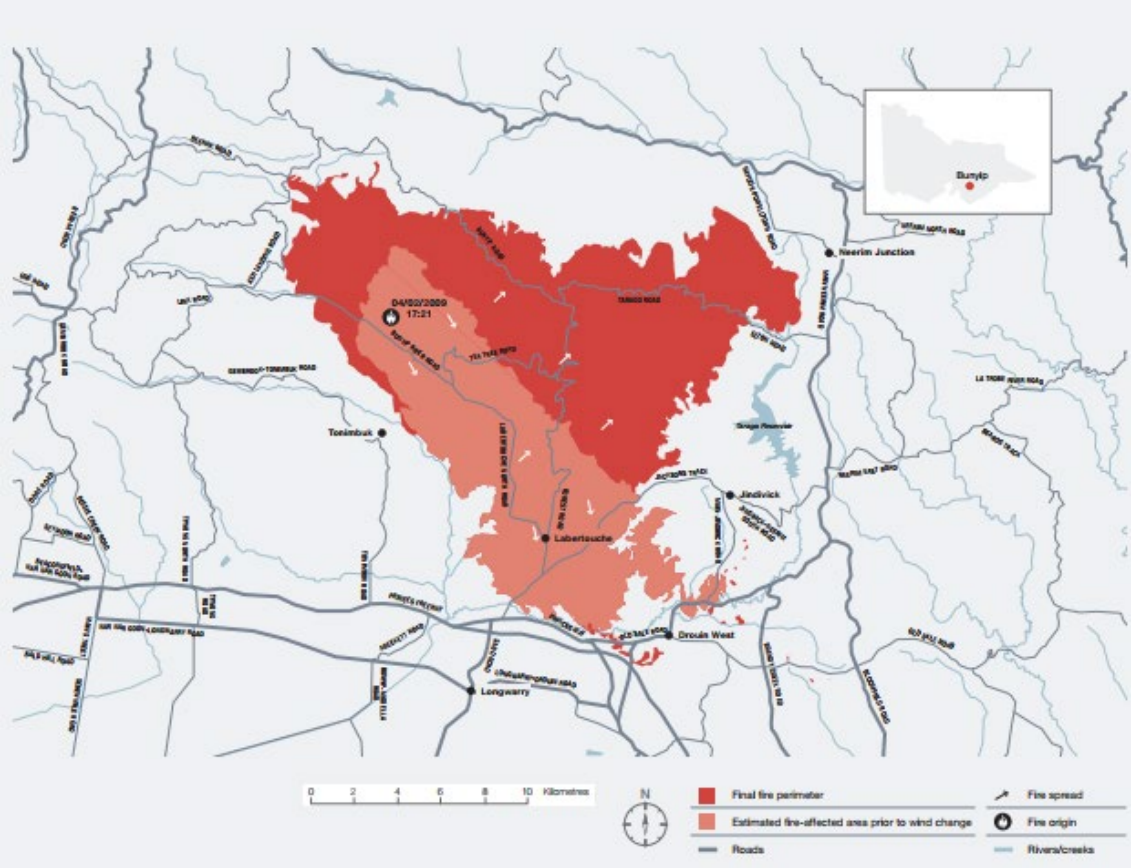
The Black Saturday Royal Commission (2009) provides detailed mapping of 12 different bushfire pockets, all of which constitute the BSB-hit areas in this study (see chapters 3–14 of Black Saturday Royal Commission, 2009). To illustrate how we construct the BSB-hit SA2s, consider FIGURE 10; a map of the fire extent in one of these SA2s. We use these maps to apply location-based analysis and vectorise and transform our raster data to map coordinates by using the ESRI shapefile formats provided by ABS (Australian Bureau of Statistics, 2016). FIGURE 1 (in Executive Summary above) displays our geo-referencing outcome using ArcGIS; colours of red identify the percentage of areas that were burnt during the BSBs for a given SA2. Blue coloured areas represent the unburnt SA2s that share a border with a burnt SA2 and the individuals within this unburnt area form our

[11] Relaxing this assumption and including all individuals that are in the work force and reported non-negative income, our main results remain highly similar.

control group. Green coloured areas do not have any borders with the directly hit areas.

The true income cost of the BSBs is likely to be larger than what is reported in this study because of possible economic spillovers between our treatment and control groups. Using the information on individuals' place of work at the SA2 level, we document that around 50% of individuals in our control group commutes to BSB-hit SA2s for work. Thus, one may anticipate that some of these commuting individuals are adversely affected as well.

FIGURE 10 THE EXTENT OF FIRES FOR DELBURN



SOURCE: BLACK SATURDAY ROYAL COMMISSION (2009).

5.3 FULL SAMPLE DESCRIPTIVE STATISTICS

Section 12.3 in the appendix presents the sample descriptive statistics for each census year. TABLE 9, below, presents the number of observations in our modelling.

TABLE 9 NUMBER OF OBSERVATIONS, BY YEAR AND SAMPLE GROUP

Year	Full sample	BSB-hit areas	Control group sample
2006	20,070	4,702	15,368
2011	19,779	4,731	15,048
2016	18,242	4,373	13,869
Total observations	**58,091**	**13,806**	**44,285**

In this study, "observation" refers to individuals. As shown in TABLE 9, the number of observations for the treatment sample (BSB-hit areas) is lower than the number of observations in our control group. This is mainly because our estimation approach exploits the differences in disaster severity of 37 SA2s vis-a-vis the unburnt 77 neighbouring SA2s. The large numbers of observations comfortably provide the statistical variations needed to detect significant income effects (if they indeed exist). However, in certain sub-group analyses, such as disabled individuals, we run into a small sample size problem, which may result in an inability to detect any significant effects (even if they exist).

5.4 CHECKS AND CONTROLS

Our modelling aims to bring individuals in the treatment and control groups on to 'equal footing'. In other words, so that the treatment and control group individuals differ only in terms of the bushfire exposure of the treatment group. We adopt several approaches to help this happen, and perform the necessary robustness checks and sensitivity analyses.

While we control for most factors, we are unable to exclude income effects from other disasters that may have hit parts of the treatment or control group after the BSBs in the medium term. We report this as a limitation of our study, and include the necessary cautions in our results section.

5.4.1 Controlling for time-invariant and time-variant factors

Our modelling eliminates all the time-invariant factors at the SA2 level, such as topography, climate, bushfire proneness and institutional structure. Our modelling also nets out all the time-invariant individual-specific characteristics.[12] These characteristics include observable (i.e. measurable) factors and unobservable features, such as an individual's ability, risk-taking behaviour, and psychological resilience. These factors would influence an individual's coping mechanism for economic shocks, and if not eliminated, they would result in confounded bushfire effects on income.

5.4.2 Measurement error checks

As the ACLD provides income for individuals in intervals,[13] we use the mid-point of the income interval for each individual. This could introduce measurement error (i.e. under-estimating or over-estimating effects of the bushfires).

5.4.3 Cross-sector transitions

Over time, individuals might move between sectors, which could affect their income and may impair our sectoral-level analysis, if many of them do this. Investigating the data, most cross-sectoral transitions were below 3% and we believe this relatively small number would have a negligible effect on the estimates.

[12] These are characteristics that will remain the same no matter when they are observed. For instance, date of birth does not change, whether this information is collected in 2006 or 2011.

[13] This is because census respondents tick a box that corresponds with an income range (e.g. $1-$7799), which provides interval-based annual income data.

5.4.4 Controlling for migration

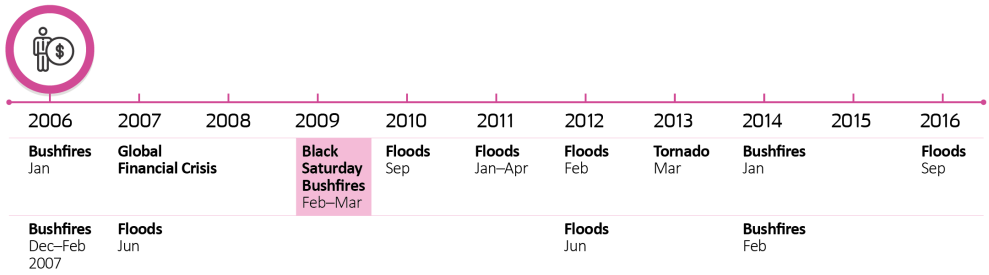
Some individuals who are severely hit by a disaster might decide to migrate out of the disaster-hit area. Conversely, some individuals may travel or migrate to the disaster zone for work in disaster-related economic activities.

To account for that, we consider three alternative exercises. We first estimate our regressions with the full sample. Second, we obtain our estimates with the non-movers sample without controlling for an individuals' migration decision. Here, we define an individual as a non-mover if their reported SA2 address in 2011 is the same as in 2006. Third, we include migration fixed effects in our modelling.[14] We find that the results remain similar across the three approaches. However, the estimates are slightly smaller with the non-movers sample and the standard errors are slightly larger. This is not surprising, as one would expect the severely hit individuals to leave their residential area.

5.4.5 Controlling for other shocks

Our results must also not be driven by any other shocks that occurred between the census periods. Between 2006 and 2016, some of the SA2s in our treatment and control groups experienced relatively mild adverse shocks (see FIGURE 10). This is in addition to the Global Financial Crisis (GFC) in 2008 and the millennium drought (1996 to mid-2010).

FIGURE 11 TREATMENT AND CONTROL AREA DISASTERS ACROSS THE STUDY PERIOD



SOURCE: AUTHOR COMPILATION. SEE APPENDIX FOR FULL DETAILS.

[14] We compute the following migration indicators that take 1 if an individual: (i) moved out of the treatment area to rest of Australia, excluding the control area, between 2006 and 2011; (ii) moved into the treatment area from rest of Australia, excluding the control are between 2006 and 2011; (iii) moved into the treatment area from control the area between 2006 and 2011; (iv) moved out of the treatment area into the control area between 2006 and 2011; (v) moved out of the control area to the rest of Australia, excluding the treatment are, between 2006 and 2011; (vi) moved into the control area from the rest of Australia, excluding the treatment area, between 2006 and 2011; (vii) moved into the control area from treatment area between 2006 and 2011; (viii) moved out of the control area into the treatment area between 2006 and 2011; (ix) moved out of the treatment area to the rest of Australia, excluding the control area, between 2011 and 2016; (x) returned to the treatment area after moving out of the treatment area between 2011 and 2016; (xi) moved out of the control area to the rest of Australia, excluding the treatment area, between 2011 and 2016; (xii) returned to the control area after moving out of the control area, between 2011 and 2016; (xiii) moved into the treatment area from the rest of Australia, excluding the control area, between 2011 and 2016; (xiv) moved into the treatment area from the control area between 2011 and 2016; (xv) moved out of the treatment area into the control area between 2011 and 2016; (xvi) moved into the control area from the rest of Australia, excluding the treatment area, between 2011 and 2016; (xvii) moved into the control area from the treatment area between 2011 and 2016 and' (xviii) moved out of the control area into the treatment area between 2011 and 2016.

While we are confident our 2006–11 findings can be attributed to the Black Saturday Bushfires, one should be cautious about interpreting the medium-term results, as there may be other confounding factors over the years that we cannot isolate in our modelling.

Beginning with the 2006–11 period, the GFC was a universal shock to Australia, but we believe that it is adequately controlled for by our approach in constructing the comparison group, which pools individuals from comparable groups. Moreover, the bushfires hit 12 non-contiguous pockets, so that our samples are sufficiently diverse and represent the Australian population, such that the GFC effect in the treatment and control groups may not be dramatically divergent.

The millennium drought is another possible confounding shock in Australia in the sample period. If the drought affected an average individual differently across the treatment and control groups between 2006 and 2011, then our results may partly reflect the effect of this shock. One alleviating factor here is our comparison of neighbouring SA2s.[15] Another mitigating factor is, once again, that bushfires happened in 12 non-contiguous pockets, such that the drought effect in the treatment and control groups may not be too different. However, if the drought finds its way to the average individual in BSB-hit areas during our time period differentially than it does to the average person in our control group, we cannot entirely rule out the drought's confounding effect on our results. We interpret this to be of low possibility given the measures taken in our modelling. This is similar to our inability to confirm parallel trend assumption using the ABS census, discussed earlier.

We acknowledge that our modelling alone cannot account for and exclude all other disaster shocks from our estimations. This is a limitation of using the ABS census dataset, which only provides data at five-year intervals, and the limited publicly available information on all SA2-level disaster damage and recovery data, which could have assisted in completely isolating the effects of recovery programs from the effects of bushfires.

5.5 ASSUMPTIONS AND LIMITATIONS

In this section, we outline the key assumptions and limitations of our report. While we have made every effort to address key assumptions and limitations, data restrictions have severely inhibited our ability to make precise estimates of the income effects of the BSB.

5.5.1 Assumptions

5.5.1.1 Assumption 1: Parallel trends assumption

A key difference-in-differences model assumption we need to meet is that treatment and control group incomes were growing in parallel *before* the BSBs (see FIGURE 8).

Put simply, if we know that the control and treatment groups were growing at similar rates prior to the disaster, and we have properly accounted for other potential reasons for variations in income, including socioeconomic

[15] See discussion in section 5.3.

characteristics and topography, this gives us more confidence that the bushfires alone were responsible for any deviations of the treatment group from its expected trajectory post disaster.

We know from the descriptive statistics in our baseline year (2006) that the income levels of our treatment and control groups (TABLE 25) and industry sector share of employment (TABLE 26) were broadly comparable prior to the BSBs.

A credible way of testing whether the parallel trends assumption holds is through statistical modelling. Our baseline period is 2006, and so to satisfy the parallel trends assumption, we need to establish within our model that there is no statistical difference between the treatment and control group income growth prior to 2006. This means that, for the ABS five-year interval census dataset, we would need the 2001 Census data linked for all individuals in our sample. Unfortunately, the ABS ACLD does not have the 2001 Census linked to the 2006 Census data.

This means we are not able to formally assess the parallel trends assumption. Nevertheless, geographic proximity of the treatment and control SA2s and the regional nature of both groups, along with other modelling approaches detailed above, give us a good degree comfort for our results.

5.5.1.2 Assumption 2: Broader economic spillover effects in the region

The joint combination of massive outmigration, destruction of buildings and infrastructure, burnt hectares of land and decline in tourism could have hampered the economic conditions of those in the control group, whose homes and businesses remained intact, even though they were not directly hit, because of the broader economic effects. Thus, any adverse impact between the bushfire-affected areas and the neighbouring unaffected areas is likely to be an underestimate of the true effect of the disaster.

This means that the individuals in our control group might have been adversely affected because of the spillover effects from bushfire-hit areas to their immediate neighbours. We document that around 50% of individuals residing in our control group commutes to the treatment area for work. This suggests that our estimates might in fact be an underestimate of the true income effects of the disaster.

5.5.2 Limitations

As with any study, multiple limitations constrain the applicability of our findings.

5.5.2.1 Data limitations

Most critically, data limitations have hampered our ability to investigate the effect of the BSBs on individual income in the BSB-hit areas.

5.5.2.1.1 General data limitations

As acknowledged in the 2018 National Disaster Risk Reduction Framework, "disaster risk data and information is not always available to those who need it

and it does not adequately integrate climate science" (Commonwealth of Australia, 2018b, p. 12).

Related to this, information useful to:

- constructing measures such as disaster severity (including infrastructure and insurance data);
- estimating effects of government assistance on income; and
- estimating the effects of insurance pay-outs on income

is not readily available and/or requires significant consultation lead time before being made available. This has limited the scope of the project. These data limitations are general in nature and would affect other similar studies.

5.5.2.1.2 ACLD data limitations

The five-year interval collection period of the ACLD dataset is another major limitation. Coupled with the lack of SA2-level data discussed above, this makes it difficult to completely isolate the effects of the BSBs from other shocks, particularly in the medium term (2006–16). This is why we make a distinction between the reliability of the 2006–11 and 2006–16 results. In addition, the 2011 Census took place almost 2.5 years after the BSB. Thus, the true cost of the BSB effects may be higher than what we document here, as individuals would have undergone some recovery during this time.

5.5.2.2 Project scope limitations

Even if we could completely address these limitations, our choice of measure (individual income) and reporting of estimates (as point estimates) add further limitations in how our results can be interpreted.

5.5.2.2.1 Use of individual income as a measure of economic resilience

Disasters such as the BSBs cause immediate and profound distress for individuals and communities, and their broad social impacts can still be felt many years later. These impacts are often significantly greater than tangible market costs, such as the income losses that we examine in our study.

In disaster-hit areas, the cumulative impacts of the bushfires and other subsequent disasters are likely to have compounded the social issues and affected the coping and adaptive capacities of local communities to disasters and, in turn, their resilience in the face of future disasters. For this reason, as we have done in our analysis section, our results should be interpreted within this broader social context, including the broader coping and adaptive capacity (see 4.2) of each SA2 within the region.

While income is an important measure of economic resilience, other financial dimensions are also likely to influence an individual's financial capacity to cope and recover from disasters. This includes access to credit cards, home loans, mortgage payments, insurance arrangements and ability to draw loans on existing assets.

Even when the income trajectory remains stable, the additional financial pressures created by disasters may be beyond the budget of an individual to cope with, even if government and other assistance is provided. In certain cases, disasters can push already income-poor households further into poverty, or drive a non-poor household below the income poverty line (United Nations Office for Disaster Risk Reduction, 2019).

Although our project does not consider such factors, we report the effects of the bushfires on each income group separately (i.e. low, middle, and high income) and confirm that the BSBs led to an increase in inequality between lower-income and middle-income groups, as the lower income group was severely affected. However, inequality between high-income and middle-income groups declined, as high-income group experienced significant income falls. The effect of the bushfires on the medium income group is not detectable.

5.5.2.2.2 The results reported are average point estimates, which do not provide the complete distribution of effects of the bushfires.

The aforementioned result also means there will always be certain individuals who are more (or less) severely impacted by disasters. Again, this is why we break down our overall main result to consider the bushfires' effect on the income of different socioeconomic and demographic groups (e.g. by age, gender, sector of employment, type of employment, and so on).

6. REPORT FINDINGS

In this section, we report all key findings. Overall, we find evidence that the BSBs were associated with both income losses and gains for individuals with different demographic and work characteristics, particularly in the short term, which we analyse and explore further in section 6.2.1.

Guide to interpreting findings

1. **Our baseline period is 2006, and so all our results are relative to 2006.**
2. **The income losses/gains we report are changes in income levels compared to our control group, which determines what the normal income path would have been had the bushfires not happened in the short term (i.e., between 2006 and 2011) and medium term (i.e., between 2006 and 2016).**
3. **The income losses/gains we report include the disaster effect plus the relief and recovery effect.**
4. **The true income cost of the disaster might be larger than what is documented in this report because of the 2.5-year period between the disaster and the 2011 Census, and the possible economic spillover effects between our treatment and control groups.**

6.1 SUMMARY OF RESULTS

6.1.1 Overall income effect

Overall, the 2009 Black Saturday Bushfires led to a significant decline in average annual individual income within the bushfire-hit areas during our study period (TABLE 10). Our geo-referencing prior to the empirical modelling indicates that the range of the share of burnt area in total SA2 surface area among the 37 SA2s hit by the BSB is 0.1% to 72.2%, with the mean share in our estimation sample being 12.5%.

Our subsequent empirical approach documents that in the mean group of SA2s, bushfires were associated with short-term losses in average annual individual income by -5.1%, which corresponds to about A$2,000. This effect is statistically significant almost at a 5% level (i.e., credible at 95% confidence interval).

Our short-term estimates also suggest that every additional 10 percentage point increase in the share of burnt area in an SA2 (e.g. an increase from 12.5% to 22.5%) is associated with an additional reduction in average annual individual income by 5.5%.

Considering the medium-term effect, it appears that the adverse shock in average annual incomes may have persisted somewhat into the period ending with the 2016 Census, but our estimate (2006–2016) for the average *overall* effect falls short of being statistically significant at the conventional levels.

TABLE 10 OVERALL RESULTS: INDIVIDUAL INCOME CHANGES ASSOCIATED WITH THE BSB (RELATIVE TO 2006 AND CONTROL GROUP)

	Full sample with migration accounted for
post × ***Intensity***	
2006-2011	-0.0044*
	(0.0022)
2006-2016	-0.0027
	(0.0019)
Observations	58,760
R-squared	0.023

post × Intensity is the difference-in-differences estimate. Standard errors are in parenthesis and clustered at SA2 level. Significance levels are denoted by: *p <0.10, ** p <0.05, *** p <0.01. Findings are based on use of ABS Microdata.

6.1.2 Economic characteristics

We now delve into the income effects by disaggregating the average population effect based on an individual's:

- employment type: employment hours (full-time, part-time); employment category (employed, unemployed);
- business size and type (if an employer);
- employment sector.

Exploring these different attributes helps us better understand the mechanisms through which the income of individuals might be affected by the disaster.

6.1.2.1 Labour force

We infer from TABLE 11 that individuals who were in the labour force in 2006 were at higher risk of bearing the income cost of the BSBs. For labour force participants who were *employed*, there seems to be some adverse income effects flowing into 2011. While the estimate is marginally outside of the conventional levels (with t-statistic being 1.55), the coefficient implies an annual income loss for the employed group by 3.7% (-A$1,468). As indicated in our limitations section, the 2011 Census was institutionalized 2.5 years after the BSB, during which some of the immediately affected individuals, such as laid-off workers, may have found new jobs. Thus, our point coefficients may have turned out to be smaller (less significant) than what they actually were just after the bushfires.

We do not identify any concerning adverse effects for the *unemployed* in 2011. It is likely that their entitlements would have continued in the post-disaster period, such that their incomes are not affected. It also appears that adverse income shock may have persisted until 2016 for individuals who were employed but our coefficient of interest (2006–2016) just falls short of being statistically significant. Even though this persistence might be attributed to the disastrous nature of the shock, as noted earlier, one should be cautious about interpreting the medium-term results, as our model may not isolate the confounding factors over the years. Yet, it is reassuring that unemployed individuals continued to be unaffected.

TABLE 11 RESULTS BY LABOUR FORCE STATUS: INDIVIDUAL INCOME CHANGES ASSOCIATED WITH THE BSBs (RELATIVE TO 2006 AND CONTROL GROUP)

	Labour force status (in 2006)		
	In labour force	Employed	Unemployed
post × *Intensity*			
2006-2011	-0.0044*	-0.00297	-0.01190
	(0.0022)	(0.00191)	(0.02701)
2006-2016	-0.0027	-0.00227	0.00544
	(0.0019)	(0.00142)	(0.03050)
Observations	58,760	56,223	2,537
R-squared	0.023	0.028	0.424

post ×Intensity is the difference-in-differences estimate. Standard errors are in parenthesis and clustered at SA2 level, Significance levels are denoted by: *p <0.10, ** p <0.05, *** p <0.01. Findings are based on use of ABS Microdata.

6.1.2.2 Business ownership

Our results show that the bushfires were not associated with differential income losses for business owners (TABLE 12). Put differently, business owners were generally uniformly affected by the deteriorating economic conditions. It appears, however, that owners of unincorporated businesses may have been somewhat more adversely affected (with t-statistic being 1.43) compared to the owners of incorporated businesses. Note again that the 2.5-year gap between the bushfires and the census might have pushed down the genuine adverse effect incurred by unincorporated businesses. It is also possible that the small business recovery programs might have helped these businesses recover to some extent by the census date, so that the observed income effect in 2011 is lower than what it could have been otherwise.

TABLE 12 RESULTS BY BUSINESS OWNERSHIP STATUS: INDIVIDUAL INCOME CHANGES ASSOCIATED WITH THE BSB (RELATIVE TO 2006 AND CONTROL GROUP)

	Business ownership status			
	Does not own business	Owns small business (1-19 employees)	Owns incorporated business	Owns unincorporated business
post × *Intensity*				
2006-2011	-0.00220	-0.0034	0.00164	-0.00452
	(0.00190)	(0.0058)	(0.00599)	(0.00317)
2006-2016	-0.00322*	0.0001	0.00533	-0.00027
	(0.00176)	(0.0047)	(0.00505)	(0.00293)
Observations	44,396	5,530	4,144	6.256
R-squared	0.035	0.136	0.156	0.15

post ×Intensity is the difference-in-differences estimate. Standard errors are in parenthesis and clustered at SA2 level, Significance levels are denoted by: *p <0.10, ** p <0.05, *** p <0.01. Findings are based on use of ABS Microdata. Unincorporated enterprises include sole proprietors and partnerships.

6.1.2.3 Part-time versus full time status

We now consider whether there are any differences in the income changes of part-time versus full-time workers (TABLE 13). The part-time (full-time) sample is approximately one-third (two-thirds) of the full sample. While the observed short-term effects are negative for both groups, the estimates fall out of the conventional confidence intervals. Again, this result can be attributed to the 2.5 years of time interval between the BSB and 2011 Census collection. It is also important to mention again that possible economic spillovers across the treatment and control groups might push down the estimates. Nonetheless, the effect is not to be ignored from the policy perspective.

A noteworthy additional result in the medium-term is in regard to part-time workers, which is negative and statistically significant at 5% level.

TABLE 13 RESULTS BY PART-TIME VS FULL-TIME: INDIVIDUAL INCOME CHANGES ASSOCIATED WITH THE BSBs (RELATIVE TO 2006 AND CONTROL GROUP)

	Part-time vs full-time employment (as at 2006)	
	Part-time	**Full-time**
post $\times$ ***Intensity***		
2006-2011	-0.00365	-0.00313
	(0.00277)	(0.00238)
2006-2016	-0.00599**	-0.00074
	(0.00258)	(0.00201)
Observations	17,100	35,833
R-squared	0.06	0.044

post ×Intensity is the difference-in-differences estimate. Standard errors are in parenthesis and clustered at SA2 level, Significance levels are denoted by: *p <0.10, ** p <0.05, *** p <0.01. Findings are based on use of ABS Microdata.

6.1.2.4 Sector of Employment

TABLE 14 RESULTS BY SECTOR OF EMPLOYMENT: INDIVIDUAL INCOME CHANGES ASSOCIATED WITH THE BSB (RELATIVE TO 2006 AND CONTROL GROUP)

	Employment sector (as reported in 2006)							
	 Manufacturing	 Retail trade	 Construction	 Health care and social assistance (private)	 Agriculture	 Education and training	 Public administration and safety	 Accommodation and food services
post × *Intensity*								
2006-2011	-0.00208	-0.00185	0.00415	0.00466	-0.01871	-0.00278	-0.00884	-0.01323**
	(0.00303)	(0.00622)	(0.00339)	(0.00316)	(0.01180)	(0.00196)	(0.00911)	(0.00610)
2006-2016	-0.00288	-0.00177	-0.00014	-0.00529	-0.00065	-0.00156	0.00627**	0.00440
	(0.00330)	(0.00525)	(0.00279)	(0.00564)	(0.00755)	(0.00275)	(0.00271)	(0.00451)
Observations	6958	6471	5056	5937	3348	4397	3018	2653
R-squared	0.128	0.122	0.132	0.149	0.146	0.189	0.239	0.239

post ×Intensity is the difference-in-differences estimate. Standard errors are in parenthesis and clustered at SA2 level, Significance levels are denoted by: *p <0.10, ** p <0.05, *** p <0.01. Findings are based on use of ABS Microdata.

In TABLE 14, we present the results for eight industries that are the top-employment sectors in the bushfire-hit areas in 2006.[16] These industries provide an important source of income for employed residents (refer to TABLE 4 for top eight industries across the bushfire-affected areas).

In examining the sectors of employment, we find important differences in income outcomes. TABLE 14 outlines the most important three sectoral results. In the short term, income losses by individuals employed in the accommodation and food services are estimated to be -16% (A$4,600). Employees in the agricultural sector also seem to be hard hit, with an estimated reduction in income by 23.4% (A$8,057). This estimate has a t-statistic of 1.59, which is not ignorable from a policy perspective.[17] Note again our two key research limitations that might have pushed this estimate down: the 2.5-year time interval between the BSB and the 2011 Census, and the possible spillover effects of the bushfires across treatment and control groups. These two negative effects contrast with the positive effects found in the case of the arts sector: the employees in this sector are associated with 12% income gains following the bushfires. These three sectors exhibit insignificant effects in the medium term (i.e., the 2016), suggesting that individuals seem to have reverted back to their 2006 income levels. Another positive effect identified is for the construction sector. Our point estimate implies a 6% increase in income in the sector in the short-term, but it is far from being significant. It might have been the case that the construction sector boomed immediately as a result

[16] The Australian National Accounts categorise economic sectors into 19 different sectors.

[17] While the economics literature has certain conventions in evaluating the empirical estimates around certain thresholds of t-statistics (e.g. a t-statistic of 1.65 corresponds to 90% confidence interval for large sample), it would be misleading, at least from a policy perspective, to assume a coefficient with a t-statistic of 1.59 – about 87% confidence interval – to be "zero".

of the recovery efforts, and then levelled off until the 2011 Census. Supporting this interpretation is the evidence that our medium-run estimate (i.e. 2016) implies no difference in construction income compared to that in the control group.

The income losses within the agricultural sector are well explained by the sector's prominence within bushfire-hit areas and its more land-intensive nature, which is evident once overlayed by sector-specific losses (TABLE 15), as well as other known losses including the burning of 3% of Yarra Valley's vineyard area and the loss of some 220 tonnes of trout (Parliament of Victoria 2010).

TABLE 15 SUMMARY OF AGRICULTURAL ASSET TYPES DESTROYED OR DAMAGED IN THE BUSHFIRES

Asset type	Number lost
Fencing (kilometres)	8,618
Agricultural buildings	1,411
Stock losses	11,800[A]
Sheep	4,449
Cattle	3,673
Horses	4,449
Stock losses	65,065
Softwood plantation timber (hectares)	12,416

SOURCE: UNLESS OTHERWISE INDICATED: DSE 2010. ^VICTORIAN BUSHFIRES ROYAL COMMISSION FINAL REPORT (PARLIAMENT OF VICTORIA, 2010)

These results are broadly consistent with the known sectoral effects of the BSBs on industry sectors we discussed in section 4.3.1.

Meanwhile, the accommodation and food services sector is a tourism-oriented sector, which is likely to have been adversely impacted by business closures, weakened demand from tourists for their services, and reduced hours of the service people working in the sector.

6.1.3 Social characteristics

So far, we have analysed some of the labour market and economic conditions that influence how individual income is likely to be affected by bushfires. We now turn to how the bushfires correlate with changes in individual income of different demographic groups. We categorize individuals according to their income groups (low, middle or high), gender, age, and home ownership status. Lastly, we investigate the income effects of BSB on individuals with a disability and individuals who do not speak English at home.

6.1.3.1 Income group

There are marked differences in outcomes for low-, middle- and high-income earners (TABLE 16). The key result is that poor individuals have become poorer.

TABLE 16 RESULTS BY INCOME GROUP: INDIVIDUAL INCOME CHANGES ASSOCIATED WITH THE BSB (RELATIVE TO 2006 AND CONTROL GROUP)

	Income group (in 2006)		
	Low income	Middle income	High income
post $\times$ ***Intensity***			
2006-2011	-0.00685*	0.00065	-0.00589*
	(0.00386)	(0.00148)	(0.00358)
2006-2016	-0.00365	-0.00358**	-0.00118
	(0.00252)	(0.00180)	(0.00322)
Observations	26,060	18,109	14,591
R-squared	0.048	0.090	0.118

post ×Intensity is the difference-in-differences estimate. Standard errors are in parenthesis and clustered at SA2 level, Significance levels are denoted by: *p <0.10, ** p <0.05, *** p <0.01. Findings are based on use of ABS Microdata.

In the short term, the bushfires were associated with income losses among low-income earners (-8.6% or -$A2,240). While no effect is observed for the middle-income earners, high-income earners seem to be hit as well (-8.6% or -A$4,381). Both low- and high-income estimates are significant at 10% level.

Importantly, while the negative income effect for low-income earners seem to have continued somewhat in the medium term, the effect becomes insignificant for high-income earners. This finding may suggest that high-income individuals exhibit resilience to go back to their pre-disaster income levels, whereas low-income earners may not have the same resilience.

Turning to middle-income earners, while the short-term effect seems to be insignificant, the medium-term effect is estimated to be negative and significant at 5% level (-4.1%; -A$1,620).

These findings, particularly for low-income earners, are supported by the existing literature. A lower socioeconomic status has been consistently associated with greater post-disaster hardship, with the poor suffering significant disaster losses due to lower financial capacity and limited access to public and private (e.g. insurance) recovery assets (Gladwin and Peacock, 2000; Fothergill and Peek, 2004).

The result is also important from the perspective of relief and recovery programs. It may be suggested that tailored household support programs are likely to help low-income individuals to become economically more resilient to disasters from an income perspective.

6.1.3.2 Gender

Breaking down income changes by gender yields important results (TABLE 17).

We find that the BSBs were associated with persistent income losses for females in the short (-9.7%; -A$2,961) and the medium term (-8.2%; -A$2,618).

TABLE 17 RESULTS BY GENDER: INDIVIDUAL INCOME CHANGES ASSOCIATED WITH THE BSBS (RELATIVE TO 2006 AND CONTROL GROUP)

	Gender	
	Male	Female
post × *Intensity*		
2006-2011	-0.00144	-0.00775**
	(0.00191)	(0.00323)
2006-2016	0.00087	-0.00715***
	(0.00176)	(0.00248)
Observations	31,043	27,717
R-squared	0.037	0.042

post ×Intensity is the difference-in-differences estimate. Standard errors are in parenthesis and clustered at SA2 level, Significance levels are denoted by: *p <0.10, ** p <0.05, *** p <0.01. Findings are based on use of ABS Microdata.

These findings are in line with the existing literature, which suggests women are likely to be more vulnerable to and adversely affected by disasters than men. In the context of the BSB, this can be attributed to the type of jobs they are employed in and the number of hours worked. For instance, 73.2 percent of part-time workers are females. In other words, almost 50 percent of females who are in the work force work part-time.

6.1.3.3 Age

Breaking down the income changes by age group, we find that the BSBs were associated with significant income losses for the 26–45-year age group in the short term (-6%; -A$2,560) as well as in the medium term (-5.3%; -A$2,450) (TABLE 18). While the coefficients for other age groups are negative, they are not statistically significant.

TABLE 18 RESULTS BY AGE GROUP: INDIVIDUAL INCOME CHANGES ASSOCIATED WITH THE BSB (RELATIVE TO 2006 AND CONTROL GROUP)

	Age (as at 2006)		
	Under 26	26 to 45	Over 45
post × *Intensity*			
2006-2011	-0.00268	-0.00483*	-0.00067
	(0.00521)	(0.00258)	(0.00252)
2006-2016	0.00713	-0.00462**	0.00266
	(0.00571)	(0.00225)	(0.00195)
Observations	9,392	27,334	22,034
R-squared	0.134	0.04	0.08

post ×Intensity is the difference-in-differences estimate. Standard errors are in parenthesis and clustered at SA2 level, Significance levels are denoted by: *p <0.10, ** p <0.05, *** p <0.01. Findings are based on use of ABS Microdata.

6.1.3.4 Home ownership type

The Victorian Black Saturday Bushfires destroyed 2,131 houses (Victorian Bushfire Commission, 2010), of which an estimated 74% were residential properties (Fire Recovery Unit, 2012).

We now disaggregate the overall effect by home ownership type (TABLE 19). The first two columns present the results for renters and owners, and the last two columns decompose the owners into owners (outright) and owners (with mortgage). It appears that home owners of different types were similarly affected by the bushfires. In other words, there is no differential effect observed across the groups. The estimated income loss ranges between 4.1% (for outright home owners) and 5.6% (for mortgage home owners). The estimates are generally significant around the 90% confidence interval, except for the owner (outright), for which it is somewhat less significant.

Crucially, we note that within the first 18 months following the bushfires (coinciding with our short-term study results), over $200 million had been spent by VBAF on rehousing, house repair and recovery assistance for those whose principle place of residence was destroyed or damaged by the bushfires (TABLE 23 in Appendix). The majority of these payments were directed to home owners and/or landlords, with much smaller gifts made available to tenants directly. We cannot quantify the impact of these recovery assistance programmes, however, one implication of our results is that channelling the funds to only home-owners is likely to exacerbate income inequality. Outright homeowners, and to some extent, owners with mortgage are likely to be in the upper-end of the income distribution, while renters are likely to be in the lower end.

TABLE 19 RESULTS BY HOME OWNERSHIP STATUS: INDIVIDUAL INCOME CHANGES ASSOCIATED WITH THE BSBs (RELATIVE TO 2006 AND CONTROL GROUP)

	HOME OWNERSHIP STATUS (AS AT 2006)			
	Renter	Owner	Owner outright	Owner with mortgage
post × *Intensity*				
2006-2011	-0.00416	-0.00417	-0.00325	-0.00447
	(0.00273)	(0.00255)	(0.00258)	(0.00277)
2006-2016	0.00075	-0.00286	-0.00181	-0.00361
	(0.00239)	(0.00212)	(0.00248)	(0.00264)
Observations	9,727	47,445	16,034	31,411
R-squared	0.092	0.027	0.069	0.036

post ×Intensity is the difference-in-differences estimate. Standard errors are in parenthesis and clustered at SA2 level, Significance levels are denoted by: *p <0.10, ** p <0.05, *** p <0.01. Findings are based on use of ABS Microdata.

6.1.3.5 Other demographic characteristics

Finally, we investigate the income effects for other demographic groups: disabled individuals, and user of English at home (i.e. spoken/not spoken) (TABLE 20).

We do not observe any concerning income effect on disabled individuals. While the income estimate is negative, it is far from being significant. Our insignificant result could possibly be due to the small proportion of residents with this attribute, which makes it difficult to detect statistically significant results.[18] An alternative explanation could be that their entitlements would have continued in the post-disaster period so that their main income stream was not affected.

Importantly, we observe a non-trivial significant relationship with respect to English being spoken or not spoken at home. In the short term, the bushfires were associated with income gains among individuals who do not speak English at home (12.3% or A$4,629), while individuals who speak English at home experienced income losses (-6% or A$-2,344). The 2006 Census includes only 171 individuals in the bushfire-hit areas who do not speak English at home. Our analysis shows that the majority of these individuals work in the transportation, manufacturing, insurance, agricultural, and other sectors. A great majority of our benchmark sample is English-speaking, so their estimated effect closely follows the *overall* effect presented at the beginning.

TABLE 20 RESULTS BY SELECTED CHARACTERISTICS: INDIVIDUAL INCOME CHANGES ASSOCIATED WITH THE BSB (RELATIVE TO 2006 AND CONTROL GROUP)

	 Disability	 English not spoken at home	 English spoken at home
post × *Intensity*			
2006-2011	-0.01997	0.00979*	-0.00481**
	(0.03799)	(0.00563)	(0.00224)
2006-2016	-0.03204	0.00394	-0.0028
	(0.04034)	(0.00802)	(0.00198)
Observations	295	5,453	53,307
R-squared	0.308	0.157	0.024

post ×Intensity is the difference-in-differences estimate. Standard errors are in parenthesis and clustered at SA2 level, Significance levels are denoted by: *p <0.10, ** p <0.05, *** p <0.01. Findings are based on use of ABS Microdata.

[18] For instance, while representative, there were only 26 disabled residents that were reported to be in the labour force in our treatment group sample. This may impact on the ability to statistically pick up the relationship between the disaster and income changes for these individuals.

6.2 ANALYSIS OF RESULTS

Considering our results altogether, income losses predominantly occurred in the short term, and ranged between A$1,435 and A$8,057. The losses are primarily associated with vulnerable groups, such as female residents or low-income earners.

While we have analysed and been able to explain some of these results through known disruptions (both positive and negative) in economic activity at the time of the bushfires, we are yet to explore the interlinkages between our demographic results, sectoral results and the government relief and recovery assistance programs. We do this here, before offering final conclusions.

6.2.1 Interrelationships between results

The richness of the ACLD dataset allows us to explore the relationships between multiple attributes concurrently. Using a matrix (see Appendix 12.3.5), we can establish some of the underlying relationships between our sectoral and demographic results. For instance, we can see which sectors are over-represented in certain demographic groups, and from this, examine whether there is consistency between demographic and sectoral results.

For simplicity, we presented in FIGURE 2 a visual representation of this matrix where we find clear overlaps between our demographic groups and the employment sectors in which they have the highest representation.

It is evident that the income losses for females and low-income earners are likely due to their high employment rates in the accommodation and food services sector, which is known to have been adversely impacted in the short term by the bushfires. We also notice that these two groups are similarly highly represented in other sectors (e.g. retail trade), thus suggesting a strong degree of overlap between females and low-income earners.

The relationships are less clear for other demographic groups and so are not included in FIGURE 2. However, from the matrix, medium- and high-income earners are more heavily represented in industry sectors where we do not observe statistically significant income changes. Likewise, older age groups present similar employment characteristics and insignificant income changes. For instance, the top five sectors that high-income earners worked in as of 2006 were manufacturing, construction, public administration and safety (private), health care (private) and professional, scientific and technical services. For medium-income earners, the top five sectors are listed as manufacturing, health care (private), construction, retail and lastly education (private). Thus, the sector of employment is likely to offer a buffer for possible adverse income effects due to the bushfires.

6.2.2 The role of government assistance

So far, we have not modelled the role of intervention mechanisms due to the unavailability of related data at the SA2 level. We have assumed that such government relief and recovery interventions are *subsumed* in the income effects that we have estimated.

While we are unable to formally assess whether government packages played a mitigating role, we can shed light on the role of government assistance in income changes by mapping the relief and recovery programs to different groups and any related sectors.

We overlay our sectoral results with government relief and recovery assistance provided for the BSBs.[19] While not capturing all monetary assistance provided, it nevertheless provides a good representation of the likely *proportional* expenditure per program.

We use ABS ANZSIC classifications to guide sector categorisations and divide the assistance into:

- Packages that create stimulatory economic activity (e.g. result in or encourage employment and/or income generation activities, whether directly or indirectly) in particular sectors.
- Packages that assist particular sectors in repair activities (e.g. primary producer assistance would go under agricultural sector).

FIGURE 3 attempts to establish some links between government disaster recovery efforts and subsequent economic activity in different sectors. These recovery programs include, among others, rehousing and recovery, state-wide community projects, psychological support, scholarship, school holiday programs, and primary producer repair and restoration. We provide a detailed account of these programs in TABLE 23 and TABLE 24 in the appendix.

It's clear that government community recovery programs are likely to produce increased money flows to particular sectors than otherwise would have occurred. Mapping these programs onto economic sectors reveal the beneficiary sectors as: manufacturing, construction, arts and recreation, health care and social assistance, retail trade, education and training, and agriculture, forestry and fishing.

Our estimated income results indicate that the recovery programs may not have been sufficient for the agricultural sector given that our economic modelling still identifies negative income effects for this sector. The programs may have muted otherwise negative effects accruing to manufacturing and retail trade sectors given the insignificant income effects estimated for these sectors. Finally, with positive income effects identified, there is some evidence that the construction and arts and recreation sectors have benefitted from the recovery efforts.

[19] See appendix 12.2.2.

7. CONCLUSIONS

The key highlight of this report is an analysis of income trajectories of residents hit by a catastrophic bushfire, the 2009 Black Saturday bushfires, which ravaged regional Victoria, using a nationally representative longitudinal census dataset over the short- and medium-term.

Our findings shed light on how disasters interact with existing economic conditions and workforce composition to affect individuals within the community.

We first document a significant decline in individuals' overall income following the bushfires. We then continue on, to find the socioeconomic groups and economic sectors that were particularly vulnerable.

In exploring reasons behind income changes, our research identifies one main channel through which disaster-induced economic shocks can be transmitted to individuals, vis-à-vis income: working in sectors with economic activity particularly susceptible to disaster shocks (both positive and negative).

Disruptions, both positive and negative, to sectors of employment explain many of the statistically significant income changes we report. For instance, short-term income losses for workers in agriculture and tourism-oriented sectors are in line with the weakened economic conditions these sectors faced following the BSBs.

We also find that the sector-level disruptions had flow-on consequences for particular demographic groups. For instance, short-term income losses reported for females and low-income earners are explained by heavy representation of female residents and low-income earners in agriculture and accommodation and food services sector. Both agriculture and accommodation sectors are typically the sectors in which individuals' average incomes are lower.

We also identify that both low-income earners and the female workforce exhibit weak economic resilience to disasters, in that they are not fully able return back to their pre-disaster income trajectories in the medium-term.

While the key vulnerable groups identified in this study (i.e. low-income individuals and female residents) are similar to those that we identified in our other case studies, there is also evidence that a catastrophic disaster such as the BSBs inflicts heavy losses on every part of a regional community. Notably, even high-income earners cannot escape income losses in the short-term.

The core policy implication of this report is related to the design of government relief and recovery programs. To alleviate the financial and cognitive burdens of disasters and to expedite successful economic rebound, well-designed recovery and relief programs, targeted at both public domain and individual economic wellbeing, are the principal way forward. Our report provides evidence to make informed decisions regarding how governments can better facilitate the recovery assistance programs for recent or future bushfire events, especially in regard to individual and household wellbeing.

8. KEY MILESTONES

Year	Milestone	Milestone date	Status
2018-19	Submit a demographic profile analysis of the Queensland Floods 2010-11 disaster-hit areas	31 December 2018	Completed
2018-19	Disseminate the preliminary findings of the Queensland Floods 2010-11 Case Study to beneficiaries	31 December 2018	Completed
2019-20	Disseminate final findings (including medium-term effects) of the Queensland Floods 2010-11 Case Study to beneficiaries	30 September 2019	Completed
2019-20	Submit the final report on the Queensland Floods 2010-11 Case Study	31 January 2020	Completed
2019-20	Submit Policy briefing for the Queensland Floods 2010-11 Case Study	31 March 2020	Upcoming
2019-20	A national seminar to sensitise the policymakers on the economic and social effects of disasters	30 May 2020	Upcoming
2019-20	Submit guidance note on the methodology of estimating economic and social impacts of natural disasters	30 June 2020	Upcoming
2019-20	Submit a research brief to facilitate the adoption of research findings at agency level	30 June 2020	Upcoming

9. UTILISATION OUTPUTS

9.1 ACHIEVEMENTS

9.1.1 Commercialisation/Utilisation

9.1.2 End-user engagement

Since inception, the project has enjoyed the guidance, support and engagement of multiple government end-users, including the Inspector General Emergency Management - Victoria, Emergency Management Victoria, Queensland Reconstruction Authority and Emergency Management Australia. This engagement has strengthened the research design and utilisation potential.

Apart from project deliverables, the project team has also produced multiple stakeholder updates, which have provided end-user representatives with a more nuanced understanding of research methodology, and updates on relevant economic literature on disasters arising from natural hazards.

9.1.3 Opportunities

9.1.4 Impacts

9.1.5 Tracking

9.2 WHAT THIS PROJECT HAS REVEALED

The *Disasters and Economic Resilience: The Effects of the Black Saturday Bushfires on Individual Income - A Case Study* report has revealed the income streams within industries and demographics of the workforce that are more vulnerable to disaster-induced disruptions.

It is revealed that disruptions, both positive and negative, underlie the short-term income losses for workers in agriculture and tourism-oriented sectors.

Moreover, these sector-level disruptions had flow-on consequences on particular demographic groups. For instance, short-term income losses reported for females and low-income earners are explained by high female employment in the accommodation and food services sector.

The report has also revealed that the poor become poorer following disasters. In addition, both low-income and female residents exhibit lower economic resilience to disasters, in that they may not be fully able to return to their pre-disaster trajectory in the medium-term. This highlights the potential for disasters to widen income inequality over time.

Finally, while the key vulnerable groups identified in this study (i.e. low-income individuals and female residents) are similar to those that we've identified in our

other case studies, there is also evidence that a catastrophic disaster such as the BSBs inflicts heavy losses on *every part* of a regional community. Notably, even high-income earners cannot escape income losses in the short-term.

This information can help policymakers plan for and better target economic recovery programs so that long-term recovery is not only achieved more quickly, but also spread more evenly across the community.

To summarise, by quantifying income losses and gains associated with a catastrophic disaster that ravaged regional Victoria, the report has shown how these losses can be distributed unevenly across segments of the workforce, and has exposed vulnerabilities that require policy attention. The research has helped demonstrate how such quantification exercises using individuals' income can be done, a current gap in disaster impact estimation, using national accounts records.

9.3 GAPS

10. PUBLICATIONS LIST

10.1 PEER REVIEWED JOURNAL ARTICLES

1 Ulubasoglu M, Rahman MH, Önder Y, Chen Y, Rajabifard A. "Floods, bushfires and sectoral economic output in Australia, 1978–2014", 2019, 95(308): 58–80, *Economic Record*.

2 Rahman MH. "Earthquakes don't kill, built environment does: Evidence from cross-country data", *Economic Modelling*, 2018, 70: 458–468.

3 Rahman MH, Anbarci N, Bhattacharya P, Ulubasoglu M. "Can extreme rainfall trigger democratic change? The role of flood-induced corruption", *Public Choice*, 2017, 171: 331–358.

4 Rahman MH, Anbarci N, Bhattacharya P, Ulubasoglu M, "The Shocking Origins of Political Transitions? Evidence from Earthquakes", *Southern Economic Journal*, 2017, 83: 796–823.

10.2 PAPERS

10.2.1 Refereed conference papers

1 Rahman, M.H., M. Ulubasoglu, P. Bhattacharya, K. Potts, Y. Chen, M. Kalantari and A. Rajabifard. "Natural Disasters and Economic Development: Evidence from Australia", Australian Conference of Economists, 7–10 July 2015, Brisbane.

10.2.2 Non-refereed conference papers

2 Ulubasoglu, M. "Disasters and economic resilience: income effects of the Black Saturday bushfires on disaster-hit individuals." AFAC18 (Bushfire and Natural Hazards CRC, 2018). Google Scholar BibTeX XML

3 Ulubasoglu M, Önder YK, Rahman MH. "*Evaporative Heating: The Negative Income Effects of the Black Saturday Bushfires in Disaster-Hit Areas*." The 2018 Annual Conference of the Australasian Fire and Emergency Service Authorities Council, 5-8 September 2018, Perth.

4 Ulubasoglu M, Rahman MH. "Unpacking the Sectoral Income Effects of Natural Disasters: Evidence from the 2010-11 Queensland Floods". The 2017 Annual Conference of the Australasian Fire and Emergency Service Authorities Council, 3–5 September 2017, Sydney.

5 Rahman MH, Chen Y, Potts K, Bhattachary P, Rajabifard A, Ulubasoglu M, Kalantari M. "Bringing hazard and economic modellers together: A spatial platform for damage and losses visualisation" 2015, Research proceedings from the Bushfire and Natural Hazards CRC and AFAC conference, Report No. 2015.084, Adelaide.

6 Rajabifard A, Ulubasoglu M, Potts K, Rahman MH, Kalantari M, Bhattacharya

P. "A pre-disaster multi-hazard damage and economic loss estimation model for Australia." The 2014 Annual Conference of the Australasian Fire and Emergency Service Authorities Council, 2–5 Sep 2014 Wellington.

10.2.3 Working papers

In the coming year, we will also be progressing several working papers. These papers, while strictly outside the scope of our project, nevertheless have greatly benefited from and been informed by our BNHCRC research program methodology and learnings, underscoring the positive externalities that CRCs such as the BNHCRC effect on the quality and relevance of Australian research:

- Önder, Rahman, Ulubasoglu: *The Spillover Effects of Black Saturday Bushfires: A Network Approach*
- Önder, Rahman, Ulubasoglu: *Droughts and Crop Yield in Australia*
- Rahman, Anbarci, Ulubasoglu: *"Storm Autocracies": Islands as Natural Experiments*
- Rahman, Guven, Ulubasoglu: *Floods and Agricultural Productivity: Natural Field Experimental Evidence from Micro Plot-Level Data on Sri Lanka*.

10.2.4 Other

1 Ulubasoglu M, Beaini F. "*Black Saturday bushfires: counting the cost*", *Australian Journal of Emergency Management*, 2019:5–6.

2 Beaini F, Ulubasoglu M. "Demographic profiling: Toodyay Bushfire 2009 case study", *Bushfire and Natural Hazards CRC*, 2019.

3 Beaini F, Ulubasoglu M. Demographic profiling: Victorian bushfires 2009 case study", *Bushfire and Natural Hazards CRC*, 2018, https://www.bnhcrc.com.au/node/5214.

4 Beaini F, Ulubasoglu M. "Demographic profiling: Queensland Floods 2010-11 case study", *Bushfire and Natural Hazards CRC,* 2018.

11. TEAM MEMBERS

Professor Mehmet Ulubasoglu – Project lead

Professor Mehmet Ulubasoglu is the Head of the Department of Economics and the Director of the Centre for Energy, the Environment and Natural Disasters at Deakin University. Professor Ulubasoglu is one of Australia's foremost experts on the economic impacts of natural disasters, with many years' experience working on these questions with governments in Australia, through his work with the Bushfire and Natural Hazards Cooperative Research Centre, and in South-East Asia with the Asia Disaster Preparedness Centre.

His current BNHCRC research project *Optimising Post-disaster Recovery Interventions in Australia* fills a major gap by estimating economic impacts of several Australian natural disasters on economic sectors and vulnerable groups.

He has published extensively in leading international journals, including the *Review of Economics and Statistics*, *Journal of Development Economics*, *American Journal of Agricultural Economics*, *European Economic Review*, and *American Journal of Political Science*.

Ms Farah Beaini – Research fellow

Farah Beaini was a member of the team until 31 January 2020 as a Research Fellow in the Department of Economics at Deakin University, and the Industry Program and Research Coordinator at the Deakin Business School's Centre for Energy, the Environment and Natural Disasters.

Farah brought in a wealth of stakeholder engagement and project management experience from her previous state and Commonwealth government roles in digital transformation, service delivery, administrative law and economic research. As part of the BNHCRC project, Farah oversaw the stakeholder management and end-user engagement.

Other

In addition to the core research team, several casual members contribute valuably to the project by working on the ArcGIS, statistical programming, and performing regressions as part of the Australian Bureau of Statistics visits.

12. APPENDIX

12.1 ANDRI SCORING INFORMATION

TABLE 21 ANDRI DESCRIPTION OF HIGH, MODERATE AND LOW ANDRI SCORE, COPING AND ADAPTIVE CAPACITY BANDS

Sector	Class	Percentile	Description
ANDRI Overall scoring	Low	<25th percentile 0 – 0.4461	Communities in areas of low disaster resilience may be limited in their capacity to use available resources to cope with adverse events, and are limited in their capacity to adjust to change through learning, adaptation and transformation. Limitations to disaster resilience may be contributed by entrenched social and economic disadvantage, less access to or provision of resources and services, lower community cohesion and limited opportunities for adaptive learning and problem solving.
	Moderate	25-75 percentile 0.4462 – 0.6598	Communities in areas of moderate disaster resilience have some capacity to use available resources to cope with adverse events, and some capacity to adjust to change through learning, adaptation and transformation. Moderate disaster resilience is generally contributed by moderate levels of coping and adaptive capacity, which in turn are associated with moderate levels of economic capital, moderate provision of or access to services, moderate community cohesion and variable encouragement for adaptive learning and problem solving.
	High	>75th percentile 0.6598 –1	Communities in areas of high disaster resilience have enhanced capacity to use available resources to cope with adverse events, and enhanced capacity to adjust to change through learning, adaptation and transformation. Factors contributing to high disaster resilience may include employment, education, income, good access to or provision of resources and services, strong community cohesion and ample opportunities for adaptive learning and problem solving.
Coping capacity scoring	Low	<25th percentile 0 – 0.3945	Communities in areas of low coping capacity may be constrained in their capacity to use available resources to cope with adverse events and to prepare for, absorb and recover from a natural hazard event.
	Moderate	25-75 percentile 0.3946 – 0.6311	Communities in areas of moderate coping capacity have some capacity to use available resources to cope with adverse events and to prepare for, absorb and recover from a natural hazard event.
	High	>75th percentile 0.6312 - 1	Communities in areas of high disaster resilience have enhanced capacity to use available resources to cope with adverse events and to prepare for, absorb and recover from a natural hazard event.
Adaptive capacity scoring	Low	<25th percentile 0 – 0.4515	Communities in areas of low adaptive capacity may be constrained in their capacity to adjust to change through learning, adaptation and transformation.
	Moderate	25-75 percentile 0.4516 – 0.6656	Communities in areas of moderate adaptive capacity have some capacity to adjust to change through learning, adaptation and transformation.
	High	>75th percentile 0.6657 - 1	Communities in areas of high adaptive capacity have enhanced capacity to adjust to change through learning, adaptation and transformation.

12.2 BLACK SATURDAY BUSHFIRES DISASTER INFORMATION

12.2.1 BSB AREA DISASTER EVENTS (2006-2016)

TABLE 22 BSB-AREA DISASTER EVENTS THROUGHOUT STUDY PERIOD (2006-16)

Disaster type	Disaster date	NDRRA Category activated	Affected areas	Description	Source
Bushfires	January 2006		Bendigo; Yea; Kinglake; Stawell; Grampians; Ararat; Baw Baw; Glenelg; Golden Plains; Horsham.	500 fires 4 death(s) 6 injured $22 million insurance costs 57 home(s) destroyed 359 farm building(s) destroyed 160 hectares burnt	Australian Institute for Disaster Resilience (2018)
Bushfires	December 2006 – February 2007		Golden Plains; Bendigo; Mansfield (Vic.); Bright – Mount Beauty; Camperdown; Colac.	1 death(s) 1400 injured 51 home(s) destroyed 1.2 to 1.3 million hectares burnt	Disaster Resilient Australia (2014)
Floods	June 2007	A, C	Golden Plains; Bendigo; Longford – Loch Sport; Maffra; Sale.	1 death(s) $15 million insurance costs	Australian Institute for Disaster Resilience (2019)
Floods	September 2010	A, B	Creswick – Clunes; Bendigo; Euroa; Benalla; Wangaratta; Bright – Mount Beauty; Myrtleford; Horsham; Wimmera.	The floods, which followed heavy rain across south-eastern Australia in early September 2010, caused the inundation of about 250 homes, hundreds of evacuations and millions of dollars of damage.	ABC News (2010)
Floods	January - April 2011	A, B, C, D	Creswick – Clunes; Beaufort; Golden Plains; Maryborough; Bendigo; White Hills – Ascot; Kyneton; Loddon; Warragul; Whittlesea; Healesville – Yarra Glen; Mooroolbark; Yarra Valley; Horsham; Wimmera; Grampians.	2 death(s) Total economic cost to agriculture: $1.5 billion to $2 billion. 2000 kilometres of fences, 83,000 tonnes of hay and silage, 51,700 hectares of pasture and 41,200 hectares of field crops. Confirmed stock losses for sheep are 6106 reported dead and 1822 missing or injured, with more than 100 cattle killed.	Darren Gray and David Rood
Floods	February 2012	A, B, C	Castlemaine; Seymour; Benalla; Chiltern – Indigo Valley; Emerald – Cockatoo (Vic.); Wimmera.	The Insurance Council of Australia estimated the 2012 damage at $108.2 million, which incorporated figures for both New South Wales and Victoria.	(2011)
Floods	June 2012	A, B, C	Bendigo; Baw Baw; Trafalgar (Vic.); Morwell; Traralgon; Yallourn North – Glengarry; Sale; Montrose.	Up to 100 residents in low-lying parts of Traralgon were evacuated when 45 homes were flooded from overspill out of Traralgon Creek.	Australian Institute for Disaster Resilience (2019)
Tornado	March 2013	A, B	Euroa; Rutherglen; Moira.	At approximately 8.00pm on 21 March 2013, a category F3 tornado with winds between 250-300	Australian Institute for Disaster Resilience (2019)

				kilometres per hour crossed north-east Victoria and travelled up to the border of New South Wales. 24 injured 24 home(s) destroyed	
Bushfires	January 2014	A, B, D	Ararat; Horsham; Stawell; Camperdown, Grampians.	The fire coincided with a heatwave across Victoria with temperatures reaching over 40 C in the Grampians region from 15 - 20 January. The fire eventually burnt 52,000 hectares including bushland and farms and was declared contained on 21 January 2014.	Australian Institute for Disaster Resilience (2018)
Bushfires	February 2014	A, B, C, D	Bendigo; Kilmore – Broadford; Drouin; Morwell; Wallan; Craigieburn – Mickleham; Warrandyte – Wonga Park.	3 injured 40 home(s) destroyed Major fires: The Mickleham Road Complex fire: A total of 13 homes were destroyed as well as other farm infrastructure and approximately 10,000 sheep and 600 cattle also perished. East Gippsland fires: More than 130,000 hectares were burnt and 15 homes destroyed. Approximately 100 farm properties were also affected with stock and fencing losses.	Australian Institute for Disaster Resilience (2017)
Floods	September 2016	A, B, C	Creswick – Clunes; Golden Plains; Loddon; Alexandra; Ararat; Horsham; Wimmera; Yarriambiack; Glenelg (Vic.); Hamilton (Vic.); Grampians; Colac; Corangamite; Moyne; Otway.	In Victoria, the State Emergency Service received 1,500 calls for assistance between 9 and 19 September and performed more than 20 flood rescues. Thirteen schools were closed; mid-month, over 190 roads were closed at some point. Twenty-five Local Government Areas were impacted; parts of some towns were evacuated. One person drowned in Wallacedale, south of Hamilton, after his ute was washed away by floodwaters.	Australian Institute for Disaster Resilience (2018)

12.2.2 Black Saturday Bushfires Government Assistance Programs

TABLE 23 VBAF HOUSING PROPERTY RELATED ASSISTANCE PAYMENTS (FEBRUARY 2009 - 31 AUGUST 2010)

Gift	Housing Group	Gift Amount	Distributed funds ($m)	Number of payments

Initial home dislocation	All	• $5000 per household • $2000 per person over 18 • $1500 per child under 18	$27.52	4,273
Emergency household repairs	Home owners Landlords	• $3000 lump sum	$2.78	931
Rehousing and recovery (destroyed properties)	Home owners	• $35,000 lump sum plus • $15,000 contents payment • needs-based payment of up to $50,000	$149.07	6,663
Rehousing and recovery (damaged properties)	Home owners	• $15,000 lump sum, plus • a further, needs-based payment of up to $20,000		
Rehousing and recovery (tenant properties)	Tenants ^	• $15,000 lump sum		
Rehousing and recovery (construction)	Home owners	• Up to $25,000 pre lock-up (during construction stage) • $35,000 for post lock-up (certificate of occupancy; house ready to be moved into post construction)		
Essential services for temporary accommodation	All	• Case-by-case financial support	$3.91	22
Transitional Support for Homeowners, Tenants and Boarders	Home owners Tenants	• Homeowners $10,000 for singles and couples, $15,000 per family of three or more • Tenants and boarders – $5000 per home for up to two residents and $7500 per home for three or more residents	$16.84	1,635
Support for Boarders to Rehouse	Tenants / Renters	• $5000 for less than two people • $7,500 for three or more people	$0.43	89
Total			**$200.55**	**13,613**

SOURCE: VBAF 2010 (A), VBAF 2010 (B). ^ BASED ON AVAILABLE VBAF INFORMATION, TENANT PROPERTIES REHOUSING AND RECOVERY PROGRAM DISTRIBUTIONS ACCOUNT FOR AN ESTIMATED 5% OF TOTAL DISTRIBUTIONS WITHIN THIS PROGRAM.

TABLE 24 BSB GOVERNMENT ASSISTANCE PROGRAMS

Gift	Programs	Description	Amount ($m)	Sector
Rebuilding and Recovery Payments	**1.** Household Repairs	A short term measure to help people affected by the bushfires make minor repairs to properties damaged by fire, water or smoke.	2.8	
	2. Rehousing and Recovery: destroyed properties	Payment to home owners whose principal place of residence was destroyed by the bushfires. This gift was also available to sole asset owners, houses under construction or for people who lived in other structures which were non standard dwellings, such as sheds, caravans or granny flats.	111.6	Construction, manufacturing, (retail trade, transport)
	3. Rehousing and Recovery: damaged properties	Payment to people whose principal place of residence was damaged by the bushfires. Up to $15,000 was available for the repair or replacement of other external structures including sheds.	31	Construction, retail
	4. Rehousing and Recovery: tenant properties	Payment to tenants whose rented property was destroyed to assist with the replacement of lost or damaged contents.	6.7	Real estate
	5. Essential Services Temporary Accommodation	Provision of essential services such as toilets and showers to people whose principal place of residence was destroyed in the 2009 Victorian bushfires and are living in temporary accommodation. This gift was extended until 30 March, 2012.	6.4	retail
	6. Rural Property Recovery Assistance	Support for rural landowners who suffered hardship or distress due to damage caused to rural properties of more than two hectares.	8.1	agriculture
	7. Primary Producers Repair and Restoration	To assist and relieve the stress of primary producers who have suffered loss and damage to their properties and farming activities.	5.6	agriculture

	8.	Safe Removal of Hazardous Trees	To help residents in bushfire affected areas meet the cost of assessing and removing hazardous trees on their private properties.	6.4	utilities
Support Payments	**9.**	Severe Injury	Support for people with a severe injury who were hospitalised and required extended hospitalisation and/or surgery.	1.4	Health care
	10.	Severe Injury Transition to Home	Lump sum payment to the severely injured who had a prolonged stay in hospital. An additional payment was also made available for those who required specialist support to return to home after hospital.	1.9	Health care
	11.	Winter Needs	Assistance for people whose principal home was destroyed or damaged to assist with the purchase of items such as blankets, clothing and fuel.	8.4	Retailing
	12.	Bereaved Children and Young Adults	Financial support for bereaved children and young adults who lost one or more parents as a result of the bushfires.	10.5	
	13.	School Holiday Programs	Funding for the YMCA to implement free school holiday programs for primary and secondary school students in bushfire affected areas during winter, spring and summer school holidays. The program was extended until the end of the summer 2011/2012 school holidays.	6.5	Education, arts
	14.	Transitional Support for Homeowners and Tenants	Support for the transition to a new home for home owners whose property was destroyed and for boarders and tenants where the property they resided in was destroyed.	16.8	
	15.	Psychological Support - Phase 1	This gift provides individuals with a variety of psychological support services and community based programs, including youth focused programs	8.2	Health care
	16.	Psychological Support - Phase 2	To provide support for older people, families, men and women, who may be experiencing stress, trauma and isolation, to cope, rebuild support networks and reconnect with their communities.	3.5	Health care, social work
	17.	Compassionate Financial Support	Support for next of kin suffering financial hardship as a result of losing a loved one in the 2009 Victorian bushfires.	5.5	
	18.	Scholarships	Grants of up to $15,000 per year were available for bushfire-affected students undertaking tertiary or vocational studies.	7.0	education
	19.	Psychological Support – Children's Recovery Project	To help relieve the distress of children and young people by identifying potential difficulties they may be experiencing after the bushfires and to provide the appropriate referral pathway for access to treatment and support.	1.0	Health care, social work
	20.	Extended Support for Young People (10-26 years)	Programs assisting in the recovery of young people aged 10 to 26 years impacted by the bushfires. Three types of support services were made available for those continuing to experience personal and psychological distress as a result of the bushfires	2.8	
	21.	Financial Hardship and in Need of Permanent Accommodation	Financial assistance for people who lost their principle place of residence in the bushfires, are not yet in permanent accommodation and are still experiencing financial hardship as a result of the bushfires.	111.6	Construction, manufacturing, (retail trade, transport)
	22.	Permanently Impaired	Support for people with the most severe permanent impairments (either physical or psychological) sustained as a direct result of the bushfires and who continue to experience financial hardship.	31	Construction, retail
	23.	Further Housing Assistance	Further assistance for people who lost their principal place of residence in the 2009 Victorian bushfires, are not yet in permanent accommodation and are experiencing financial hardship. This gift provides eligible households with up to $50,000 to find permanent accommodation, and access to specialist support services	6.7	Real estate
Community Payments	**24.**	Community Assistance Gift	To assist bushfire affected councils to deliver disaster related services that directly benefit residents. Assistance provided to local governments through this payment is for works in addition to the Community Recovery Plans	6.4	retail
	25.	Winter Community Events	To help relieve the psychological distress of communities in bushfire affected areas during winter and promote wellbeing over the winter months.	8.1	agriculture
	26.	Statewide Plan - Community Projects	Assistance provided to bushfire affected communities for community projects which have been identified by local Community Recovery	5.6	agriculture

		Committees as priorities for their recovery.		
	27. Medium to Long Term Recovery	Funding for 73 local projects to help meet medium to long term recovery needs in bushfire affected areas, and for a range of statewide services to support individuals and families.	6.4	utilities
	28. Community and Cultural Facilities in Kinglake and Marysville	Assistance for new community and cultural facilities in Kinglake and Marysville, both of which are being developed in close consultation with the two communities.	1.4	Health care

12.3 BSB CASE STUDY ANALYSIS

12.3.1 2006 descriptive statistics

TABLE 25 2006 SAMPLE DESCRIPTIVE STATISTICS: DEMOGRAPHIC AND EMPLOYMENT ATTRIBUTES

	Full sample (2006)			Treatment sample (2006)			Control Group sample (2006)		
	Mean	Std. dev.	Observations	Mean	Std. .dev.	Observations	Mean	Std. dev	Observations
Income (A$)	37,976.712	24,373.234	19,661	38,062.187	25,194.497	4,605	37,950.568	24,117.257	15,056
Low income (%)	0.441	0.496	20,070	0.449	0.497	4,702	0.438	0.496	15,368
Middle income (%)	0.305	0.460	20,070	0.290	0.454	4,702	0.309	0.462	15,368
High income (%)	0.255	0.436	20,070	0.260	0.439	4,702	0.253	0.435	15,368
Age	40.197	12.540	20,070	41.855	12.408	4,702	39.690	12.537	15,368
Female (%)	0.471	0.499	20,070	0.462	0.499	4,702	0.474	0.499	15,368
English not spoken at home (%)	0.093	0.291	20,070	0.036	0.187	4,702	0.111	0.314	15,368
Disability (%)	0.005	0.071	20,070	0.006	0.074	4,702	0.005	0.070	15,368
Home ownership status									
Owner (outright) (%)	0.274	0.446	20,070	0.305	0.460	4,702	0.264	0.441	15,368
Owner (with mortgage) (%)	0.533	0.499	20,070	0.547	0.498	4,702	0.529	0.499	15,368
Renter (%)	0.165	0.371	20,070	0.120	0.325	4,702	0.179	0.383	15,368
Employment status									
Employed (%)	0.956	0.205	20,070	0.964	0.187	4,702	0.954	0.210	15,368
Unemployed (%)	0.044	0.205	20,070	0.036	0.187	4,702	0.046	0.210	15,368
Hours worked									
Part-time (%)	0.291	0.454	20,070	0.303	0.460	4,702	0.287	0.452	15,368
Full-time (%)	0.609	0.488	20,070	0.596	0.491	4,702	0.612	0.487	15,368

Business ownership									
Does not own business (%)	0.752	0.432	20,070	0.713	0.453	4,702	0.764	0.425	15,368
Owns small business (%)	0.095	0.293	20,070	0.117	0.321	4,702	0.088	0.284	15,368
Owns incorporated business (%)	0.071	0.257	20,070	0.082	0.274	4,702	0.067	0.251	15,368
Owns unincorporated business (%)	0.108	0.310	20,070	0.141	0.349	4,702	0.098	0.297	15,368

NOTE: % REFERS TO THE SHARE OF THE GROUP IN THE RELATED SAMPLE.

TABLE 26 2006 SAMPLE DESCRIPTIVE STATISTICS: SHARE OF TOTAL EMPLOYMENT, BY SECTOR

	Full sample (2006)			Treatment sample (2006)			Control group sample (2006)		
	Mean	Standard deviation	Observations	Mean	Standard deviation	Observations	Mean	Standard deviation	Observations
Agriculture (%)	0.062	0.242	18,780	0.093	0.290	4,430	0.053	0.224	14,350
Mining (%)	0.004	0.066	18,780	0.005	0.072	4,430	0.004	0.065	14,350
Manufacturing (%)	0.126	0.332	18,780	0.121	0.327	4,430	0.128	0.334	14,350
Electricity, gas, water and waste services (%)	0.013	0.113	18,780	0.012	0.111	4,430	0.013	0.114	14,350
Construction (%)	0.092	0.289	18,780	0.107	0.309	4,430	0.088	0.283	14,350
Wholesale trade (%)	0.043	0.204	18,780	0.040	0.196	4,430	0.044	0.206	14,350
Retail trade (%)	0.118	0.322	18,780	0.109	0.312	4,430	0.120	0.325	14,350
Accommodation and food services (%)	0.048	0.215	18,780	0.044	0.205	4,430	0.050	0.218	14,350
Transport, postal and warehousing (%)	0.043	0.203	18,780	0.042	0.200	4,430	0.044	0.204	14,350
Information media and telecommunications (%)	0.017	0.130	18,780	0.016	0.125	4,430	0.018	0.132	14,350
Financial and insurance services (%)	0.026	0.158	18,780	0.020	0.139	4,430	0.028	0.164	14,350
Rental, hiring and real estate services (%)	0.012	0.111	18,780	0.012	0.107	4,430	0.013	0.112	14,350
Professional, scientific and technical services (%)	0.043	0.203	18,780	0.037	0.189	4,430	0.045	0.207	14,350
Administrative and support services (%)	0.028	0.166	18,780	0.028	0.164	4,430	0.029	0.167	14,350
Public administration and safety (private) (%)	0.054	0.227	18,780	0.050	0.217	4,430	0.056	0.230	14,350
Education and training (private) (%)	0.079	0.270	18,780	0.080	0.272	4,430	0.079	0.269	14,350
Health care and social assistance (private) (%)	0.108	0.310	18,780	0.103	0.304	4,430	0.109	0.312	14,350
Arts and recreation services (%)	0.014	0.117	18,780	0.014	0.119	4,430	0.014	0.116	14,350
Other services (%)	0.040	0.196	18,780	0.040	0.197	4,430	0.040	0.196	14,350

NOTE: % REFERS TO THE SHARE OF THE GROUP IN THE RELATED SAMPLE.

12.3.2 2011 Descriptive statistics

TABLE 27 SAMPLE DESCRIPTIVE STATISTICS: DEMOGRAPHIC AND EMPLOYMENT ATTRIBUTES

	Full sample (2011)			Treatment sample (2011)			Control Group sample (2011)		
	Mean	Std. dev.	Observations	Mean	Std. dev.	Observations	Mean	Std. dev	Observations
Income	41,360.437	23,587.976	19,430	40,632.407	23,938.401	4,640	41,588.839	23,473.126	14,790
Low income (%)	0.427	0.495	19,779	0.324	0.468	4,731	0.460	0.498	15,048
Middle income (%)	0.318	0.466	19,779	0.424	0.494	4,731	0.285	0.451	15,048

High income (%)	0.255	0.436	19,779	0.252	0.434	4,731	0.256	0.436	15,048
Age	43.337	12.498	19,779	44.992	12.143	4,731	42.816	12.562	15,048
Female (%)	0.474	0.499	19,779	0.464	0.499	4,731	0.478	0.500	15,048
English not spoken at home (%)	0.094	0.292	19,779	0.041	0.198	4,731	0.111	0.314	15,048
Disability (%)	0.006	0.080	19,779	0.007	0.081	4,731	0.006	0.080	15,048
Home ownership status									
Owner (outright) (%)	0.269	0.444	19,779	0.296	0.457	4,731	0.261	0.439	15,048
Owner (with mortgage) (%)	0.549	0.498	19,779	0.563	0.496	4,731	0.545	0.498	15,048
Renter (%)	0.155	0.362	19,779	0.111	0.314	4,731	0.169	0.375	15,048
Employment status									
Employed (%)	0.966	0.181	19,779	0.972	0.165	4,731	0.964	0.186	15,048
Unemployed (%)	0.034	0.181	19,779	0.028	0.165	4,731	0.036	0.186	15,048
Hours worked									
Part-time (%)	0.297	0.457	19,779	0.313	0.464	4,731	0.292	0.455	15,048
Full-time (%)	0.611	0.488	19,779	0.596	0.491	4,731	0.615	0.487	15,048
Business ownership									
Does not own business (%)	0.750	0.433	19,779	0.708	0.455	4,731	0.764	0.425	15,048
Owns small business (%)	0.102	0.303	19,779	0.123	0.329	4,731	0.095	0.294	15,048
Owns incorporated business (%)	0.082	0.274	19,779	0.092	0.289	4,731	0.078	0.269	15,048
Owns unincorporated business (%)	0.106	0.307	19,779	0.136	0.343	4,731	0.096	0.295	15,048

NOTE: % REFERS TO THE SHARE OF THE GROUP IN THE RELATED SAMPLE.

TABLE 28 2011 SAMPLE DESCRIPTIVE STATISTICS: SHARE OF TOTAL EMPLOYMENT, BY SECTOR

	Full sample (2011)			Treatment sample (2011)			Control group sample (2011)		
	Mean	Standard deviation	Observations	Mean	Standard deviation	Observations	Mean	Standard deviation	Observations
Agriculture (%)	0.060	0.238	18,794	0.088	0.284	4,535	0.052	0.221	14,259
Mining (%)	0.006	0.078	18,794	0.007	0.081	4,535	0.006	0.077	14,259
Manufacturing (%)	0.112	0.315	18,794	0.109	0.312	4,535	0.112	0.316	14,259
Electricity, gas, water and waste services (%)	0.016	0.124	18,794	0.016	0.127	4,535	0.016	0.124	14,259
Construction (%)	0.102	0.303	18,794	0.109	0.312	4,535	0.100	0.300	14,259
Wholesale trade (%)	0.043	0.202	18,794	0.043	0.203	4,535	0.043	0.202	14,259
Retail trade (%)	0.096	0.295	18,794	0.086	0.280	4,535	0.100	0.300	14,259
Accommodation and food services (%)	0.038	0.192	18,794	0.040	0.195	4,535	0.038	0.191	14,259
Transport, postal and warehousing (%)	0.046	0.209	18,794	0.045	0.206	4,535	0.046	0.210	14,259
Information media and telecommunications (%)	0.014	0.118	18,794	0.013	0.111	4,535	0.015	0.120	14,259
Financial and insurance services (%)	0.027	0.161	18,794	0.019	0.136	4,535	0.029	0.168	14,259
Rental, hiring and real estate services (%)	0.012	0.108	18,794	0.009	0.096	4,535	0.013	0.112	14,259
Professional, scientific and technical services (%)	0.049	0.216	18,794	0.047	0.212	4,535	0.050	0.218	14,259
Administrative and support services (%)	0.028	0.164	18,794	0.030	0.170	4,535	0.027	0.163	14,259
Public administration and safety (private) (%)	0.060	0.238	18,794	0.061	0.239	4,535	0.060	0.238	14,259
Education and training (private) (%)	0.087	0.282	18,794	0.085	0.278	4,535	0.088	0.284	14,259
Health care and social assistance (private) (%)	0.124	0.329	18,794	0.113	0.317	4,535	0.127	0.333	14,259
Arts and recreation services (%)	0.014	0.119	18,794	0.015	0.122	4,535	0.014	0.118	14,259
Other services (%)	0.060	0.238	18,794	0.088	0.284	4,535	0.052	0.221	14,259

NOTE: % REFERS TO THE SHARE OF THE GROUP IN THE RELATED SAMPLE.

12.3.3 2016 Descriptive statistics

TABLE 29 2016 SAMPLE DESCRIPTIVE STATISTICS: DEMOGRAPHIC AND EMPLOYMENT ATTRIBUTES

	Full sample (2016)			Treatment sample (2016)			Control Group sample (2016)		
	Mean	Std. dev.	Observations	Mean	Std. .dev.	Observations	Mean	Std. dev	Observations
Income	46,020.005	28,308.199	17,948	44,596.616	28,125.123	4,304	46,469.013	28,351.907	13,644
Low income (%)	0.370	0.483	18,242	0.397	0.489	4,373	0.362	0.481	13,869
Middle income (%)	0.358	0.479	18,242	0.271	0.445	4,373	0.385	0.487	13,869
High income (%)	0.272	0.445	18,242	0.332	0.471	4,373	0.253	0.435	13,869
Age	46.601	11.908	18,242	47.944	11.584	4,373	46.178	11.977	13,869
Female (%)	0.484	0.500	18,242	0.475	0.499	4,373	0.486	0.500	13,869
English not spoken at home (%)	0.096	0.294	18,242	0.045	0.207	4,373	0.112	0.315	13,869
Disability (%)	0.010	0.098	18,242	0.009	0.095	4,373	0.010	0.099	13,869
Home ownership status									
Owner (outright) (%)	0.266	0.442	18,242	0.282	0.450	4,373	0.261	0.439	13,869
Owner (with mortgage) (%)	0.546	0.498	18,242	0.573	0.495	4,373	0.538	0.499	13,869
Renter (%)	0.157	0.364	18,242	0.110	0.313	4,373	0.171	0.377	13,869
Employment status									
Employed (%)	0.964	0.186	18,242	0.968	0.175	4,373	0.963	0.189	13,869
Unemployed (%)	0.036	0.186	18,242	0.032	0.175	4,373	0.037	0.189	13,869
Hours worked									
Part-time (%)	0.315	0.464	18,242	0.340	0.474	4,373	0.307	0.461	13,869
Full-time (%)	0.597	0.491	18,242	0.576	0.494	4,373	0.603	0.489	13,869
Business ownership									
Does not own business (%)	0.740	0.439	18,242	0.710	0.454	4,373	0.749	0.433	13,869
Owns small business (%)	0.071	0.257	18,242	0.086	0.281	4,373	0.066	0.249	13,869
Owns incorporated business (%)	0.085	0.279	18,242	0.100	0.301	4,373	0.080	0.272	13,869
Owns unincorporated business (%)	0.104	0.306	18,242	0.115	0.319	4,373	0.101	0.301	13,869

NOTE: % REFERS TO THE SHARE OF THE GROUP IN THE RELATED SAMPLE.

TABLE 30 SAMPLE DESCRIPTIVE STATISTICS: TOTAL EMPLOYMENT, BY SECTOR AND YEAR

	Treatment Group				Control group			
	2001	2006	2011	2016	2001	2006	2011	2016
Accommodation and food services	7,371	7,448	8,396	9,225	15,824	15,051	17,368	18,774
Administrative and support services	3,249	3,419	3,864	4,441	7,442	7,029	7,812	8,883
Agriculture, forestry and fishing	14,764	13,278	11,983	12,003	26,134	23,499	21,215	21,468
Arts and recreation services	1,605	1,758	2,043	2,296	3,136	3,186	3,839	4,588
Construction	9,985	13,404	16,213	17,089	20,744	24,528	29,470	30,771
Education and training	9,819	10,292	11,096	12,006	20,694	20,371	23,072	25,228
Electricity, gas, water and waste services	1,555	1,774	2,091	2,126	3,828	3,687	4,699	4,969
Financial and insurance services	2,334	2,453	2,620	2,587	7,130	6,328	6,802	6,506
Health care and social assistance	12,086	13,980	16,653	18,326	27,296	29,476	35,802	40,509
Information media and telecommunications	1,959	1,739	1,425	1,436	4,869	3,741	3,455	3,462
Manufacturing	16,928	16,166	15,547	12,472	40,787	31,956	30,866	25,325
Mining	456	718	964	981	1,145	2,057	2,658	2,531
Professional, scientific and technical services	5,194	5,114	5,907	6,543	11,709	11,240	13,363	14,227
Public administration and safety	5,371	7,213	8,020	8,477	12,507	15,168	17,706	18,322
Rental, hiring and real estate services	1,452	1,462	1,554	1,745	3,332	3,074	3,340	3,711
Retail trade	13,291	14,950	15,261	14,254	33,108	32,582	32,802	31,474
Transport, postal and warehousing	4,955	5,772	6,283	6,211	11,188	10,701	11,952	12,188
Transport, postal and warehousing	5,973	5,597	5,670	4,046	14,111	10,981	11,227	8,401
Other services	4,996	5,274	5,915	6,098	11,034	9,770	10,928	11,697
Inadequately described/Not stated	2,944	3,484	3,439	6,979	6,657	6,662	6,413	13,476

SOURCE: OBTAINED USING ACLD MICRODATA.

TABLE 31 2016 SAMPLE DESCRIPTIVE STATISTICS: SHARE OF TOTAL EMPLOYMENT, BY SECTOR

	Full sample (2016)			Treatment sample (2016)			Control group sample (2016)		
	Mean	Standard deviation	Observations	Mean	Standard deviation	Observations	Mean	Standard deviation	Observations
Agriculture (%)	0.066	0.249	16,910	0.078	0.268	4,068	0.063	0.243	12,842
Mining (%)	0.007	0.083	16,910	0.008	0.087	4,068	0.007	0.081	12,842
Manufacturing (%)	0.087	0.282	16,910	0.084	0.277	4,068	0.088	0.284	12,842
Electricity, gas, water and waste services (%)	0.019	0.136	16,910	0.020	0.139	4,068	0.019	0.135	12,842
Construction (%)	0.105	0.306	16,910	0.116	0.320	4,068	0.101	0.301	12,842
Wholesale trade (%)	0.031	0.174	16,910	0.032	0.177	4,068	0.031	0.173	12,842
Retail trade (%)	0.085	0.278	16,910	0.078	0.268	4,068	0.087	0.282	12,842

Accommodation and food services (%)	0.033	0.178	16,910	0.032	0.177	4,068	0.033	0.178	12,842
Transport, postal and warehousing (%)	0.046	0.210	16,910	0.045	0.207	4,068	0.046	0.210	12,842
Information media and telecommunications (%)	0.013	0.115	16,910	0.011	0.106	4,068	0.014	0.118	12,842
Financial and insurance services (%)	0.027	0.161	16,910	0.018	0.135	4,068	0.029	0.169	12,842
Rental, hiring and real estate services (%)	0.014	0.118	16,910	0.012	0.108	4,068	0.015	0.121	12,842
Professional, scientific and technical services (%)	0.053	0.224	16,910	0.048	0.213	4,068	0.055	0.227	12,842
Administrative and support services (%)	0.032	0.176	16,910	0.032	0.177	4,068	0.032	0.176	12,842
Public administration and safety (private) (%)	0.064	0.244	16,910	0.065	0.247	4,068	0.063	0.243	12,842
Education and training (private) (%)	0.100	0.300	16,910	0.101	0.302	4,068	0.099	0.299	12,842
Health care and social assistance (private) (%)	0.140	0.347	16,910	0.134	0.341	4,068	0.142	0.349	12,842
Arts and recreation services (%)	0.013	0.115	16,910	0.014	0.118	4,068	0.013	0.114	12,842
Other services (%)	0.038	0.192	16,910	0.041	0.199	4,068	0.038	0.190	12,842

NOTE: % REFERS TO THE SHARE OF THE GROUP IN THE RELATED SAMPLE.

12.3.4 Full Sample Results

TABLE 32 FULL SAMPLE RESULTS, DISSAGGREGATED BY SECTOR OF EMPLOYMENT

Panel A										
	(1) Agriculture	(2) Mining	(3) Manufacturing	(4) Electricity, gas, water and waste services	(5) Construction	(6) Wholesale trade	(7) Retail trade	(8) Accommodation and food services	(9) Transport, postal and warehousing	(10) Information media and telecommunications
Intensity_2011	-0.01871	0.0165	-0.0021	0.00084	0.00415	0.00374	-0.0019	-0.0132**	-0.0231	0.01235
	(0.0118)	(0.01552)	(0.0030)	(0.0056)	(0.0034)	(0.008)	(0.006)	(0.0061)	(0.0161)	(0.0093)
Intensity_2016	-0.00065	0.01328	-0.0029	0.0028	-0.00014	0.00509	-0.00177	0.0044	-0.00573	0.00569
	(0.0076)	(0.01487)	(0.0033)	(0.008)	(0.00279)	(0.01124)	(0.0055)	(0.00451)	(0.0107)	(0.00729)
Observations	3348	246	6958	715	5056	2382	6471	2653	2361	960
R-squared	0.146	0.297	0.128	0.322	0.132	0.274	0.122	0.239	0.309	0.329

Panel B									
	(11) Financial and insurance services	(12) Rental, hiring and real estate services	(13) Professional, scientific and technical services	(14) Administrative and support services	(15) Public administration and safety (private)	(16) Education and training (private)	(17) Health care and social assistance (private)	(18) Arts and recreation services	(19) Other services
Intensity_2011	0.00852	0.00199	-0.00419	-0.01321	-0.00884	-0.00278	0.00466	0.00994**	0.00194

	(0.01207)	(0.00769)	(0.00322)	(0.01244)	(0.00911)	(0.00196)	(0.00316)	(0.00452)	(0.00503)	
Intensity _2016	-0.02728	-0.00452	-0.00686*	0.01353**	0.00627**	-0.00156	-0.00529	0.00376	0.00306	
	(0.02023)	(0.01006)	(0.00414)	(0.00599)	(0.00271)	(0.00275)	(0.00564)	(0.00553)	(0.00510)	
Observations	1431	699	2385	1555	3018	4397	5937	773	2186	
R-squared	0.322	0.471	0.233	0.389	0.239	0.189	0.149	0.484	0.255	

post ×D is the difference-in-differences estimate. Standard errors in parenthesis. For significant results, significance levels are denoted by: *p <0.10, ** p <0.05, *** p <0.01. Findings based on use of Australian Bureau of Statistics Microdata

12.3.5 Matrix

TABLE 33 PERCENTAGE OF TOTAL SECTOR EMPLOYEES, BY ATTRIBUTE (TREATMENT GROUP, AS REPORTED IN BASELINE YEAR)

	Gender		Income group			Part-time vs full-time		Business owner	Age group			Other characteristics	
	Male	Female	Low	Middle	High	Part-time	Full-time	Small Business	Under 26	26-45	Over 45	Other language than English spoken at home	Disability
Agriculture	65.9	34.1	45.3	31.1	23.6	22.4	77.6	23.1	5.4	39.7	55.0	4.1	0.5
Mining	91.2	8.8	0.0	26.2	74.0	0.0	100	0.0	4.3	47.9	47.9	0.0	0.0
Manufacturing	71.9	28.1	30.9	39.4	29.7	17.8	82.2	7.2	10.0	50.0	40.0	4.8	1.1
Electricity, gas, water and waste services	89.1	10.9	10.9	16.3	72.7	10.9	89.1	1.8	3.7	47.3	49.1	1.8	1.8
Construction	88.0	12.0	31.7	33.8	34.5	17.5	82.5	25.8	14.4	54.3	31.3	3.4	0.2
Wholesale trade	71.2	28.8	34.5	34.5	31.1	21.5	78.5	10.7	10.2	46.9	42.9	1.7	0.6
Retail trade	40.9	59.1	71.1	20.0	8.9	47.3	52.7	10.9	27.7	36.8	35.5	2.5	1.0
Accommodation and food services	33.8	66.2	78.5	13.3	8.2	52.3	47.7	13.8	33.9	34.9	31.3	3.6	0.5
Transport, postal and warehousing	70.7	29.3	38.6	37.0	24.5	24.5	75.5	15.2	6.0	44.6	49.5	4.9	0.0
Information media and telecommunications	62.9	37.1	25.7	37.1	37.1	27.1	72.9	5.7	11.4	44.3	44.3	2.9	1.4
Financial and insurance services	29.9	70.1	34.5	31.0	34.5	35.6	64.4	13.8	8.1	51.7	40.2	4.6	0.0
Rental, hiring and real estate services	41.2	58.8	49.1	27.5	23.5	27.5	72.5	27.5	27.5	27.5	45.1	1.9	0.0
Professional, scientific and technical services	46.7	53.3	35.8	26.1	38.2	33.9	66.1	21.2	6.7	46.7	46.7	2.4	0.0
Administrative and support services	54.9	45.1	55.7	26.2	18.0	42.6	57.4	8.2	17.2	41.0	41.8	4.1	2.5
Public administration and safety (private)	45.5	54.5	22.3	33.6	44.1	30.5	69.5	0.4	5.5	46.4	48.2	2.7	0.0
Education and training	27.6	72.4	31.8	26.8	41.4	36.3	63.7	2.3	5.4	39.4	55.2	2.8	0.3
Health care and social assistance	15.8	84.2	47.4	32.0	20.6	50.7	49.3	3.7	6.1	42.3	51.5	3.9	0.0
Arts and recreation services	43.7	56.3	67.2	21.9	10.9	46.9	53.1	4.7	18.7	43.7	37.5	3.2	1.5
Other services	62.6	37.4	57.0	29.0	14.0	27.4	72.6	19.5	16.8	41.3	41.9	5.6	0.6

SOURCE: OBTAINED USING ACLD MICRODATA.

13. REFERENCES

1 Ai Group. *Economics Factsheet: Underemployment In Australia in 2019*. Accessed: 2 January 2020. (https://cdn.aigroup.com.au/Economic_Indicators/Fact_Sheets/2019/Underemployment_in_Australia_2019.pdf).

2 ABS: Australian Bureau of Statistics, 2017. Australian Statistical Geography Standard (ASGS): Volume 1 - Main Structure and Greater Capital City Statistical Areas, July 2016.

3 Alderman K, Turner L, Tong S. *Assessment of the Health Impacts of the 2011 Summer Floods in Brisbane*. Disaster Medicine and Public Health Preparedness, 2013: 7(4), 380-386.

4 Australian Bureau of Statistics. *2080.0 - Microdata: Australian Census Longitudinal Dataset, ACLD*. 2018. Expanded Confidentialised Unit Record File (CURF), DataLab.

5 Australian Bureau of Statistics (2016), 1270.0.55.001 Australian Standard Geographical Classification: volume 1. Main structure and greater capital city statistical areas, July.

6 Australian Bureau of Statistics (2017a) 2024.0 – Census of Population and Housing.

7 Australian Bureau of Statistics (2017b), 8165.0 – Counts of Australian Businesses, including Entries and Exits.

8 Australian Bureau of Statistics (2017c), 3218.0 Regional Population Growth, Australia.

9 Beecroft A, Peters E, Toole T. *Life-cycle costing of rain and flood events in Queensland – case studies and network-wide implications*, Road & Transport Research: A Journal of Australian and New Zealand Research and Practice, Sep 2017; 26(3): 22-35.

10 Black Saturday Royal Commission (2019), "The 2009 Victorian Bushfires Royal Commission final report," 2009. Accessed: 13 December 2019.(http://www.royalcommission.vic.gov.au/Commission-Reports/Final-Report.html.)

11 Boustan L, Kahn M.K, Rhode PW, Yanguas, ML. *The effect of Natural Disasters on Economic Activity in US Counties: A Century of Data*, NBER Working Paper No. 23410. May 2017.

12 Clemens SL, Berry HL, McDermott BM, Harper CM. *Summer of sorrow: measuring exposure to and impacts of trauma after Queensland's natural disasters of 2010–2011*. Med J Aust. 2013; 199 (8): 552-555.

13 Commonwealth of Australia (2018a). Department of Home Affairs. 2018. Profiling Australia's Vulnerability: the interconnected causes and cascading effects of systemic disaster risk.

14 Commonwealth of Australia (2018b). Department of Home Affairs. *National Disaster Risk Reduction Framework*. 2018. Accessed: 13 December 2019. (https://www.homeaffairs.gov.au/emergency/files/national-disaster-risk-reduction-framework.pdf).

15 Commonwealth of Australia (2018c). Treasury. *National Disasters Insurance Review: Inquiry into flood insurance and related matters*. June 2011. Accessed: 1 September 2018. (https://treasury.gov.au/sites/default/files/2019-03/c2011-ndir-ip-NDIRIssuesPaper.pdf)

16 Commonwealth of Australia. Treasury. *Natural Disaster Insurance Background Paper*. 2018. Accessed: 2 May 2019. (https://financialservices.royalcommission.gov.au/publications/Documents/enright-paper-15.pdf).

17 Cutter S, Barnes L, Berry M, Burton C, Evans E, Tate E, Webb J. *Community and regional resilience: perspectives from hazards, disasters, and emergency management*, CARRI Research Report 1. 2008 University of South Carolina.

18 Deloitte Access Economics. *The economic cost of the social impact of natural disasters*. 2016. Commissioned by the Australian Business Roundtable for Disaster Resilience & Safer Communities. Accessed: 1 July 2018. (*http://australianbusinessroundtable.com.au/assets/documents/Report%20%20Social%20costs/Report%20-%20The%20economic%20cost%20of%20the%20social%20impact%20of%20natural%20disasters.pdf*)

19 Deloitte Access Economics. *Building resilience to natural disasters in our states and territories*. November 2017. Commissioned by the Australian Business Roundtable for Disaster Resilience & Safer Communities. Accessed: 8 January 2019. (http://australianbusinessroundtable.com.au/assets/documents/ABR_building-resilience-in-our-states-and-territories.pdf)

20 Deryugina, T. *The Fiscal Cost of Hurricanes: Disaster Aid versus Social Insurance*. American Economic Journal: Economic Policy. 2017; 9(3): 168–198

21 Deryugina T, Kawano L, Levitt S. *The economic impact of hurricane Katrina on its victims: evidence from individual tax returns*. American Economic Journal: Applied Economics. 2018; 10(2): 202–233.

22 Emergency Management Queensland. *Submission to the Queensland Flood Commission*

Inquiry: Event Chronology Queensland Floods: 24 Dec 2010 to 26 Jan 2011. 2011. Accessed: 7 December 2019. (http://www.floodcommission.qld.gov.au/__data/assets/file/0003/2955/State-of-Qld_Part-4-Community-Safety-2-of-3.pdf)

23 Fitzgerald G, Toloo G, Baniahmadi S, Crompton D, Tong, S. *Long-term consequences of flooding: a case study of the 2011 Queensland floods*. Australian Journal of Emergency Management. 2019; 34: 35.

24 Fitzgerald G, Du W, Aziz J, Clark M, Hou XY. *Flood fatalities in contemporary Australia (1997-2008)*. Emergency Medicine Australasia. 2010; 22:180-6.

25 Flood Response Review Board. *Independent Review of Brisbane City Council's Response to the January 2011 Flood*. 2011. Accessed: 1 July 2018. (https://www.brisbane.qld.gov.au/sites/default/files/emergency_management_Independent_Review_of_BCCs_Response_Final_Report_v4.pdf).

26 Food and Agriculture Organisation. *The Impact of Natural Hazards and Disasters on Agriculture and Food Security and Nutrition: A call for action to build resilient livelihoods*. of the United Nations. 2015. Accessed: 10 August 2018. (http://www.fao.org/3/a-i4434e.pdf).

27 Fothergill A, Peek LA. *Poverty and disasters in the United States: a review of recent sociological findings*. Natural Hazards. 2004; 32: 89–110.

28 Gallagher J, Hartley D. *Household finance after a natural disaster: The case of Hurricane Katrina*. American Economic Journal: Economic Policy. 2017; 9(3): 199-228.

29 Gibbs L, Bryant R, Harms L, Forbes D, Block K, Gallagher C, Ireton G, Richardson J, Pattison P, MacDougall C, Lusher D, Baker E, Kellett C, Pirrone A, Molyneaux R, Kosta L, Brady K, Lok M, Van Kessell G, Waters E. *Beyond bushfires: community resilience and recovery - final report*. 2016. Retrieved from Analysis and Policy Observatory. (https://apo.org.au/node/70873).

30 Gladwin H, Peacock WG. *Warning and evacuation: a night for hard houses*. 2000. In: Peacock, et al. (Ed.), Hurricane Andrew: Ethnicity, Gender, and the Sociology of Disasters. Routledge, New York, pp. 52–74.

31 Hallegatte S. *Natural Disasters and Climate Change: An Economic Perspective*. 2014. Springer.

32 Ibarrarán M, Ruth M, Ahmad S, London M. *Climate change and natural disasters: macroeconomic performance and distributional impacts*. Environment, Development and Sustainability. 2009; 11(3): 549-569.

33 Ipswich City Council. *First Submission to the Queensland Flood Commission Inquiry: Submission on Flood Preparedness by the Ipswich City Council*. 2011. Accessed: 1 July 2018 (http://www.floodcommission.qld.gov.au/__data/assets/file/0006/10878/Ipswich_City_Council_first_submission.pdf).

34 Kelly JF, Donegan P, Chisholm C, Oberklaid M. *Mapping Australia's Economy: Cities as engines of prosperity*. 2014. Grattan Institute. Accessed: 11 December 2019. (https://grattan.edu.au/wp-content/uploads/2014/07/814-mapping-australia-economy1.pdf)

35 Kennedy P. *A Guide to Econometrics: Fifth Edition*. 2003. Cambridge; MA: The MIT Press.

36 Kitching A, Chiew C, Hughes L, Newton PCD, Schuster SS, Tait A, and Whetton P. *2014: Australasia. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects.* 2014. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros VR, Field CB, Dokken DJ, Mastrandrea MD, Mach KJ, Bilir TE, Chatterjee ME, Ebi KL, Estrada YO, Genova RC, Girma B, Kissel ES, Levy AN, MacCracken S, Mastrandrea PR, White LL (eds.)]. Cambridge University Press.

37 Kousky C. *Informing climate adaptation: A review of the economic costs of natural disasters*. Energy Economics. 2014; 46: 576–592.

38 Local Government Association of Queensland. *Submission into the Inquiry into Natural Disaster Funding, Productivity Commission Issues Paper: Appendix A: Estimates of cost of natural disaster events for Queensland council assets*. 2014. Accessed: 3 June 2018. (https://www.pc.gov.au/inquiries/completed/disaster).

39 Lockyer Valley Regional Council. *Submission to the Australian Government Productivity Commission Inquiry: Natural Disaster Funding Arrangements.* 6 June 2014. Accessed: 1 July 2018. (https://www.pc.gov.au/inquiries/completed/disaster-funding/submissions/submissionstest2/submission-counter/subdr125-disaster-funding.pdf)

40 Munich Re. *Expect the unexpected: Scientific facts and economic impacts of natural disasters (Australia and New Zealand)*. 2015. Accessed: 27 May 2019. (https://www.munichre.com/site/corporate/get/documents_E284843648/mr/Australia-Hazards/documents/Downloads/302-08732_en.pdf).

41 OECD. *Measuring and fostering the progress of societies*. Document prepared for OECD meeting of the Council at Ministerial Level, 27–28 May 2010. C/MIN(2010)13. 12 May 2010. OECD, Paris. Accessed: 8 January 2020. (https://unstats.un.org/unsd/envaccounting/ceea/meetings/UNCEEA-5-19.pdf)

42 Parsons M, Reeve I, McGregor J, Marshall G, Stayner R, McNeill J, Hastings P, Glavac S, Morley P. *The Australian Natural Disaster Resilience Index: Volume I – State of Disaster Resilience Report*. 2019. Melbourne: Bushfire and Natural Hazards CRC

43 Penman T, Parkins K, Cirulis B, Florec V. *Quantifying Catastrophic Bushfire Consequences*. 2019. Final report prepared for Energy Networks Australia as part of the Bushfire and Natural Hazards CRC project: Quantifying Catastrophic Bushfire Consequences.

44 Stephenson, C. *The impacts, losses and benefits sustained from five severe bushfires in south-eastern Australia, Fire and adaptive management Report No. 88. Bushfire Cooperative Research Centre, July 2010: 32.*

45 Queensland Department of Employment. *Labour market conditions in the Ipswich-Logan region*. 2014. Accessed: 1 July 2018. (https://docs.jobs.gov.au/system/files/doc/other/survey_of_employers_recruitment_experiences_in_ipswich-logan_report.pdf).

46 Queensland Floods Commission of Inquiry. *Final Report*. March 2012. Accessed: 1 July 2018. (http://www.floodcommission.qld.gov.au/publications/final-report).

47 Queensland Government. *Submission to the Australian Government Productivity Commission Inquiry: Natural Disaster Funding Arrangements.* 6 June 2014. Accessed: 1 July 2018. (https://www.pc.gov.au/inquiries/completed/disaster-funding/submissions/submissions-test/submission-counter/sub031-disaster-funding.pdf)

48 Queensland Office of the State Coroner. *Inquest into the deaths caused by the south-east Queensland floods of January 2011*. 5 June 2012. Accessed: 1 October 2019. (https://www.courts.qld.gov.au/__data/assets/pdf_file/0019/152362/cif-seq-floods-20120605.pdf).

49 Queensland Reconstruction Authority. *Operation Queensland, Monthly Board Report*. September 2011. Accessed: 10 February 2019. (https://www.qra.qld.gov.au/sites/default/files/2018-10/ceo-report-sep-11-full.pdf).

50 Queensland Treasury. Queensland Economic Review: 2011 reports. ISSN: 1038-3182. Accessed on: 1 July 2018. (http://archive.qgso.qld.gov.au/products/reports/qld-econ-review/)

51 Queensland Treasury. *Budget Paper 2: Budget Strategy and Outlook, Queensland Budget 2011-12*. 2012. Accessed 1 July 2018. (https://s3.treasury.qld.gov.au/files/bp2-2011-12.pdf).

52 Regional Australia Institute. *From Disaster to renewal: The centrality of business recovery to community resilience: Final Report*. 2013. Accessed: 2 December 2019. (http://www.regionalaustralia.org.au/wp-content/uploads/2013/08/From-Disaster-to-Renewal.pdf).

53 Somerset Regional Council. *Annual Report 2011-12*. 2012. Accessed: 1 October 2018. (http://www.somerset.qld.gov.au/annual-reports).

54 Stephenson C. *The impacts, losses and benefits sustained from five severe bushfires in southeastern Australia*. Department of Sustainability and Environment. 2010. Report No. 88. Bushfire and Natural Hazards CRC

55 Ulubasoglu MA, Rahman MDH, Önder YK, Chen Y, Rajabifard A, *Floods, bushfires and sectoral economic output in Australia, 1978–2014*. Economic record. 2019; 95(308): 58-80.

56 UNISDR. *Terminology on Disaster Risk Reduction*. Accessed on: 1 July 2018. (*https://www.unisdr.org/terminology*).

57 United Nations Office for Disaster Risk Reduction. Global Assessment Report on Disaster Risk Reduction 2019. 2019. Accessed: 15 December 2019. (https://gar.unisdr.org/sites/default/files/reports/2019-05/full_gar_report.pdf).

58 Wisner B, Blaikie P, Cannon T and Davis I. *At Risk: Natural Hazards, People's Vulnerability, and Disasters*. 2004. Second Edition. Routledge.

59 World Bank and Queensland Reconstruction Authority. *Queensland: Recovery and Reconstruction in the Aftermath of the 2010/2011 Flood Events and Cyclone Yasi*. June 2011. Accessed: 17 June 2019. (http://documents.worldbank.org/curated/en/842511468220781111/pdf/633930revised00BLIC00QUEENSLAND0web.pdf)

60 Xie W, Rose A, Li S, He J, Li N, Ali, T. *Dynamic Economic Resilience and Economic Recovery from Disasters: A Quantitative Assessment*. Risk Analysis. 2018;38: 1306-1318. doi:10.1111/risa.12948.

61 Victorian Bushfire Appeal Fund, (2010), *Victorian Bushfire Appeal Fund 18 Month Report and Financial Information (as at 31 August 2010)*, https://www.dhhs.vic.gov.au/publications/victorian-bushfire-appeal-fund-vbaf-reports (accessed: 9 September 2018)

62 Yu KD, Tan RR, Aviso KB, Promentilla MAB, Santos JR. *A Vulnerability Index for post-disaster key sector prioritization*, Economic Systems Research. 2014; 26(1): 81–97.