THE COST OF FIRE IN AUSTRALIA

Ashe, B.S.W. [1], McAneney, J. [1], Pitman, A.J. [2]
1. Risk Frontiers, Macquarie University, Sydney, Australia.
2. University of New South Wales, Australia.

Corresponding Author: Brian Ashe E-mail bashe@bigpond.com

ABSTRACT

For the first time, the total cost of fire in Australia has been estimated. This cost is approximately AUD$8,500 million per annum or approximately 1.15% of the country's Gross Domestic Product (GDP). This equates to an annual sum of approximately AUD$420 for each citizen. Comparable studies in the UK, USA, Canada and Denmark show that the cost in these countries to range from 0.9% to 2% of GDP. 55% of the Australian total is allocated to 'costs in anticipation', 30% to the 'cost of response' and 15% to the 'cost as a consequence' of fire. 93% of the cost of fire is not associated with direct loss. While most of the cost data supporting these estimates has wide bands of uncertainty and should be refined by further research, this paper provides a first step in informing debate over fire related investment in Australia.

KEYWORDS: Fire; cost; Australia; anticipation; consequence; response

1. INTRODUCTION

In Australia, fire is a significant hazard to people, property and the environment. Each year, fire is the cause of approximately 100 fatalities and approximately 3,000 injuries from structure fires[1]. Over the last century, the loss of residential homes from bushfire averaged around 83 homes per year[2]. The year-to-year variance about this mean figure is large ranging from no homes lost in 40% of years[2] to 2,500 buildings in the Ash Wednesday bushfires, Victoria (1983), which also killed 75 people[3]. In other Australian fires, the 1974/75 bushfires in the Northern Territory destroyed 117 million hectares[4]; the Longford Gas explosion cost the Victorian economy a estimated AUD$1,300 million[5]; the Childers Hostel fire, Queensland, killed 15 people, and more recently the 2003 Canberra bushfires destroyed 500 properties, killed 4 people and cost AUD$300 million[6].

While much debate takes place in Australia about fire, particularly bushfire, very little of this is informed by an understanding of its true cost to the nation. In fact, to our knowledge, no analysis of the total cost of fire to the national economy has been undertaken. Work has been undertaken in Australia by the Building Regulation Review Task Force[7]; however they focussed on buildings, estimating the cost of fire in 1991 to be AUD$2,000 million. In contrast to the situation in Australia, studies exploring the total cost of fire have been undertaken overseas. We briefly review these now.

The UK Home Office report[8] concluded the cost of fire in 1993 to be slightly over £4,500 million or around 0.9% of GDP in England and Wales. Weiner[9] provided revised estimates and, for the first time, separated the average costs of different types of fire by location and cost type. The total cost of fire was estimated to be £6,900 million, with commercial fires accounting for over 40% of this sum.

In the US, Hall[10] explored the total cost of fire based on analysis of a reporting schedule that has been running for 10 years and which also underpinned a number of the assumptions relating to the cost of fire made by Roy[8] for the UK. The cost of fire in the US in 2002 was estimated at US$187,000-251,000 million, or approximately 2% of GDP. The most detailed analysis originates from Canada where Schaenman[11] found the cost of fire to be around CAN$11,600 million in 1991 (again about 2% of GDP). Finally in Denmark, an investigation undertaken by Moller[12] concluded that the socio-economic costs of fire was in the region of 1% of GDP.

This study attempts to collate comparable data on the cost of fire in Australia. In our view, this is a first step to informing debate on all matters that may have an impact on the prevalence and severity of fires and facilitating any attempt to examine the cost-effectiveness of different means of deploying limited resources in fire prevention. While fires may stimulate the economy in some cases, and while the economic multiplier effect of recovery activities such as rebuilding may on occasions be significant, it is useful to focus on costs alone. These are a measure of losses and expenditures that if all fires were prevented could be invested elsewhere in the economy.

2. METHODOLOGY

The impacts of fire are many, and various methods could be employed to categorise associated costs. This study adopts the same logic as research into the costs of crime in the UK[13]. Costs are broken down into three categories:

- costs in anticipation - predominately protection and prevention measures undertaken by or for the benefits of potential victims of fire;
- cost as a consequence – costs incurred as a result of fire and due to the exposure of property, individuals or the environment to fire and its products, and borne by a range of victims: individuals, private firms and society, and
- costs in response – for extinguishing and clearing up after fire and which for the most part are borne by society.

In what follows, we first elaborate upon these different cost categories.

2.1. Cost in anticipation

'Cost in anticipation' has been divided into eight components:

1. Fire safety equipment: - the purchase of equipment such as automatic fire detection and portable fire-fighting equipment. These may be a requirement of fire

safety legislation. This would also include the cost of smoke alarms in domestic premises.

2. Fire safety in buildings: - Buildings regulations for fire safety protect life but increase the cost of construction. This cost is divided into: (a) the cost of building regulations on new domestic and commercial buildings; and (b) the cost imposed upon existing buildings. The latter is often referred to as retrospective regulation and the practice as “retrofitting”.

3. Fire safety measures in structures and infrastructure: –includes tunnels, bridges, power stations, roads, rail, waterworks, oil and gas facilities. As an example, fire fighting flow requirements are often a major factor in sizing water mains and determining associating pumping needs. The cost of using larger pipe and pumps than would be needed just to provide drinking water and sanitation can be attributed to fire protection.

4. Fire safety education and training: - There are a variety of activities that can be classed under fire safety education and training: fire brigades undertake inspections of certain types of property to ensure fire safety regulations are enforced and employees may be trained on fire safety as a part of induction courses or health and safety training.

5. Insurance administration: - Insurance administration represents a loss to society resulting from fire and includes commissions paid by agents as well as the cost of setting up policies of investigating and administering claims. Payment of claims for fire losses are regarded as a wealth transfer between policy holders and are not included in the cost of fire to the nation.

6. Fire safety in consumer items: - Every civilian aircraft, vehicle and train has fire safety designed into it and virtually all flammable liquids have to be stored in special containers. Heaters have cut-outs to prevent over-heating. Such examples of additional protection increase the cost of the item, a cost that is very difficult to quantify since many of the additions are multi-purpose: how much do circuit breakers, for example, exist to prevent fire and how much to prevent electrocution?

7. Fire safety research: - The cost of fire research undertaken by both the private and public sectors.

8. Maintenance of fire safety equipment and measures: - Most fire safety equipment requires ongoing maintenance to maintain the effectiveness of the equipment.

2.2. Cost as a consequence

‘Cost as a consequence’ has been divided into nine components:

9. Property losses: - one of the most obvious costs of fire is the cost of repairing or replacing damaged property. For many people fire losses will be covered by insurance, but the insurance payments only represent a transfer payment of insurance premiums from those who do not suffer losses to those who do. For this

reason insurance payments are not included in the cost of fire. However, the destruction of the original property is a cost to society.

10. Lost output: - Fire victims will often need time off work. This represents a loss in productivity to the economy. However, since aggregate reductions in production are often offset by short-term increases in the production of others, the losses are not generally large to the economy as a whole.

11. Fatalities and Injuries: - It has been argued[14] that it is not possible to place a value on casualties and its specification remains controversial [14]. Nonetheless, such values are implicit in choices made every day. The decision on whether to fund a road improvement or to target fire prevention in domestic dwellings over say public buildings requires explicit judgements by decision-makers that place an implicit value on casualties. The emotional and physical suffering of victims is also a significant cost and the hardest to quantify. While it is difficult, if not impossible, to value the cost of trauma to victims of incidents - different people will be affected in very different ways, it is possible to derive the value society places in preventing this incident occurring.

12. Healthcare costs: - Fire casualties result in additional demands on the healthcare system. Reducing these casualties will free up money to be used on other healthcare needs.

13. Loss of business: - Fire can result in significant business losses in terms of lost production, market share and customer goodwill. Even a minor fire at crucial stages of production may mean very large losses for individual firms. In addition, fire resulting in the closure of firms could have significant effects on staff. However, as has already been implied, the losses are rarely large for the country as a whole with lost output of one firm often resulting in a gain for another: a fire in a local supermarket means that customers will simply go to another. In this particular case, the only cost to society is the increased travel time to reach an alternative supermarket. In the same way, a company that gains business may employ more staff to meet the increased demand and so the effect on net employment may be zero. The only loss to the country from fire is in the case where output is lost and not compensated by increases in production by other firms. Foreign competitors may have to pick up the shortfall, or where the goods are unique, society will have to go without until fire-damaged premises are back in business or substitute products are found.

14. Environmental costs: - caused by polluting the atmosphere with the products of combustion, or ground water with the run-off of chemicals from a fire, often from water sprayed on the fire.

15. Heritage and cultural costs: - Fires can destroy or damage property with unique cultural or heritage value. It is difficult to replace or repair these pieces, and their loss has a greater value to society than the simple replacement cost: a recent example was the loss of the historic Mount Stromlo Observatory in the 2003 Canberra fires[15].

16. Clean up: - Building occupants may have to move out whilst damage is repaired, local authorities must remove burnt out cars and repair road surfaces. These are just a few of the possible costs of cleaning up.

17. Wider economic distortions: - Fire and arson, in particular, may affect local communities. Large numbers of burnt-out cars and buildings can discourage new business and residents.

2.3. Cost in response

18. Fire service response costs: - The fire service performs a variety of duties, some of which are a legislative requirement. These include:

- responding to emergency calls, including special service incidents and false alarms;
- carrying out regulatory inspections, and
- providing community fire safety advice and education.

Special services incidents (such as the response to a flood emergency) have not been deemed to be a cost of fire. In contrast, the cost of false alarms is a cost of fire as in the absence of fire there would be no false alarms.

19. Volunteer fire service: - Many thousands of Australians give their time to the volunteer fire services, particular rural and bushfire brigades. This is a huge contribution and the lost opportunity cost to the national economy is significant.

20. Private fire brigade responses: - Only relatively large or remote organisations have their own fire brigades. The majority of their personnel are drawn from within the organisation. Only a small part of their time is attributable to fire protection and adding to the cost of fire.

21. Criminal justice costs / arson fires / coronial inquires: - Many fires result in some police effort to control traffic and crowds. Police also investigate fires, particular arson fires. Crime laboratories detect accelerants and perform other investigation services. Coronial inquiries established to investigate major fires require significant resources; NSW, for example, has had at least seven bushfires inquiries since 1994[16].

3. ESTIMATES OF COST COMPONENTS

In reporting on estimates for the various cost components, it is important to bear in mind that while based on the best available data, there are many ways where these costs could be refined. Because of the uncertainty and the variation in the annual figures, e.g. due to an extreme bushfire season, only average costs have been assumed. In other cases, we have resorted to first order extrapolation of comparable overseas figures after making appropriate adjustments for population differences, exchange rates and inflation.

3.1. Cost in anticipation

1. Fire safety equipment: - this cost has been combined with fire safety in buildings with which it is closely aligned.

2. Fire safety in buildings: - The bulk of the cost of fire protection in buildings is in the commercial and public sectors[17]. A study undertaken for the Building Research Establishment, UK[15] estimated that the cost of fire regulations in buildings ranged from 1% for houses to 9% for shopping complexes. The Warren Centre[18] found that the cost of fire protection in Australian buildings accounted for 3% of the cost of a typical apartment block and 6% for a typical office building. The total value of residential construction for 2003 was estimated at AUD$34,000 million, with commercial construction estimated at AUD$16,000 million[19]. For this study, the cost of fire safety in buildings is assumed to be 1% of the value of residential construction, as the majority of residential construction is houses, and 4% of commercial construction assuming that the lower end of the 1 to 9%.range given above would be more typical

The above relates to the cost of fire safety in new or renovated buildings. Retrospective fire safety regulations, i.e. changes to the requirements of existing buildings are rare in Australia and are only likely after a major fire event. As an example, the Victoria Government[20] amended the Building Regulations following the Childers fire to require all residential care buildings, boarding or guest houses or hostels constructed prior to 1 August 1997 to install hard wired smoke detectors, and mandated the installation of sprinkler systems in all shared accommodation. The cost to Victoria of this change was estimated at AUD$20 million[20] per annum. The States of Queensland and New South Wales implemented similar retrospective legislation, bringing the national estimate up to approximately AUD$50 million. For this study, an annual figure of AUD$20 million is assumed for retrospective regulation.

3. Fire safety measures in structures and infrastructure: - The Australia Bureau of Statistics[19] value infrastructure in Australia in 2003 at AUD$25,000 million. A study undertaken in Canada[11] estimated that the cost of fire safety in structures and infrastructure to range from 0.1% for roads, 10% for oil refineries to 20% for water systems. Another study undertaken for the US[21] estimated the figure to be between 9 and 11% for similar structures. Given the absence of similar studies in Australia, a mid-range figure of 5% has been adopted in this study.

4. Fire safety education and training: - In the UK, Weiner[9] estimated that the cost of fire safety education and training to be £40 million. It is assumed that the majority of this figure is accounted for in the cost of the fire service. We have assumed a nominal AUD$10 million is used to cover fire safety education and training not undertaken by the fire services.

5. Insurance administration: - Due to a lack of data, this study considered the insurance administration costs estimated in the UK[9] and adjusted these for population and exchange rate. This equates to a sum of approximately AUD$400 million. Converting equivalent results for Canada [11], we obtain a figure of AUD$250

million (CAN$400 million). For this study a mid-range figure of AUD$325 million is assumed.

6. Fire safety in consumer items: - In the absence of any data from Australia, we again look overseas. Given that a high proportion of consumer goods are imported, these figures are should be relevant. The Canadian study[11] estimated that the cost of fire safety in consumer items was CAN$2,300 million, a figure which converts to approximately AUD$1,700 million in Australia after again adjusting for population differences and exchange rates. In the US, Meade[21] estimates that the cost of fire safety in consumer items can be as high as 20% of the total cost of fire, a figure that translates to approximately AUD$1,500 million. Weiner[9] did not estimate this cost component for the UK. Both the US and Canadian studies imply similar figures for Australia and thus we adopt a conservative mid-point figure of AUD$1,600 million.

7. Fire safety research: - While aggregate data on the cost of fire safety research is unavailable for Australia, two research programs provide a guide to this cost. The Fire Code Reform Centre[22] was provided with AUD$1 million per annum over 5 years (1995-2000), and the recently established Bushfire Cooperative Research Centre[23] has funding of approximately AUD$15 million per annum (2004-2011). Given this information, it is assumed that the average cost of fire research in Australia is AUD$10 million per annum.

8. Maintenance of fire safety equipment and measures: - The most comprehensive coverage of this cost comes from Canada [11] where it was estimated that the cost of maintenance of fire safety measures equated to 8% of the cost of the annual built-in fire safety measures. Importantly, this estimate only covers new in-built systems and not previous generations of in-built systems. Using the 8% figure for Australia suggests a cost of maintenance of AUD$180 million per annum. As this figure does not account for the previous generations of in-built systems, we consider it to be low. Consider, for example, the adoption of the same amount of fire safety measures over a 5-year period. This would eventually require an annual maintenance bill of approximately AUD$1,000 million. For this study; the annual cost of maintenance has been conservatively assumed to be AUD$500 million.

3.2. Cost as a consequence

9. Property losses: - Every year the Productivity Commission undertakes a 'Report on Government Services'[1] in which it outlines that the median dollar loss per structure fire and the total property loss from structure fires. Structure fires are those affecting housing and other buildings. Nationally, the total property loss from structure fires was AUD$27 per person or approximately AUD$540 million for Australia. It is assumed that this figure considers other fire losses, including losses from engineering structures.

10. Lost output: - The US National Fire Protection Association[24] studied indirect losses for properties other than direct losses to residential homes. They found that indirect losses as a fraction of direct damage varied considerably from one type of property to another, ranging from 10% for residential buildings to 65% for manufacturing and industrial properties. Schaenman[11] estimated that loss of output

ranged from 10 to 15% of direct property losses. Lost output in Australia is assumed here to be 12.5% of the property loss; this equates to AUD$68 million.

The above estimate may appear low to anyone whose sense of indirect loss is based primarily on a few well-publicised incidents where indirect losses were much larger than the direct damage. From a statistical standpoint however, such incidents are more than offset by the far more numerous incidents where indirect loss is either small or nonexistent. The UK Home Office carried out two research studies between 1970 and 1980 on consequential losses to the national economy[25]. The main conclusion was that most fires, except those in chemical and allied industries, produced no consequential losses to the national economy.

11. Fatalities and injuries: - The Bureau of Transport and Regional Economics in their study into rail accident costs in Australia[14] concluded that the average economic cost of a fatality was around AUD$1.9 million in 2002. In his earlier report into the economic costs of Natural Disasters in Australia, Slatyer[26] estimated the average cost to be AUD$1.3 million in 2001 dollars per fatality. Considering these studies[14][26], an estimate of AUD$ 2 million is assumed to be the current cost of a fatality in Australia. Given the average annual fire-related fatality numbers for Australia (97 taken from the 'Report on Government Services'[1]), this equates to a cost of AUD$194 million.

12. Healthcare costs: - In 2001, Slatyer[26] estimated that the average economic costs associated in the case of serious injury at AUD$317,000 for a serious injury and for a minor injury, AUD$10,600. For this study, we adopt AUD$200,000 for a serious injury and AUD$20,000 for a minor injury. The injury numbers (2,975 number) have been taken from the 'Report on Government Services'[1] with 10% assumed to be serious. This equates to a national cost of approximately AUD$110 million.

13. Loss of business: - Information on the loss of business due to fire in Australia is hard to find. Due to this lack of information, this study adopted estimates from the UK of £40 million[9], a figure that translates to approximately AUD$30 million for Australia.

14. Environmental costs: - Fires, including bushfire, may produce fine particulates leading the atmospheric haze. These particles can exacerbate respiratory and cardiovascular illnesses, such as bronchitis, pneumonia and asthma, leading to increased hospital admissions and emergency room visits. Particulate matter has also been linked to deaths. Up to 2,400 deaths a year in Australia are estimated to be linked to particles (PM10), with an associated health cost of AUD$17,200 million[27]. The actual contribution of fires to this national sum is unknown, however it is not considered significant. For this study, it is assumed that fire contributes 1% of the health costs, i.e. AUD$172 million. Other environmental costs, such as run-off and chemical pollution are assumed to be incorporated into this sum.

15: Heritage and cultural costs: - Information on the annual heritage and cultural costs in Australia due to fire is unknown. In the UK, the Windsor Castle fire, UK, in October 1992, is an example of a heritage and cultural loss. It took 5 years and £37 million (AUD$100 million) to renovate [28]. Rebuilding the 1924 Mount Stromlo

Observatory after the 2003 Canberra bushfires has been estimated to cost at between AUD$20 and $50 million[15]. For this study we have used an annual cost figure of AUD$20 million.

16. Clean up: - We have assumed that this cost is already included in loss output (cost component 10).

17. Wider economic distortions: - Further research is required into this cost in Australia, as information is limited. For this study a nominal figure of AUD$50 million is used.

3.3. Cost in response

18. Fire service response costs: – The total cost of funding fire services in Australia according to the 'Report on Government Services'[1] was AUD$1,600 million in 2002-3. Since Fire services in Australia also undertake tasks not related to fire, we need to adjust the above cost figure for this and have assumed that 80% of the fire services' efforts are related to fire safety after analysis of fire statistics for New South Wales fire brigade[29]. This results in an estimate of AUD$1,280 million.

19. Volunteer fire service: - The recent Council of Australian Governments (COAG) Inquiry into bushfires [30] investigated to impact of the volunteer fire service. It is estimated that each year around 250,000 such volunteers (predominantly rural fire volunteers) contribute about 21.5 million hours assisting the Australian community. The unpaid contribution of these volunteers is large: recent estimates from Victoria put the annual contribution of voluntary fire services at AUD$460 million[31]. Australia-wide, an annual contribution approaching AUD$1,200 million is likely.

20. Private fire brigade responses: - Information on this cost item is limited. For this study the cost of private fire brigades in Australia is put at a notional AUD$10 million.

21. Criminal justice costs / arson fires / coronial inquires: - Aggregate information on this cost component is not available. For this study the cost is assumed to be AUD$50 million. Further research is required on this cost item.

4. DISCUSSION

Table I summarises and totals the component cost estimates given above. The total cost of fire in Australia is estimated at AUD$ 8,400 million per annum. This sum represented approximately 1.15% of Gross Domestic Product for 2003.

Table I. Cost estimate

Cost component	**Mean Annual Cost estimate (AUD$)**
Cost in anticipation	
1. Fire safety equipment	Included in item 2
2. Fire safety measures in buildings	1,000,000,000
3. Fire safety measures in structures and infrastructure	1,250,000,000
4. Fire safety education and training	10,000,000
5. Insurance administration	325,000,000
6. Fire safety of consumer items	1,600,000,000
7. Fire safety research	10,000,000
8. Maintenance of fire safety equipment and measures	500,000,000
Sub-total (55% of total)	4,665,000,000
Cost as a consequence	
9. Property losses	540,000,000
10. Lost output	68,000,000
11. Fatalities and Injuries	194,000,000
12. Healthcare	113,000,000
13. Loss of business	30,000,000
14. Environmental	172,000,000
15. Heritage and cultural losses	20,000,000
16. Clean up	(included in item 10)
17. Wider economic distortions	50,000,000
Sub-total (15% of total)	1,200,000,000
Cost in response	
18. Fire service response	1,280,000,000
19. Volunteer fire service	1,200,000,000
20. Private fire brigade responses	10,000,000
21. Criminal Justice and investigation of arson fires	50,000,000
Sub-total (30% of total)	2,540,000,000
TOTAL	**8,435,000,000**

In considering the various cost components, it is important to bear in mind that while based on the best available data, there remains considerable uncertainty surrounding many of the estimates. In an attempt to account for this uncertainty, simulation modelling was undertaken to help estimate the variance about the mean estimate of the total cost. Of the 21 cost components, 9 represent 87% of the total cost of fire. The minimum and maximum estimates for these 9 dominant components are shown in Table II. The sum of the components was then simulated using a commercial Monte Carlo simulation package[32] assuming independence. Inputs have been expressed as simple probability density functions (in this case uniform distributions), where for each iteration, the variable is drawn with equal probability from a range

defined by minimum and maximum limits without any central tendency[33]. The available data does not warrant a more sophisticated treatment.

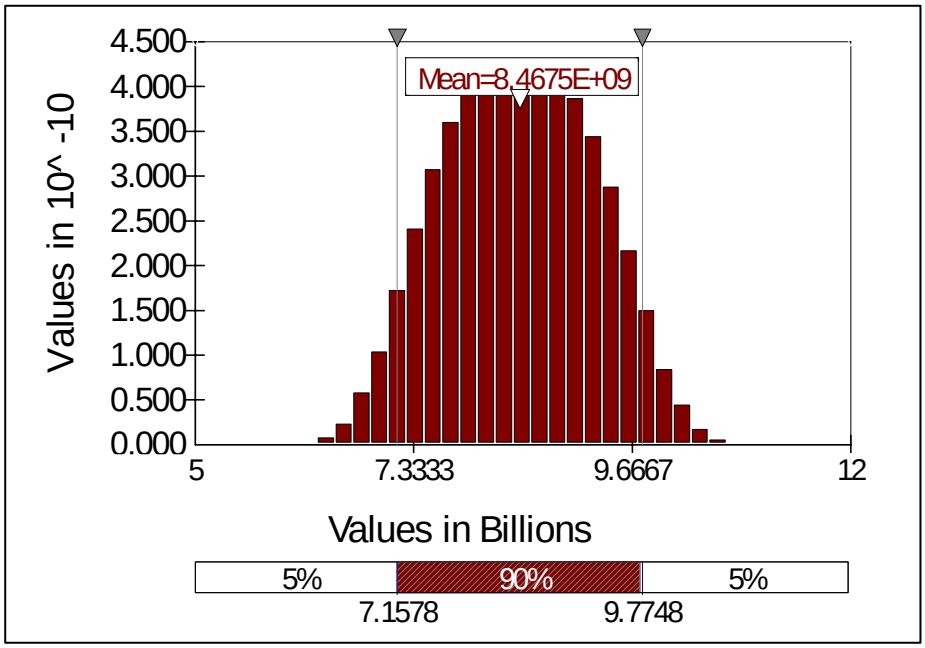
Table II. Uncertainty of the dominant cost components

Cost component	**Cost component distribution (minimum , maximum AUD $ million)**
Cost in anticipation	
2. Fire safety measures in buildings	Uniform (800,1200)
3. Fire safety measures in structures and infrastructure	Uniform (800,1600) Uniform (400,2800)
6. Fire safety of consumer items	Uniform (250,750)
8. Maintenance of fire safety equipment and measures	
Cost as a consequence	
9. Property losses	Uniform (500,800)
Cost in response	
18. Fire service response costs	Uniform (1100,1600)
19. Volunteer fire service	Uniform (800,1600)

Figure 1 shows the result. The total cost is roughly normally distributed around a mean value of AUD$8,500 million with a standard deviation of AUD$808 million. The bar below the x-axis (Figure 1) shows the 5 and 95 percentile values: AUD$7,200 million and AUD$9,800 million figures respectively that are equivalent to 1.0% and 1.3% of GDP. We note that this expression of the variance does not deal with inter-annual variation, a calculation that lies beyond the current study.

The familiar bell-shaped Gaussian result in Figure 1 is not unexpected and is often obtained when simulating the sum of multiple inputs independent of the character of the underlying probability density functions of the inputs and so long as no one particular variable dominates the outcome. Strictly speaking a Gaussian shape follows from the Central Limit Theorem when all of the inputs are randomly drawn from the same distribution. The ranges listed in Table II shows this to be almost true.

Figure 1. Simulated probability density function of the total cost of fire



The y-axis is the probability density scaled so that the area under the graph equals unity. The horizontal bar underneath the x-axis gives the 5 and 95-percentile values of the cost of fire.

To put the cost of fire in context, it is useful to compare it with other major cost components in the Australian economy. The most recent OECD statistical profile of Australia 2005 [(34)] states that Australia invests 1.5% of GDP on research and development and 6% on education. Clearly then, the cost of fire in Australia is significant.

Other than the quantification of the total cost of fire in Australia, the next most important finding of the study has been the distribution of costs between the three cost categories, ‘cost in anticipation’, the ‘cost as a consequence’ and the ‘cost of response’.

Figure 2. Comparison of the component costs of fire between Australia, UK, USA, Canada and Denmark

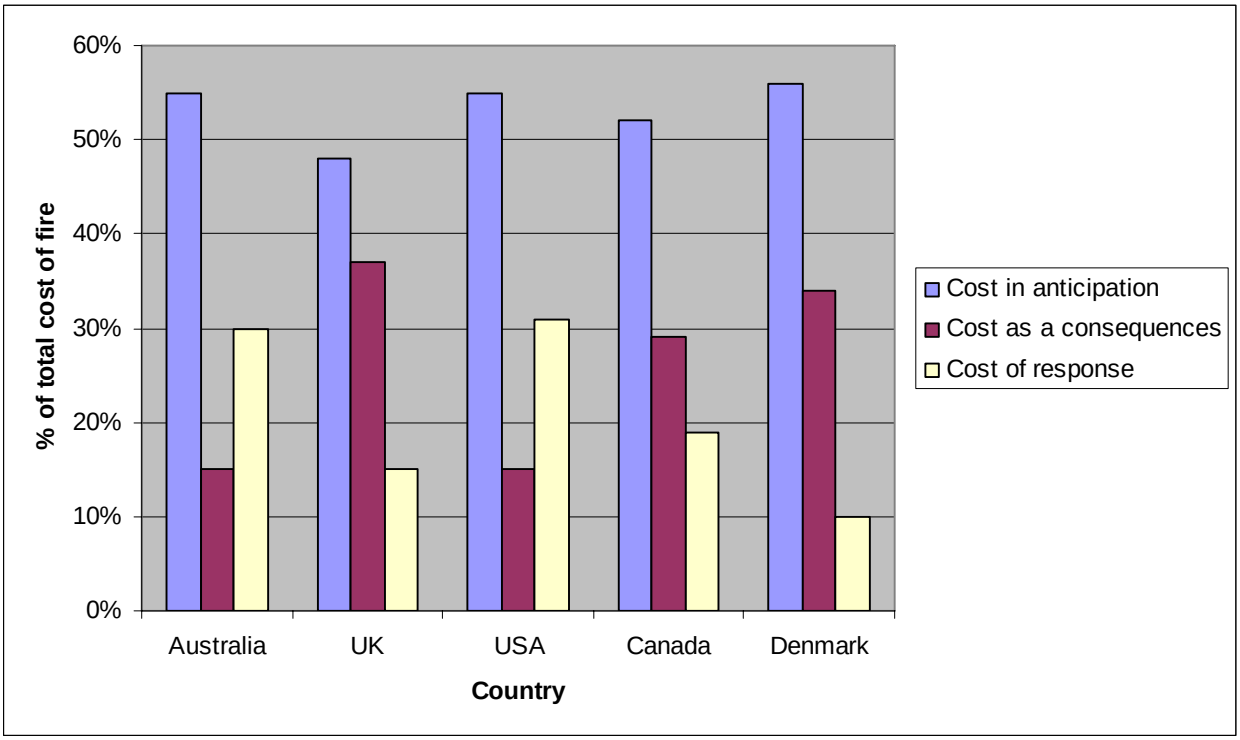


Figure 2 compares the breakdown of costs with the results of similar studies overseas[9][10][11][12]. It should be recalled that some of the cost components contributing to these sums were drawn from the same overseas studies but these inputs do not materially affect the comparison. While it is important to acknowledge that different methodologies and definitions have been used in the various studies, the comparison is nonetheless useful in order to benchmark Australia against other countries.

The comparisons between the countries illustrated in Figure 2 provide some interesting trends, similarities and differences. 'Cost in anticipation' between the countries is similar, ranging from 48% to 55% of the total. Australia and the USA have the lowest percentage 'cost as a consequences' at 15%, while Denmark has the highest at 34%. In terms of 'cost of response' Australia and the USA has the highest percentage, at 30%, while Denmark has the lowest at 10%. It is interesting that Australia and the USA have a similar approach in the way they allocate resources to the three cost categories, i.e. 'cost in anticipation' receives the largest proportion, followed by 'cost of response' and then 'cost as a consequence'. This is in contrast to the UK, Canada and Denmark who allocate relatively more resources to 'cost as a consequence' than 'in response'. This highlights contrasting national philosophies in the allocation of resources that have been developed in various countries to address the hazard of fire.

Is there an optimum philosophy to address the hazard of fire, or will the approach vary depending on country or region? Based on the information presented, the approaches of the USA and Australia compared to the other countries, suggest that the 'cost in response' is high, in relation to the other cost categories. Is this a result of the fire hazard in both countries, for example large conflagrations such as

bushfires / wildfires? Or is it a result of the Federal political systems, or a result of how the fire hazard has been historically managed? These questions remain unanswered and are areas of future research.

Having shown that the cost of fire prevention, management and response is a significant economic cost, it is natural to pose the question as to whether Australia receives value from this investment. Our study has provided the foundation from which questions of this type can begin to be addressed. While we cannot answer this type of question here, it is useful to reflect briefly on international differences in fire fatality rates as one example measure of outcomes. For the year 2000, the fatality rate in Australia was 0.6 per 100,000 population [35] with only Singapore experiencing a lower rate: 0.3 per 100,000 population. Fatality rates [35] for other selected countries were 1.6 for the USA, 1.2 for Canada, 1.1 for the UK and 1.6 for Denmark. The relatively low Australian fire fatality rate is potentially due to the significant allocation of resources and it would appear that this investment has been effective. However, given a much higher resource allocation in the US results in a fatality rate almost double that of Australia's, implies that there must be other reasons underlying Australia's relatively low fatality rate from fire. In a similar vein, Denmark, Canada and the UK, who all adopt broadly similar resource allocation philosophies (Figure 2) experience quite variable outcomes, at least in terms of fatalities and for this one year.

5. CONCLUSIONS

We have quantified the cost of fire in Australia. Our estimate is that the total annual cost of fire to Australia is approximately AUD$8,500 million with a standard deviation of around AUD$800 million. At 1.15% of GDP, cost of fire in Australia is comparable to that of Denmark (1% GDP) and the United Kingdom (0.9% GDP), but lower than the costs in the USA (2% GDP) and Canada (2% GDP). The results also show that Australia is investing approximately AUD$7,200 million (or 85% of the total cost of fire) to manage a loss of approximately AUD$1,300 million (or 15% of the total cost of fire), a result that raises questions as to the most effective and efficient investment of approximately AUD$420 for every Australian.

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