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A PRE-DISASTER MULTI-HAZARD DAMAGE AND ECONOMIC LOSS ESTIMATION MODEL FOR AUSTRALIA

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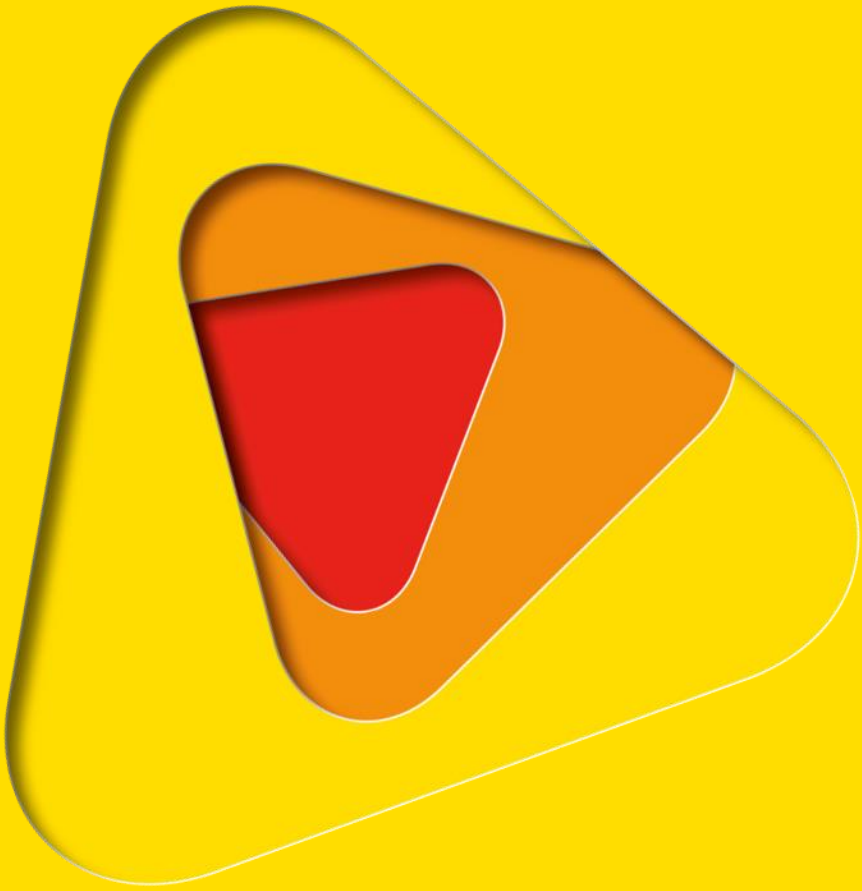

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ABSTRACT

Australia has witnessed a series of natural disasters throughout history that significantly affects its development trajectory. Examples include: cyclones Mahina (1899) in northern Queensland and Tracy (1974) in Darwin; floods in New South Wales (1955) and South-east Queensland (1974; 2011; 2012); earthquake in Newcastle (1989); landslide in Thredbo (1997); and bushfires in Victoria, South Australia, Tasmania and Australia Capital Territory (Black Saturday 2009; Canberra Fires 2003; Ash Wednesday 1983; Black Tuesday 1967; and Black Friday 1939). The resulting economic impact of these natural disasters is estimated to cost an average of AU$1.14 billion annually (BTE, 2001). This alarming statistic alone, along with its ever growing vulnerability due to rapid economic expansion in Australia, makes natural disasters a high priority issue for policy makers. In recent catastrophic natural disaster events, the emergency response of Australia has proven to be very effective at saving human lives. However the mitigation and preparedness of disaster risk reduction (DRR) appear to be less successful in avoiding the adverse economic impacts of natural disasters. One of the significant problems observed in this connection is the lack of effort to estimate the full economic impact of natural hazards, taking into account all the affected sections of the economy. This effort should consider not only the primary effects of the natural disasters, but also its secondary effects due to losses propagated through the economy arising out of possible inter-sectoral linkages. In order to achieve a paradigm shift from reactive response to a proactive risk reduction culture, disaster risk reduction measures need to be integrated into the economic development process. With this in mind, this paper discusses the shortcomings of current approaches and identifies the steps required for developing a system for increasing the disaster risk resilience of Australia.

INTRODUCTION

History portrays numerous natural disasters that not only reshaped topographical settings but also have bearings on the economic structures of many countries, including Australia. The economic impacts are often overlooked in management planning as they are not immediately felt and focus is put onto emergency response systems. In Australia, the disaster management arrangements across all stages (mitigation, preparedness, response and recovery) have proven to be very successful at saving lives and property. However, in terms of the adverse economic impacts of the natural disasters, less attention and resources have been allocated.

In Australia, natural disasters are estimated to cost an average of AU$1.14 billion annually (BTE, 2001). This statistic, which includes the costs carried by individuals, governments, businesses etc., along with the rapid economic growth in Australia, makes natural disasters a significant issue for policy makers. One of the substantial issues identified in this connection is the inability to estimate the full economic impact of natural hazards, considering all the affected sections of the economy. This effort should take into account not only the *primary effects* of the natural disasters, but also its lingering, all-important *secondary effects* due to the pervasive losses throughout the economy emanating from various sectors within the economy.

In this paper, we identify at least two major requirements that seek immediate attention to bridge the related gap. Firstly, a disaster risk assessment system needs to be developed which provides adequately quantifiable potential damages as a result of different types of disasters for regions of Australia. Secondly, a framework needs to be established to estimate the indirect economic losses. With the identification of the disaster-specific potential damage and losses, policymakers at different levels will be able to formulate disaster risk reduction-inclusive development policies to mainstream disaster

resilience practices. Hence, modelling the potential impacts of a full range of natural disasters remains highly critical towards designing more informed national economic policies. The overarching aim is to increase the level of the disaster risk resilience of the Australian economy. To summarise, in order to move from reactive response to a proactive risk reduction culture, a pioneering effort in mainstreaming disaster risk reduction (DRR) measures into the economic development process is required.

THE TRUE COST OF DISASTERS – CALCULATING THE ECONOMIC IMPACTS

Until the 1990s, the economic impact of natural disasters received relatively little attention from both the academic as well as the practitioner communities. A series of disasters in the mid-1990s, such as the Northridge Earthquake in 1994 and the Kobe Earthquake in 1995, which occurred in developed urban areas and resulted in considerable damage and impact to the society, demonstrated how vulnerable modern industrialised cities are to severe natural hazards.

Substantial progress has been made in recent years in the economic analysis of disasters, especially in the field of economic modelling of disaster impact analysis in a regional context. Since the pioneering work by Dacy and Kunreuther (1969), various generalised frameworks for the economic analyses of natural disasters have been proposed. The recent advancements have been more toward empirical analyses and the strategies for modelling extensions and modifications to fit them to different disaster situations. The method proposed in this paper aims to formulate a macro-econometric model for Australia that would not only quantify the potential losses in various economic sectors, but would also prescribe optimal policy mix for ensuring effective reallocation of available resources in the economy.

ASSESSING CURRENT APPROACHES AND METHODS AVAILABLE

As outlined in this introduction, the approach that this research will be taking is firstly developing a disaster risk assessment system, secondly modelling economic impact analysis and finally visualising the results of the first two stages to enable more informed national economic policies (figure 1).

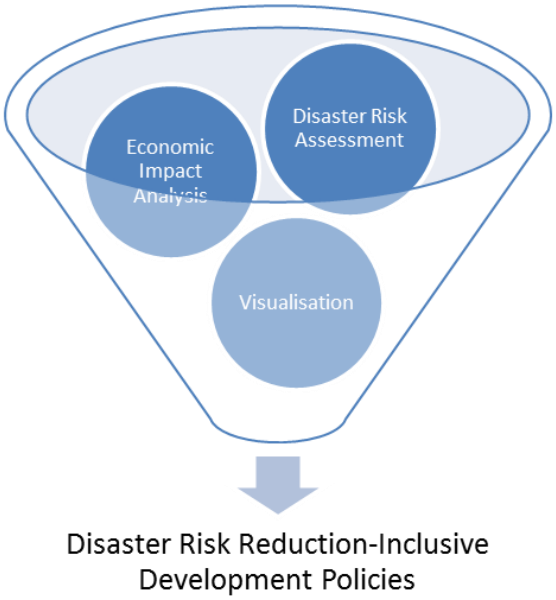

Figure 1: The research approach and outcomes

A number of different approaches and methods have been identified for developing a disaster risk assessment system and an economic impact assessment model. Below the identified approaches and methods have been summarised and their limitations identified.

Three key methodologies for developing a disaster risk assessment system have been identified in this research: HAZUS (Hazard in the US); Advanced Component Method (ACM); and CAPRA.

HAZUS was developed by the National Institute of Building Sciences for the Federal Emergency Management Agency (FEMA) in the United States and is one of the major efforts worldwide to develop a methodology for disaster risk assessment. HAZUS contains extensive databases and default values for methodology parameters, thus, making it possible to estimate potential damage and losses. However, its estimates on economic losses are *not accurate*, as it considers only linear growth patterns in economic activities.

ACM was developed by AIR Worldwide Corporation and is more advanced than HAZUS in a number of ways. With ACM, an objective and scientific methodology largely replaces the subjective measures and opinions of experts about how building damage relates to different level of disaster (i.e. earthquake) intensities. ACM assesses both physical and monetary damage at the component level (e.g., damage to beams, columns and partitions of buildings). Estimates of component damage are subsequently combined to achieve an estimate of total damage to the building. However, like HAZUS it *does not estimate indirect economic losses* associated with physical damage due to natural disasters.

CAPRA is a disaster risk information platform for assessing and estimating disaster risks. It consolidates hazard and risk assessment methodologies providing potential loss estimation with regard to different natural hazards. However, CAPRA is not *technically feasible* to adopt in the context of bushfire hazard. Further, CAPRA does not take into account broader sections of the economy given its emphasis on cost-benefit analysis.

The disaster risk assessment component for the model developed to be applied to Australia will leverage off these identified models and will aim to address some of the shortcomings which make these above models unsuitable for the proposed application. For the economic impact analysis component of the model a number of current methods and models have also been identified.

Various economic techniques have been employed to estimate the higher order effects of a disaster. One methodology developed for this purpose is the Damage and Loss Assessment (DaLA) methodology. This methodology was introduced by the Economic Commission for Latin America and the Caribbean (UN ECLAC) and has been considered as the internationally accepted standard methodology for assessing the economic impact of natural disasters. It quantifies both direct damages and indirect losses due to natural hazards in a sector-by-sector context. However, the economy is by nature very complex since all of the sectors are inter-linked simultaneously. This imposes a downward bias in the estimates of DaLA, since it ignores *inter-sectoral* relationships in assessing the overall impact of natural disasters.

Another widely used modelling framework is the Input-Output model (c.f. Cochrane 1974, 1997; Wilson 1982; Kawashima et al. 1991; Boisvert 1992; Gordon and Richardson 1996; and Okuyama et al. 1999). The application of this model to disasters dates back to strategic bombing studies during the Second World War (Rose 2004). The popularity of this modelling approach for disaster-related research is primarily based on the ability to reflect the interdependencies within a regional economy in detail for deriving higher-order effects, and partly on its simplicity - the model creates a set of limitations including

its linearity, its rigid structure with respect to input and import substitutions, a lack of explicit resource constraints, and a lack of responses to price changes (Rose, 2004).

An alternative to the Input-Output model is the Computable General Equilibrium (CGE) model (c.f. Boisvert 1992; Brookshire and McKee 1992; Rose and Guha 2004; and Rose and Liao 2005). Unlike the Input-Output approach, CGE models are nonlinear, can respond to price changes, can incorporate input and import substitutions, and can explicitly handle supply constraints. However, Rose and Liao (2005) claim that most CGE models are intended for long-run equilibrium analysis and hence, in contrast with the rigidity of the Input-Output model, a CGE model generally leads to the underestimation of economic impacts due to its flexible adjustment feature. Another limitation of CGE models is that the assumption of optimising behaviour can be considered questionable under disaster situations where increased uncertainties arise in the near and distant future. In addition, a more extensive data requirement for CGE modelling presents another major disadvantage for empirical analysis of disasters.

FLESHING IT OUT – THE STEPS TO DEVELOP A PRE-DISASTER MULTI-HAZARD DAMAGE AND ECONOMIC LOSS ESTIMATION MODEL FOR AUSTRALIA

As has been discussed above, a number of different approaches exist for modelling and estimating damage and economic loss as a result of disasters, however none of these approaches are comprehensive when applied to the country of Australia.

Given its multi-disciplinary nature, this research borrows scientific methods from both the engineering and economics disciplines. Initially, it takes a geographic information system (GIS) as a tool to develop a multi-hazard risk assessment map, and following that it uses empirical economic techniques to estimate overall effects of natural disasters. The method utilised will involve the steps of compiling available multi-hazards maps, consulting and collecting data from a number of expert organisations within Australia. This data will then be integrated to create a geographic database of exposed elements. This data will then be verified through random but systematic ground-truthing activities. Following this a vulnerability assessment will then be conducted on a selected case area, and the information will be fed through an intelligent visualisation platform to create a comprehensive multi-hazard risk map. The result will be a presentation of the risk in terms of physical and direct monetary damage pertaining to the administration units of the case study area.

Once the potential physical *damage* of natural disasters is estimated, this research will focus on integrating different scenarios of disaster risks in a macroeconomic model in not only quantifying the potential economic *losses* but also prescribing optimal policy mix for ensuring effective reallocation of available resources in the economy. First, the economists will identify an ideal macroeconomic model for incorporating disaster risks that will enable estimating the sector-specific potential economic losses, and secondly, the possible effects of various policy options for identifying the best alternative economic policy package that will maximally minimise disaster risks are forecast.

To visualise the results the research will utilise an existing geospatial platform – the Intelligent Disaster Decision Support System (IDDSS). The platform adds value to end users by enabling them to access and make use of the results of the system. The IDDSS system can store, update, analyse, and visualise data including hazard perception and vulnerability maps for bushfires, floods, storms and earthquakes in order to obtain a multi-hazard vulnerability map for Australia, which will provide estimates on potential

physical damage against a set of possible disaster scenarios. This platform is also capable of displaying the indirect economic losses that would be derived from a macroeconomic model.

EXPECTED OUTCOMES OF THE RESEARCH

Given that the main objective of this research is to build a scenario-based pre-disaster multi-hazard damage and economic loss estimation model to support decision makers in reducing disaster risks, it is expected that this initiative estimates the impact of different types of natural disasters on Australian economic growth at the national as well as state level. In particular, the expected outcomes of this research are fourfold. First, it uncovers the causal impact of natural disasters—such as bushfires, floods, storms and earthquakes—on sector-specific economic growth in Australia. Second, it develops a spatially enabled multi-hazard (i.e., bushfires, floods, and earthquakes) risk assessment map for Victoria to quantify *potential damage*. After that, such damage scenarios are expected to be subsumed as a 'shock' in a macroeconomic model for forecasting the *potential economic losses* under a set of possible scenarios. Finally, a possible set of economic policies are expected to be identified to reduce the estimated effects of disaster risks.

CONCLUSION

Measuring the economic effects of natural disasters remains traditionally challenging. The method proposed in this paper of bringing engineering and economics tools together to pin down the true impacts opens a window of opportunity for the policy makers to comprehend both direct (i.e. damage) and indirect (i.e. losses) effects of natural disasters in more detail. The identified process also takes into account the specific hazards and economic environment of Australia to enable effective policy development within the Australian context. The resulting system developed through this process will enable stakeholders to estimate the full economic impact of natural hazards, taking into account all the affected sections of the economy.

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