SIMPLIFIED ASSESSMENT OF THE REGIONAL ECONOMIC IMPACTS OF INTERRUPTION TO TRANSPORT CORRIDORS WITH APPLICATION TO THE 2011 QUEENSLAND FLOODS

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ABSTRACT: The focus of this study was on the economic costs of closures to transport corridors from flood waters at Rockhampton in January 2011. Two approaches have been used to provide for a simplified assessment of the economic impacts of the road closures. The first was to model the proportional downturn in the regional economy, using data from surveys with local businesses to assess the proportional drop in business activity over the period. Using this approach the impact on the local economy was estimated at $35 million, or about 0.77 percent of the gross regional product for Rockhampton. The second approach involved application of the travel cost savings methodology to assess the costs of transport corridor closures. The total direct costs have been assessed with the travel time approach at $66.7 million for the road closure, and $13.5 million for the airport closure, with more than half ($47.5 million) relating to the isolation of the north Queensland economy. The estimate of costs to the Rockhampton economy of $32.7 million closely matches the results of the economic slowdown approach.

KEY WORDS: Economic impact assessment; Flood disaster; transport corridors; travel cost savings

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1. INTRODUCTION

Assessing the economic costs of natural disasters is important because it can (a) inform the need to allocate funds for repairs as well as for meeting immediate economic and social consequences; (b) help predict the wider impacts on communities and economic frameworks; and (c) assist in designing infrastructure and policy settings that reduce the risks from future events (West and Lenze 1994; Hallegate, 2008). Estimating the cost of natural disasters is complex, with variations by the type of disaster (Loayza *et al.*, 2012), confounded in some cases with the positive impacts of weather events and reconstruction activities (Baade *et al.*, 2007; Loayza *et al.* 2012). The lack of a universally accepted assessment method also adds to the complexity when estimating the cost of natural disasters (Pelling *et al.*, 2002; Carvello and Noy 2010). In many cases, costs are calculated solely on the basis of direct losses, usually repair and replacement costs, typically from the reported costs of insurance repairs (West and Lenze 1994). However, the total costs of natural disasters are actually much greater than this when the wider socio-economic impacts are considered across a region (Pelling *et al.*, 2002; Hallegate 2008), including the impacts on small businesses and on longer-term regional economic development (Zhang *et al.*, 2009).

Quantifying the economic costs of natural disasters is useful in local or regional settings when evaluating the improvements to infrastructure or services that would reduce disaster impacts. However, the human resources and foundation economic data needed to prepare comprehensive assessments are rarely available at a regional level. This generates a requirement for simplified assessment approaches and estimates that can be prepared at local or regional scales, rather than focussing on specific sectors of the economy, which has been a problem in past studies (Loayza *et al.*, 2012). Estimates about the costs of natural disasters are required to evaluate proposals for investments in infrastructure, to assess economic and business vulnerability, to inform regional economic development planning, and help ensure that the impacts of future climatic disasters are properly considered (Zhang *et al.*, 2009). It can also be helpful for business owners to have access to the data compiled from a simplified microanalytic study, as this might assist business planning for disaster preparedness (Zhang *et al.*, 2009).

The combination of floods and cyclones that affected Queensland, Australia in the summer of 2010-11 provides an excellent case study example by which the substantial economic consequences of natural disasters can be calculated. The flooding in December and January, followed by Cyclone Yasi in February, is estimated to have affected 70 percent of Queensland by area and around 60 percent of the state population (PWC, 2011). Several lives were lost, and there were large personal and social impacts in many communities. Significant impacts included damage to roads, damage to more than 50,000 homes and other infrastructure across the State, major interruptions to coal production and exports, and losses in agricultural production. In economic terms, these natural disasters reduced Queensland's 2010-11 Gross State Product (GSP) by around 2.25 percent, or $6 billion (Queensland Government, 2011). As at the end of June 2011, the estimated insured losses due to the Queensland floods was $2.55 billion, with a further $1.05 billion in claims for damage suffered from Cyclone Yasi (ICA, 2011). However, these largely represent direct and private costs. In addition, direct public costs, such as the resources needed to rebuild public assets and provide community support have been predicted at around $6.8 billion (Queensland Government, 2011).

In the absence of an agreed method for calculating total costs, most formal studies for the 2011 Queensland floods (e.g. PWC, 2011; IBIS World, 2011) have divided costs into the direct and indirect components, including (a) assessing the direct costs of repairing and replacing damaged assets and infrastructure, (b) assessing the value of lost production in primary industries, and (c) assessing the impacts on overall economic performance through slowdowns in growth. The latter is typically measured as changes in Gross Domestic Product or Gross State Product (dependent on whether the analysis is at national or state level). However, although estimates of total impacts remain useful in guiding macroeconomics and policy settings, more detailed information relating to sub-regional level impacts is critical in evaluating the appropriateness of current policy settings and infrastructure, as well as in evaluating the case for future investments (such as in public infrastructure). Unfortunately, assessing the sub-regional economic impacts of natural disasters is difficult because of the complexity of events, limited data availability and the problems inherent in apportioning out a subset of effects and consequences to a particular geographic area or period of time.

The economic impacts of the flood on the city of Rockhampton provide a useful case study given the centre's strategic position on the State's major north-south road transport corridor and the lack of any significant damage to infrastructure to cause confounding stimuli from reconstruction. There was little physical damage in Rockhampton because the periodicity of the river flows (over a weeks' notice of the impending river rises), together with the long history of flooding in the region has meant that most housing stock and other assets are already located, or can be relocated, out of the danger zone. The 2010/11 flood event caused closure of the major highways and the airport, isolating Rockhampton as well as north Queensland, with subsequent impacts on the regional and state economy. Estimating the economic costs of closures in road, rail and air access into Rockhampton will be useful in evaluating the case for investment in new regional infrastructure for the Bruce Highway and the Rockhampton airport.

The key research objectives of this study were (a) to establish an appropriate methodology for the simplified assessment of the economic impacts of transport and network interruptions, and (b) assess the indirect impacts on both the Rockhampton Regional and Queensland economy of transport interruptions across road and air sectors as a consequence of the flooding at Rockhampton. The case study is notable in that it assesses only a small part of the total impacts of the flood and cyclone damage on the Queensland economy, where closure of transport options at Rockhampton had varying impacts on communities, businesses, employees and households. The study is also notable in that most of the impacts to be assessed were indirect impacts such as the inability of the public to access employment, goods and services, and for businesses to access staff, suppliers or customers. Thus, a key methodological focus for this study was the particular challenges associated with isolating and quantifying a small set of mostly indirect impacts (i.e., excluding physical damage), from the much broader set of major economic costs linked with the flooding.

An overview of the methodology used is provided in the next section, followed by a description of the flood impacts in section 3. Cost estimates using the economic slowdown and lost travel time approaches are provided in sections 4 and 5 respectively, and discussion about other costs and final points are made in sections 6 and 7.

2. METHODOLOGY: ASSESSING AND MODELLING THE COSTS OF NATURAL DISASTERS

Natural disasters are a regular occurrence in Australia. Based on data from the Insurance Council of Australia (ICA), catastrophic events in the country cost on average about $1 billion per year nationally in insured losses (ICA, 2011). However, this average can be distorted by extreme events such as the 1989 Newcastle earthquake, which alone cost $4.2 billion. In Queensland, floods, severe storms and cyclones have been identified by Gentle *et al.* (2001) as the most common, as well as the most expensive, natural disaster events, costing on average over $238 million dollars annually to 2000. However, it should be noted that these figures represent only insured losses: direct economic costs are likely to be around twice those of reported insured losses (Crompton and McAneney 2008).

Even when the direct economic costs (such as damage to buildings, infrastructure and direct income losses) can be measured accurately, these figures do not reflect the total cost of natural disasters. If the impacts of natural disasters are to be calculated holistically, this must take into account not only direct damage repair costs, but also the additional costs of reduced business turnover, as well as the expenses of additional logistics and transport alternatives (Pelling *et al.*, 2002; Cavello and Noy 2010). There are also many other flow-on economic effects from natural disasters, caused largely by indirect impacts such as interruptions to, or slowdown in, regional economies, as well as positive impacts from reconstruction activities (West and Lenze 1994; Baade *et al.*, 2007; Hallegate, 2008). Assessing the true costs of natural disasters therefore requires the use of accurate methods for assessing both direct and indirect costs and benefits (Cavello and Noy 2010).

There are few studies identifying the overall economic implications of disaster events, and how these can be confounded by business resilience and rebound effects. For example, economic resilience may arise because certain business activities can be conducted from alternative locations (e.g. home office) during a flooding disaster. This is separate to 'rebound' effects, where increased trade is experienced post-flood due to catch-up on delayed business activity, as well as the possibility for business stimulation associated with the reconstruction effort. The review by Cavallo and Noy (2010) indicated that research on these issues to date has been inconclusive, with reports listing a range of negative, positive and net-balance effects in the medium-term; and many works being focussed on only one or two sectors of the economy, rather than taking a whole-of-region approach. Most recently, Loayza *et al.* (2012) presented data that showed the potential for rebound or stimulus effects to be limited to mild or moderate-scale disasters, and only to selected industry sectors.

There is a limited pool of international studies that have identified the economic impacts of floods or cyclones at a regional level. Baade *et al.* (2007) identify the economic costs of Hurricane Andrew on Miami, highlighting that while there are short run negative impacts on sales and business activity, the positive impacts of repurchasing and re-building can subsequently outweigh the negative impacts. Vigdor (2008) reviewed the economic impacts of Hurricane Katrina on New Orleans, showing for example, that employment had fallen across almost all sectors (apart from construction) by an average of 13.6 percent. Xiao (2011) examined the long run effects of the 1993 Midwest flood in the United States, and showed that while the flood caused short-run declines in per capita income, economic activity returned to pre-flood conditions in the years after the flood (although some badly affected agricultural communities suffered economic slowdown in both short and longer time periods). Loayza *et al.* (2012) report from a meta-analysis that the economic effects of flooding appear mixed because of confounding effects on agricultural production, but estimate an average economic cost of $136 per person affected from flood events.

In this study, the economic costs associated with the closure of the transport corridors at Rockhampton were estimated and compared using two separate approaches. The first approach modelled the downturn in the affected sub-regional economy, essentially providing an estimate of the changes in Regional Gross Product or factor incomes as a consequence of the natural disaster. The second approach assessed costs in terms of the value of lost travel time (lost production per transport movement that has not occurred): this is a standard methodology used to assess the value of improvements in transport infrastructure. These two measures were chosen as they are relatively simple to implement with the limited information available for a regional case study.

These approaches measure slightly different economic concepts. The economic slowdown approach assesses changes in the total production from an economy, while the travel time approach assesses changes in the value of economic activity. In a normally functioning economy, where income (largely salaries and profits) is some proportion of total production, then changes in economic surplus would be expected to be more closely related with changes in income than changes in overall production.

Assessing an Economic Slowdown

The 'economic slowdown' approach identifies the direct value of interruptions to businesses, customers, suppliers and employment, and then assesses the subsequent indirect and final demand effects through the use of economic modelling (Cavello and Noy 2010). Dore and Etkin (2000) proposed a methodology for assessing the full costs of a natural disaster by first measuring the distortion to normal economic growth, and then estimating what would be required to restore the economy to the Gross Domestic Product (GDP) value that would have been expected in the absence of the natural disaster. Using this methodology, the total social loss is equal to the loss of value added, plus the loss of capital and the opportunity cost of labour redirected to assist with the emergency.

Modelling the indirect effects of natural disaster costs on the wider economy has most commonly been performed using Input-output (I-O) or Computable General Equilibrium (CGE) models: each of these have advantages and disadvantages. I-O models are linear, relatively simple to construct and are capable of estimating the full range of direct and indirect costs including integration with transport or engineering models if necessary (Okuyama, 2009; Hallegatte, 2008). CGE models have an advantage over I-O models as they can be non-linear, are able to respond to price changes and can endogenously incorporate import and input substitutions (Okuyama, 2009). To account for inter-regional impacts of natural disasters which specifically affect transport networks Tsuchiya *et al.* (2007) expands the standard CGE model into a spatial CGE which includes a transport model covering both freight and passenger trips. However, one of the challenges with modelling the impacts of natural disasters is that most economic models are based on annual or at best quarterly periods while events such as floods occur over relatively short time frames (Okuyama, 2009). CGE models also rely on the assumption of rational optimization, which does not necessarily occur during periods of disaster (Okuyama, 2009).

However, the value of recovery efforts, whether funded by governments, non-profit organisations, insurance payments or privately, provides a boost to the local economy and increases economic growth for a period (Guimaraes *et al.*, 1992; West and Lenze 1994). This confounds the assessment of impacts on an economy because spending inflows from recovery efforts offset production losses. The effect is to delay and minimise the net impacts of a natural disaster on an economy by avoiding large swings in confidence and expenditure. Failure to account for offsetting recovery efforts can distort predictions from both I-O and CGE models (Cavello and Noy 2010).

Value of Travel Time Lost

The value of travel time approach can be estimated by identifying the value of travel time lost across different classes of travellers and vehicles. This is performed through the application of standard travel time values to the estimated number of vehicle and passenger movements affected by a closure of a transport corridor. The advantages of this approach are that the key variables (vehicle and passenger movements) are easier to estimate with some level of accuracy, and the methodology to value impacts is well established. However, an implicit assumption of this approach is that the indirect impacts flowing through to other sectors of the economy are limited.

An alternative approach to valuing changes in travel access is to estimate the value of changes in travel time, and to then extrapolate this across different groups of vehicles and travellers (Austroads ,1997; 2003; 2011). The approach taken in Australia is typically to identify vehicle trips for private/non-business travel, business travel, commercial vehicles and freight travel. For example, time on public transport, commuting to and from work, and tourist/bicycle/pedestrian trips are classified as private travel. In Australia, the value of private travel and business travel is assessed by Austroads (1997; 2011) as 40 percent and 135 percent of average weekly earnings (assuming a 38 hour week) respectively.

The lost travel time approach relies on the proper identification and classification of the number of trips that would have occurred, the estimate of travel times that would have been involved, and the application of travel time values. There is a substantial literature available on the value of travel time savings, which has been summarised for Australian use by Austroads (2011). For passenger vehicles, this involves an analysis of typical vehicle uses and costs to generate estimates of average travel costs. Here, the most important information is summarised for three particular groups of vehicle travel, as described below.

Non-Business Travel in Passenger Vehicles

AustRoads (1997) recommended that unpaid private travel time be valued at 40 percent of seasonally adjusted full time average weekly earnings for Australia, assuming a 38 hour week. This equates to \$11.49/person-hour, which AustRoads (1997) recommended to be used in the valuation of private car travel for the following forms of travel:

- commuting to and from work;
- recreational/tourist travel;
- motor cycle travel;
- bicycle travel;
- pedestrian travel;
- public transport waiting time; and
- public transit passenger travel.

Business Travel in Passenger Vehicles

AustRoads (1997) recommended that paid private time for non-commercial vehicles (cars and vans) be valued at 135 percent of full time average weekly earnings (less 7 percent assumed for payroll tax). On this basis, business vehicle travel can be calculated at \$36.76/person-hour.

Freight Vehicles

Austroads (2003; 2011) treats the value of driver time lost for freight vehicles in the same way as for business travel (\$36.76 per person-hour). However, this does not account for the business costs in delays in load delivery. These have been estimated separately in Austroads (2011) at \$1.50 for full truck delays per pallet per hour. An ‘A’ trailer carries 12 pallets and a ‘B’ trailer 22 pallets.

Air Passenger Travel

The University of Westminster conducted a comprehensive review of the costs to airlines of delays at all stages of flights (Institute of Air Transport, 2000). Values were estimated for different groups of travellers based on the opportunity costs of their time and the travel delay costs. Results are summarised in Table 1, with adjustments to values for 2010.

Table 1. Cost of airport delays in Europe.

	Percent of travellers	$/hour (2000 values)	$/hour (2010 values)
Low			
Business	49 percent	$47	$62.28
Personal	16 percent	$28	$37.11
Tourism	35 percent	$20	$26.50
Average		$34	$45.06
High			
Business	49 percent	$63	$83.49
Personal	16 percent	$33	$43.73
Tourism	35 percent	$23	$30.48
Average		$44	$58.31

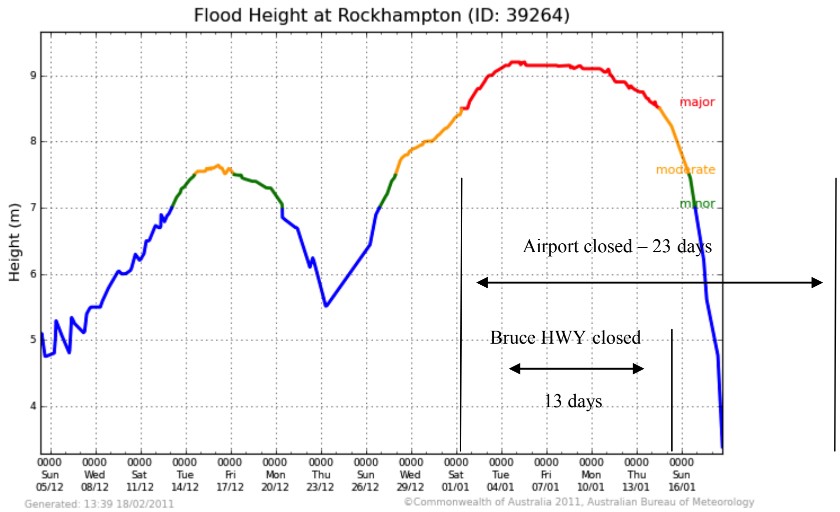
Source: Institute of Air transport (2008).

Air Freight Travel

Logistics costs are most commonly estimated through stated preference estimation of the willingness to pay to reduce travel time and indirect costs through estimation of the loss of revenue or income. In a review of 27 similar studies, Hu (2006) found that 23 had used stated preferences to estimate the value of travel time for freight transport. The average value of travel time found in these studies was $23 per shipment per hour (in 1999 US dollars, which equates to approximately AUS$32 per hour in December 2010).

3. EFFECTS OF FLOODING ON ROCKHAMPTON

The 2010-11 Rockhampton flood was the fourth highest on record (Figure 1) with over 2,000 properties inundated and over 500 people requiring evacuation (Rockhampton Regional Council (RRC), 2011). The Bruce and Capricorn highways were closed between the 3rd and the 14th of January and the airport for over three weeks between the 1st and the 24th of January, which severely disrupted business trade and caused significant losses beyond the direct damage caused by the flooding.



Source: Australian Bureau of Meteorology supplied by Rockhampton Regional Council.

Figure 1. Flood heights at Rockhampton manual gauge for December 2010 and January 2011.

Rockhampton did not suffer the direct flood impacts that many other Queensland communities experienced. The nature of the flow in the Fitzroy catchment meant that there was ample advance warning of the upstream flood peak. Existing reports suggest that the regional emergency and management systems generally worked well to deal with the direct impacts of flood inundation on the Rockhampton community, particularly given that the appropriate planning systems had ensured that new housing and developments were built away from flood zones (Queensland Flood Commission of Inquiry, 2011). Nevertheless, Rockhampton and its neighbouring communities (Gracemere and the Capricorn Coast) experienced serious flood impacts of a different kind. The closure of both the road and air transport corridors for long periods limited access between regional businesses, suppliers, customers and employees. It also effectively split the Queensland economy into two sections, disrupting the connectivity between the southern and central/northern markets.

The direct costs of the floods in Rockhampton were largely caused by impacts on roads, with some additional impacts on other infrastructure and private housing. Estimates from the Rockhampton Regional Council are that total road damage of $56 million occurred in the local government area. A further $0.9 million in damages occurred to the Rockhampton airport. In operational terms, the counter-disaster costs of managing the flood response and highway closures at Rockhampton was approximately $1.5 million, while the Council lost a further $0.6 million in direct revenue because of the airport closure (personal comment, Evan Pardon, Rockhampton Regional Council).

The closure of the Bruce Highway and the airport also generated a range of other indirect costs. With access to the region all but eliminated, the transport, tourism, service and retail sectors were severely affected. Whilst major retailers including the two main supermarket chains were able to organise supplies to be delivered by air (to Mackay) or by barge (to Rosslyn Bay) before being trucked into Rockhampton, this incurred significant additional costs and many smaller retailers were unable to implement similar strategies. In addition, key industries in the region such as mining could not access any employees, services or supplies held within Rockhampton during this time.

4. ASSESSING THE IMPACTS USING AN ECONOMIC SLOWDOWN APPROACH

The economies of the Fitzroy Statistical Division and the Rockhampton Local Government Area within it represent about 7 percent and 2 percent, respectively, of the Queensland economy. The regional economy is a complex structure of different economic sectors, with key drivers from the agriculture, mining and tourism sectors. In the economic modelling approach, the estimates of an economic slowdown can be generated by identifying the average change in economic performance across sectors from the loss of transport access, and extrapolating this as a percentage of regional economic activity. The regional economic activity is summarised as the GRP for the Rockhampton area (Table 2).

Table 2. Gross Regional Product by industry at the Queensland, statistical division and local government area level.

	Rockhampton LGA	Fitzroy SD	Queensland	Rockhampton employment
	Level ($m) 2008/09	Level ($m) 2008/09	Level ($m) 2007/08	
Agriculture, forestry & fishing	62.6	260.1	4,739	1,220
Mining	171.0	6,033.5	18,423	1,301
Manufacturing	384.3	1,005.1	19,174	2,780
Electricity, gas, water & waste services	172.8	318.7	4,218	1,145
Construction	272.0	733.9	18,086	3,778
Wholesale trade	170.0	303.8	10,125	1,544
Retail trade	353.8	645.5	12,712	5,144
Accommodation & food services	170.8	318.1	6,835	3,274
Transport, postal & warehousing	525.8	1,074.6	14,343	2,623
Information media & telecommunications	66.1	99.8	4,792	457
Financial & insurance services	116.4	188.5	14,154	890
Rental, hiring & real estate services	120.0	235.8	7,715	758
Professional, scientific & technical services	111.8	246.1	11,107	1,466
Administrative & support services	70.9	151.1	4,949	1,013
Public administration & safety	281.4	462.1	11,943	2,947
Education & training	227.3	377.7	8,758	4,441
Health care & social assistance	353.5	534.0	12,894	5,019
Arts & recreation services	36.1	54.7	1,446	365
Other services	140.1	260.0	4,561	1,802
Inadequately described/Not stated	41.8	99.1		
Total Industry Factor Income	3,848.5	13,402.0	190,974	
Total Employment				41,567
Ownership of dwellings	355.4	1,237.7	16,461	
GRP at Factor Cost / Total Factor Income ($m)	4,204.0	14,639.7	207,435	
Taxes less subsidies on production and imports	296.9	1,034.0	16,015	
Statistical discrepancy (I)	86.8	302.1	0	
Gross Regional Product ($m)	4,587.6	15,975.8	223,450	

Source: the Authors. Note: GRP models supplied by Lawrence Consulting

The level of slowdown in the regional economy was estimated through a survey of local businesses, conducted by Capricorn Enterprise, the peak business organisation within the Rockhampton region. The survey was conducted by telephone during and immediately after the flood period, with the sample drawn from Capricorn Enterprises' total membership of approximately 459 businesses. The membership is weighted towards the tourism, retail, and services sectors, which reflects the most common groupings of small to medium enterprises within the local government area (Table 3).

Table 3. Counts of Businesses by industry division by employment size ranges for Rockhampton, as at June 2011.

	Total number of businesses		
Industry	**Microbusinesses (0-4 employees)**	**SMEs (5-199 employees)**	**Large businesses (200+ employees)**
A Agriculture, Forestry and Fishing	1068	66	0
B Mining	41	24	0
C Manufacturing	168	64	0
D Electricity, Gas, Water and Waste Services	24	3	0
E Construction	1274	262	0
F Wholesale Trade	111	49	0
G Retail Trade	327	211	0
H Accommodation and Food Services	162	169	3
I Transport, Postal and Warehousing	530	57	3
J Information Media and Telecommunications	26	3	0
K Financial and Insurance Services	380	28	0
L Rental, Hiring and Real Estate Services	666	62	0
M Professional, Scientific and Technical Services	466	116	0
N Administrative and Support Services	202	68	0
Not Classified 1	117	3	0
O Public Administration and Safety	18	6	0
P Education and Training	78	12	0
Q Health Care and Social Assistance	283	91	0
R Arts and Recreation Services	74	21	0
S Other Services	381	108	0
Total (All sectors)	6396	1423	6

Source: collated from ABS 8165.0 - Counts of Australian Businesses, including Entries and Exits, June 2007 - June 2011.

A total of 138 businesses participated in the survey in January 2011, with 72.5 percent of respondents indicating that they had been affected by the flood. For the proportion that remained unaffected, the key reasons for escaping impact were that January was either a slow time, or a period during which they were normally closed. In contrast, many of the affected businesses reported that they were incurring substantial costs. Some businesses, particularly in the accommodation sector, lost 90-100 percent of their business over the period. Others reported having staff unable to get to work, lack of access to supplies, some water in their premises, or choosing to close their business as a precaution against further increases in the flood height. Across the 45 businesses that were able to indicate the proportional downturn in business conditions, 60 percent indicated that there was no major effect on their business turnover. The average downturn in business turnover across all businesses was 22 percent (declining to 18 percent when tourism businesses were excluded).

To estimate the impacts of the road closure on the economy, the estimated downturn in business conditions (18.6 percent decline) was extrapolated to the Gross Regional Product at Factor Cost (industry factor income) of the Rockhampton region (Table 4) for the period of the road and airport closures (averaged to 18 days). This generated an expected reduction in total production in the Rockhampton economy over that period of $35 million, or about 0.77 percent of the annual gross regional product. As factor income (wages and profits) is approximately 20 percent of GRP for the Rockhampton economy, the loss of economic surplus is estimated at approximately $7 million.

Table 4. Daily value of lost traffic access from flood road closure.

	Passenger vehicles	Freight vehicles
Through traffic, non-Rockhampton economy		
Number	1,094	356
Hours of delay	72	72
Value of time lost/person/hour	$24.13	$36.76
Value of truck time lost per hour		$1,560.60
Sub-total losses per day	$1,899,906	$1,498,706
Through traffic, Rockhampton economy		
Number	800	91
Hours of delay	24	24
Value of time lost/person/hour	$24.13	$36.76
Value of truck time lost per hour		$520.20
Sub-total losses per day	$462,888	$126,976
Local Traffic, Rockhampton economy		
Number	8,064	1,862
Hours of delay	8	8
Value of time lost/person/hour	$24.13	$36.76
Value of truck time lost per hour		$72.00
Sub-total losses per day	$370,624	$407,838
Total losses per day (all traffic types)	**$2,733,418**	**$2,033,520**

Source: the Authors. Note: estimates of impacts on vehicle movements from the road closure were valued by applying the rates of travel time costs reported in Austroads (1997, 2003, 2011).

5. ASSESSING IMPACTS USING THE VALUE OF TRAVEL TIME APPROACH

The volume of traffic flows that were affected by road closures to the south and west of Rockhampton have been assessed for both passenger and freight vehicles in three separate groups (Table 5), drawing on AECOM (2010), CTEDL (2010) and data provided by the Queensland Department of Transport and Main Roads. The first are vehicles travelling through Rockhampton to the north, where it can be assumed that the impacts will occur elsewhere in the Queensland economy. The second group focuses on the restrictions to vehicle movements to and from the Capricorn Coast to the east, and the third group involves restrictions on local access from Rockhampton to the south and west.

The estimates of impacts on vehicle movements from the road closure have been valued by applying the rates of travel time costs reported in

Austroads (1997, 2003, 2011), with results summarised in Table 4. Key assumptions in performing the analysis are detailed as follows.

Table 5. Estimates of daily vehicle movements affected by flood road closure.

	Total vehicles	Percent heavy vehicles	Passenger vehicles	Heavy vehicles
Group 1: Through traffic, non-Rockhampton economy				
North-south Bruce Highway	550	27.6	398	152
South-north Bruce Highway	430	27.6	311	119
West-north Capricorn to Bruce Hwy	290	20.4	231	59
North-west Bruce to Capricorn Hwy	180	14.6	154	26
Sub-total	1450		1094	356
Group 2: Through traffic, Rockhampton economy				
East-west Yeppoon Rd to Capricorn Hwy	195	6.2	183	12
East-south Yeppoon Rd to Bruce Hwy	205	6.2	193	13
West-east Capricorn Hwy to Yeppoon Rd	160	6.2	150	10
South-west Bruce Hwy to Yeppoon Rd	330	16.9	274	56
Sub-total	890		800	91
Group 3: Local Traffic, Rockhampton economy				
Bruce Highway south	5,961	17.4	4,924	1037
Capricorn Highway to west	3,965	20.8	3,140	825
Sub-total	9,926		8,064	1862
Total	12,266		9,958	2,309

Source: the Authors

The hours of delay have been assumed as an average of 72 hours for all north-south through traffic. This allows for the fact that some traffic was able to be diverted through western Queensland, and that opportunity costs are not strictly linear over time. For the east-west traffic, the hours of delay have been assessed as an average of 24 hours. This allows for the fact that some traffic was able to be diverted to the north (through Mackay), and that opportunity costs are not strictly linear over time. For local traffic, an average of 8 hours of delay per day has been used to reflect the fact that many people were not able to access work.

The value of travel time has been made on the basis that all freight vehicles are on business time ($36.76/hour), and that passenger vehicles are 50 percent business time ($36.76/hour) and 50 percent non-business time ($11.49/hour). It is assumed that there is only one passenger per vehicle. The value of truck freight time has been assessed at $1.50 per pallet per hour, with 50 percent 'A' and 'B' vehicles on through trips, and 100 percent 'A' vehicles on local trips. It is estimated that the profile of trucks travelling through Rockhampton is 50 percent singles and 50 percent B Doubles, with approximately 85 percent travelling loaded (personal comment, John Bryant, Rocky's Own Transport). Loaded capacity is estimated at 85 percent for through trips (assumes most trucks are backloaded) and 50 percent for local trips (assumes no backloading).

The results indicate that the cost to the state economy from the loss of through traffic is approximately $3.34 million per day, with many of these losses expected to be directed to north Queensland. The costs to the Rockhampton economy are approximately $0.59 million per day for the loss of the through traffic to the Capricorn Coast, and $1.42 million per day for the closure of southern and western access to local traffic. Total costs from the loss of road transport at Rockhampton are estimated to be approximately $5.41 million per day.

These losses are sensitive to the assumptions about the lost travel time involved. The time factors (72, 24 and 8 hours) are based on approximate estimates of trip delays for the different groups. If only missed travel time is considered (instead of time delays), then estimates will be reduced by about a factor of three. This would reduce the cost estimates for the road closure to approximately $1.8 million per day.

A similar process has been used to estimate the value of travel time costs for passengers and freight that was not able to be serviced through the Rockhampton airport. The Rockhampton Regional Council (2011) predicted that in 2010-11, there would be a total of 730,000 passenger movements and 283,000 landed tonnes of freight. At a daily rate, the corresponding estimates are 1,000 passengers making return trips and 775 tonnes of freight.

The loss of travel time has been assessed at 8 hours per passenger (loss of one working day) and 5 hours per tonne of cargo (alternative time to truck south from Mackay airport). The rate of travel time has been assessed at the business hourly rate for both passengers and cargo. Results show that the daily losses from the closure of the airport are approximately $588,048 (Table 6).

Table 6. Daily value of lost airport access from Rockhampton Flood Closure.

	Passengers	Freight (tonnes)	Totals
Number	1,000	775.3	
Hours of delay	8	5	
Value of time lost/person/hour	$58	$32	
Total economic losses per day	$464,000	$124,048	$588,048
Total economic losses over closure period (23 days)	$10,672,000	$2,853,104	$13,525,104

Source: the Authors

6. DISCUSSION AND CONCLUSIONS

The focus of this study was on the economic costs of transport corridor closures at Rockhampton in January 2011. Two approaches have been used to make a simplified assessment of the economic impacts of the road closures. The first was to model the proportional downturn in the regional economy, using data from surveys and interviews with local businesses to assess the proportional drop in business activity over the period. The second was to apply the travel cost savings methodology used to assess the costs and benefits of transport options in Australia. The estimates of travel values for both passenger and freight vehicles used in the Austroads (2011) methodology has been applied in this study.

The modelling of changes to economic activity indicate that the change in regional production over the period of transport closures in early January account for about $35 million in lost productive activity, or about 0.77 percent of the regional economy. This is consistent with economic impacts at the state level, where the joint impact of flooding and Cyclone Yasi has been estimated to have reduced economic growth by up to 2 percent (Queensland Government, 2011).

Assessing costs through the value of lost travel time approach indicates that the cost to the state economy from the loss of through traffic is approximately $3.34 million per day, with many of these losses expected to be directed to north Queensland. The costs to the Rockhampton economy are approximately $0.59 million per day for the loss of the through traffic to the Capricorn Coast, and $1.42 million per day for the closure of southern and western access to local traffic. The results relating to the closure of the Rockhampton airport indicate that the cost to the Rockhampton and state economy of lost travel and diverted freight opportunities were approximately $0.59 million per day. Total costs from the loss of road and air transport at Rockhampton are estimated to be approximately $5.36 million per day.

With the road corridor closed for two weeks and the airport for three weeks, the total direct costs can be assessed with the travel time approach at $66.7 million for the road closure, and $13.5 million for the airport closure, for a total cost of $80.2 million. Approximately $47.5 million was due to the road closure limiting access between southern and northern Queensland, while the remainder was a result of impacts to Rockhampton caused by the local losses to road and airport transport.

Several caveats should be noted with the analysis that has been provided here. First, the estimates from the travel time savings approach are dependent on the length of time assumed for each trip. Further research is needed to help estimate the appropriate time in trip interruptions for each travel group. Second, the two assessment techniques employed in this research measure different economic concepts. The changes to economic activity approach captures variations in production in a regional economy, while the value of travel time savings approach should measure economic surplus. The loss in regional incomes (salaries and profits) is approximately 20 percent of a $35 million change in regional production, indicating that the travel time approach used is generating inflated estimates of value. This may be because travel delays or the value of travel time have been overestimated. Reconciling these measures is another important topic for further work. Thirdly, this study has not considered the potential for resilience and rebound effects within Rockhampton. However, it was noted that the lack of physical damage and limits to subsequent infrastructure spending reduce some of the conditions for rebound effects identified by Loayza *et al.* (2012).

Nevertheless, this study has important implications for future regional planning and regional investment strategies. Resource development is underpinning rapid economic growth in the central Queensland region, and there is likely to be increased future investment in infrastructure that minimises interruptions from climatic events. Under global climate change projections, extreme events such as flooding are likely to increase in both frequency and severity; with the outcome that floods and similar events are likely to be treated as regular events, rather than aberrations (Penning-Rowsell and Wilson, 2006). Given the scale of economic impacts associated with these events as described above, there is a need for climatic disasters to be specifically included in regional economic development plans; and for research such as this study to be used to help inform investments in regional infrastructure.

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