Quantification of Infrastructure Downtime in Earthquake Reconstruction

Dr Alice Chang-Richards (PI, University of Auckland)

Sam Wilson (Masters Student, University of Auckland)

QuakeCoRE NZ Centre for Earthquake Resilience

Background

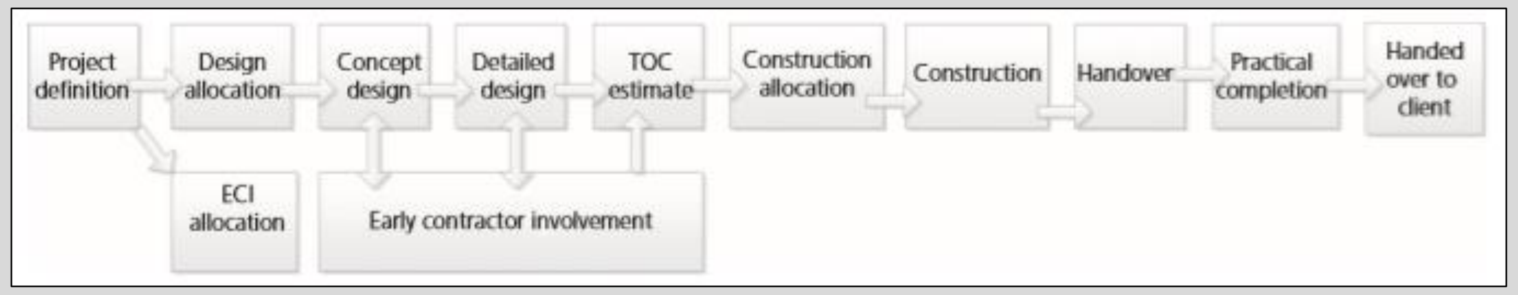

Fig 1. SCIRT delivery model (Source: Botha, P.S. and Scheepbouwer, E. (2015), "Christchurch rebuild, New Zealand: alliancing with a difference" *Journal of Management, Procurement and Law*, Vol. 168 No. 3, pp. 125.)

The time for restoring damaged infrastructure after a major earthquake is a critical issue for decision makers in deciding appropriate recovery strategies.

Post-disaster infrastructure reconstruction requires a delivery model suitable of meeting the time and financial demands that is different from "business as usual" infrastructure projects.

Stronger Christchurch Infrastructure Rebuild Team	North Canterbury Transport Infrastructure Recovery
SCIRT	**NCTIR**
Christchurch 2011 – 2016	Kaikōura 2017 - Present

Infrastructure recovery delivery models:

- Multiple asset owners
- Government subsidised
- Alliance structure with multiple contractors
- Competitive tension between contractors
- High contractor involvement at onset of recovery
- Centralised Project Management Office (PMO) and integrated services team

Question: What are the critical factors that affect each stage of the infrastructure recovery process?

Research Aim

To explore the effects of decisions and outcomes for physical reconstruction on the overall recovery process of horizontal infrastructure in New Zealand drawing from experiences in the Canterbury and Kaikōura earthquakes.

Objectives

- To recapitulate the perspectives of those involved in the infrastructure reconstruction efforts through SCIRT and NCTIR.
- Identify critical factors at each stage of the infrastructure reconstruction process
- To investigate and quantify the relationship between critical factors and the effect on recovery stages.
- To develop a theoretical mathematical infrastructure timeframe recovery predictor equation of stemming from the influence of these critical factors.

The Methodological Core of Research Strategy

Systematic Review of Literature

Review of factors affecting the recovery efforts on infrastructure in disaster reconstruction

35 factors identified, listed in table1 below.

Semi-structured Interview

Interview with stakeholders associated with local earthquake recovery agencies

Christchurch - SCIRT

Kaikōura – NCTIR

Informants

Christchurch	**Kaikōura**
Council: 5	Council: 5
Government: 3	Government: 1
Contractors: 9	Contractors: 3
Consultants: 5	Consultants: 4
QuakeCentre: 1	

Questionnaire Survey

Investigate the infrastructure recovery pathways in Christchurch by understanding the impact of critical factors on the recovery efforts

Engaged Agencies

Engineering New Zealand

Specialist Trade Contractors Federation

Respondents to date: 25

Structural Equation Modelling (SEM)

- To observe of strength of relationships between recovery stages
- To quantify the impact of critical variables specific to the recovery phase

Model Definition

The number of critical factors does not correlate to the level of influence upon the recovery stage

Table 1. Critical factors in the infrastructure recovery process

Stages of Infrastructure Recovery

Inspection and Assessment		Decision Making		Financing		Adjustment		Construction	
IA1	Technical capability of engineering professionals	DM1	Changes to building standards and practices	F1	Availability of loss adjusters/quantity surveyors	A1	Financial capacity of construction businesses to take on further work	C1	Repair/rebuild procurement method (Form of contractual agreement)
IA2	Access to site due to safety concerns	DM2	Information management (database information)	F2	Productivity of quantity surveying	A2	Availability of construction manpower	C2	Repair scope variations incurred through construction
IA3	Speed of engineer mobilisation and assessment	DM3	Incorporation of resilience and performance-based systems	F3	Work hours of loss adjusters/quantity surveyors	A3	The state of the economic system in Christchurch	C3	Clarity in scope of the works
IA4	Availability of engineers	DM4	Land zoning decisions	F4	Pace of decision making of policy holder	A4	Economic conditions elsewhere	C4	Extent of demand surge (labour wage inflation)
IA5	Fatigue of engineering assessors	DM5	Consenting and permitting process			A5	Availability of temporary accommodation for staff	C5	Competency and productivity of Contractors involved
IA6	Frequency of ongoing after shocks	DM6	Insurance claim apportionment process/process of securing finance			A6	Availability of construction materials	C6	Long lead time components and supply chain issues (logistics)
IA7	Existence of a robust inspection methodology	DM7	Mechanisms of recovery governance			A7	Needs perception delays	C7	Speed of design process
		DM8	Coordination with other sectors					C8	Rework time such as repairing defects
		DM9	Community engagement in decision making						

Structural Equation Model (SEM) of Infrastructure Reconstruction in Christchurch

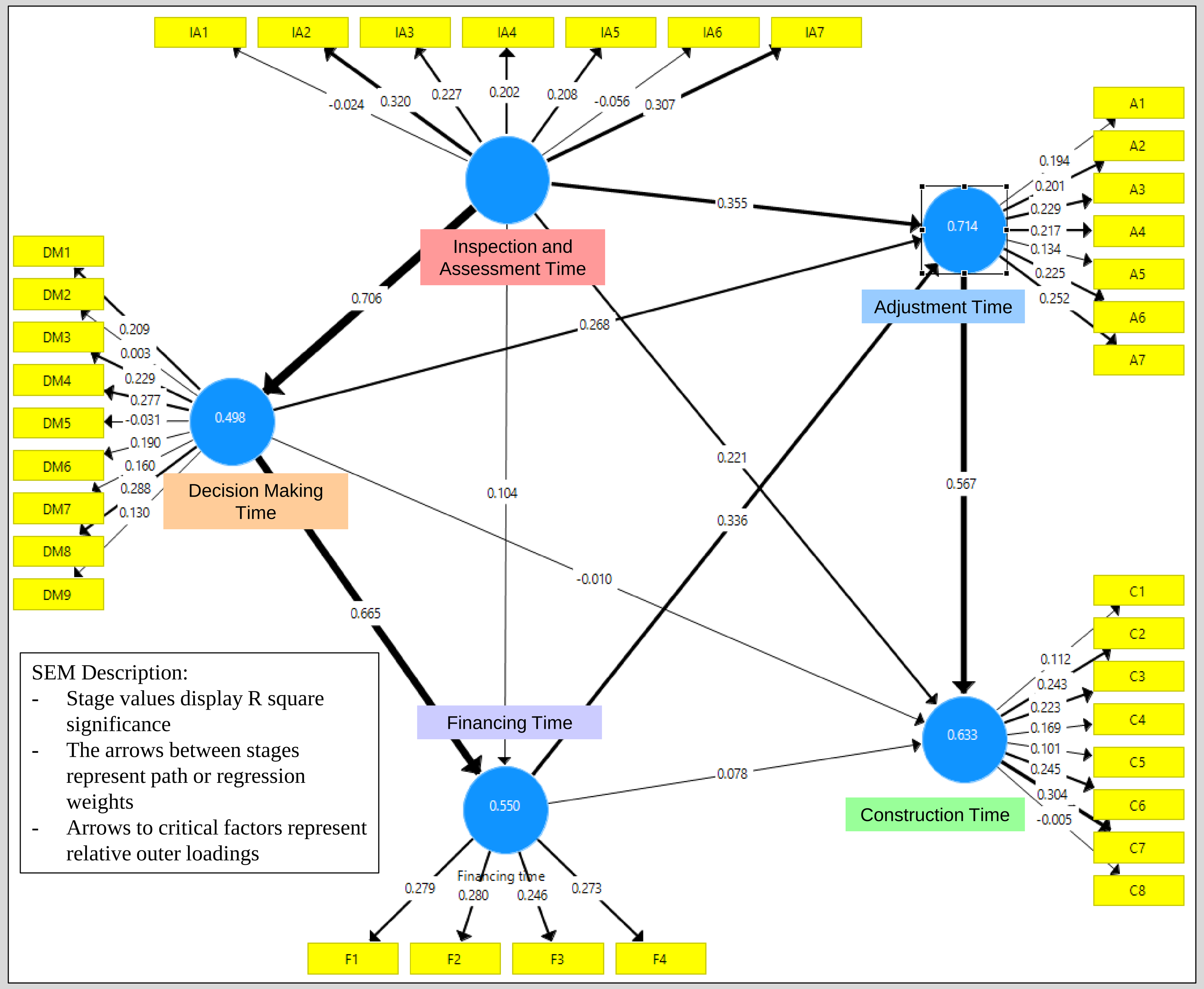

Fig 2. Structural Equation Model of the infrastructure recovery process from Questionnaire Survey Responses

Conclusions

- Variations in factor weighting indicate variable influence upon the relevant recovery stage. Critical factors of relative significance of at least 20% are highlighted in table 1. A majority of the factors are considered significant.
- The strongest path weights between recovery stages align with the linear time progression in earthquake recovery, starting at inspection and assessment.

Work in progress

- Undertake SEM with a larger data sample set of 100+ survey respondents to strengthen the relationships of path coefficients between recovery stages and trim critical factors that are not significant.
- Develop a theoretical mathematical equation to predict horizontal infrastructure reconstruction recovery time.

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Contacts:
Alice Chang-Richard, Email: yan.chang@auckland.ac.nz
Sam Wilson, Email: swil719@aucklanduni.ac.nz