Post-earthquake real estate decision-making: repair or replace?

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Background

Many buildings with relatively low damage from the 2010-2011 Canterbury were deemed uneconomic to repair and were replaced [1,2]. Factors that affected commercial building owners' decisions to replace rather than repair, included capital availability, uncertainty with regards to regional recovery, local market conditions and ability to generate cash flow, and repair delays due to limited property access (cordon). This poster provides a framework for modeling decision-making in a case where repair is feasible but replacement might offer greater economic value – a situation not currently modeled in engineering risk analysis.

Objective: model factors that drive post-earthquake decisions, and support development of engineering and recovery policies that lead to better post-earthquake outcomes.

Model Formulation

The model uses **FEMA P-58** (seismic performance assessment of buildings) and **real estate investment analysis** to quantify the probability of replacing a reparable building, i.e. ***P(Replace|Reparable,S_a)***. A graphical model representation is shown in Fig. 1.

FEMA P-58 is used to quantify the joint probability distribution of the building's loss ratio (*LR*) and repair time (*RT*) for a given level of spectral acceleration (S_a).

Investment Analysis uses present value (*PV*) calculations to construct the decision making model. Income is generated by leasing the commercial property. For a given *LR* and *RT*, three *PV*'s are estimated for both repaired and replaced buildings:

(1) the required initial investment ($Inv_{t=0}$);
(2) Net Operating Income (*NOI*) over the holding period;
(3) sale price at the end of the holding period, determined using the next year's *NOI* divided by the capitalization rate.

A discount rate (*r*) is used to determine the *PV* of future cash flows.

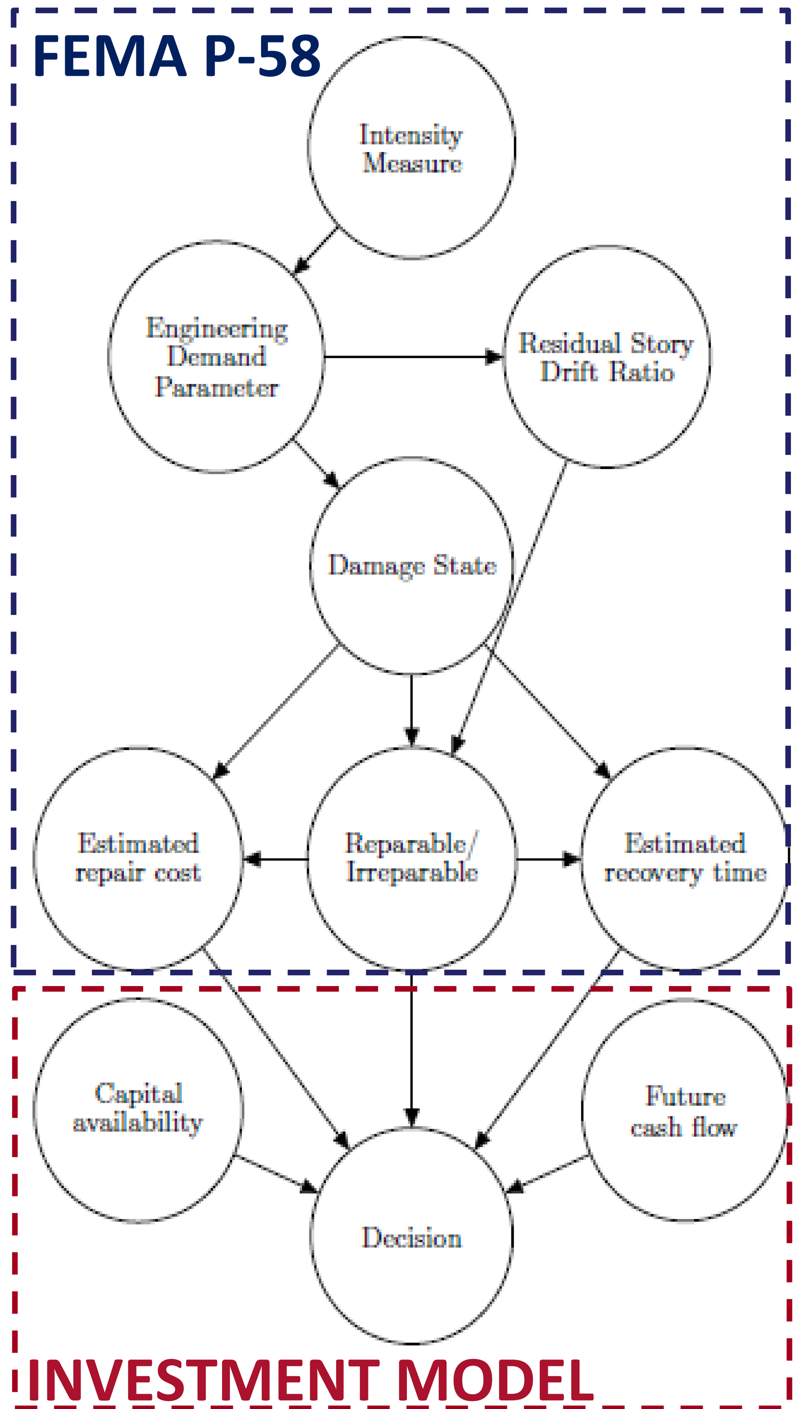


Fig 1. Graphical representation of interaction and dependencies of the model variables.

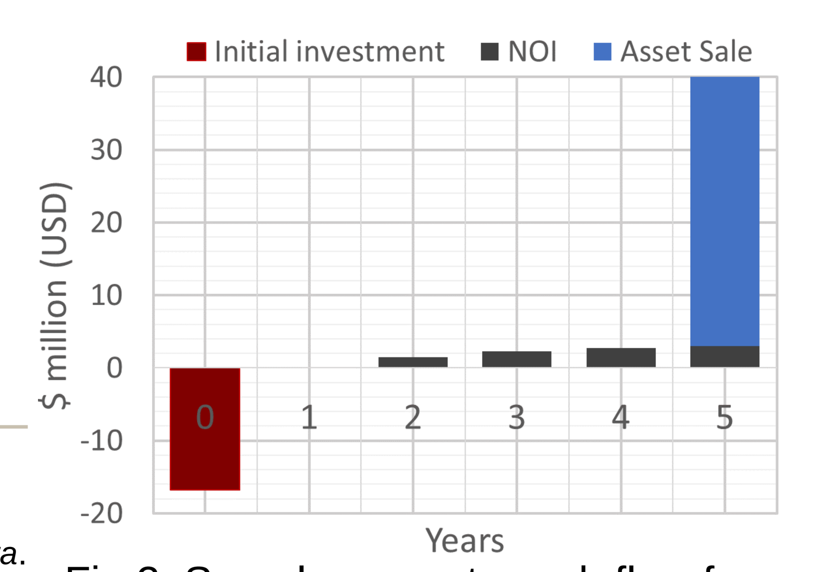


Fig 2. Sample property cash flow for a holding period that considers repair time vacancy and occupancy recovery.

For each decision (*D*), where $D \in \{repair, replace\}$, the Net Present Value (*NPV*) is calculated using the following equation:

$$NPV_D = \underbrace{-Inv_{t=0,D}}_{\text{initial investment}} + \underbrace{\sum_{t=1}^{N} \frac{NOI_{t,D}}{(1+r)^t}}_{\text{NOI}} + \underbrace{\frac{NOI_{N+1,D}}{Cap\ Rate}\frac{1}{(1+r)^N}}_{\text{sale price at holding period (N)}}$$

The decision is then determined based on the larger *NPV*:

$$\text{Decision} = \underset{D}{\operatorname{argmax}}(NPV_D)$$

The initial investment is always higher for *replace* decision, where $Inv_{t=0}$ = demolition + replacement cost, as opposed to repair cost. For both decisions, NOI is the difference between rental income and operating expenses. The rental rate for a replaced building is higher than a repaired one, due to a premium associated with a new building, while operating expenses in a replaced building are assumed to be lower. In both cases, the tenants start occupying the building after construction is done, and occupancy approaches a stable rate over a reoccupation time.

Illustrative Example

Hazard: site in Commerce, California (Los Angeles County); soil class D

Building parameters: 8-story, 1967 commercial office building after [3].

- Reinforced concrete perimeter frame, first-mode period = 1.16s
- Floor footprint: 120' x 120'
- Gross building area: 115,200 sf
- Replacement cost: $28 million ($243 per square foot)
- Replacement time: 1.6 years
- Demolition cost: 13% of the replacement cost

Real estate parameters: it is assumed that there is no existing debt on the property and calculations are done on before-tax basis.

		Repaired	Replaced
Market Parameters	Annual rental rate (psf)	$50	$65
	Annual op. expenses (psf)	$10	$7.5
	Discount rate	12%	
	Capitalization rate	7%	

FEMA P-58 Results:

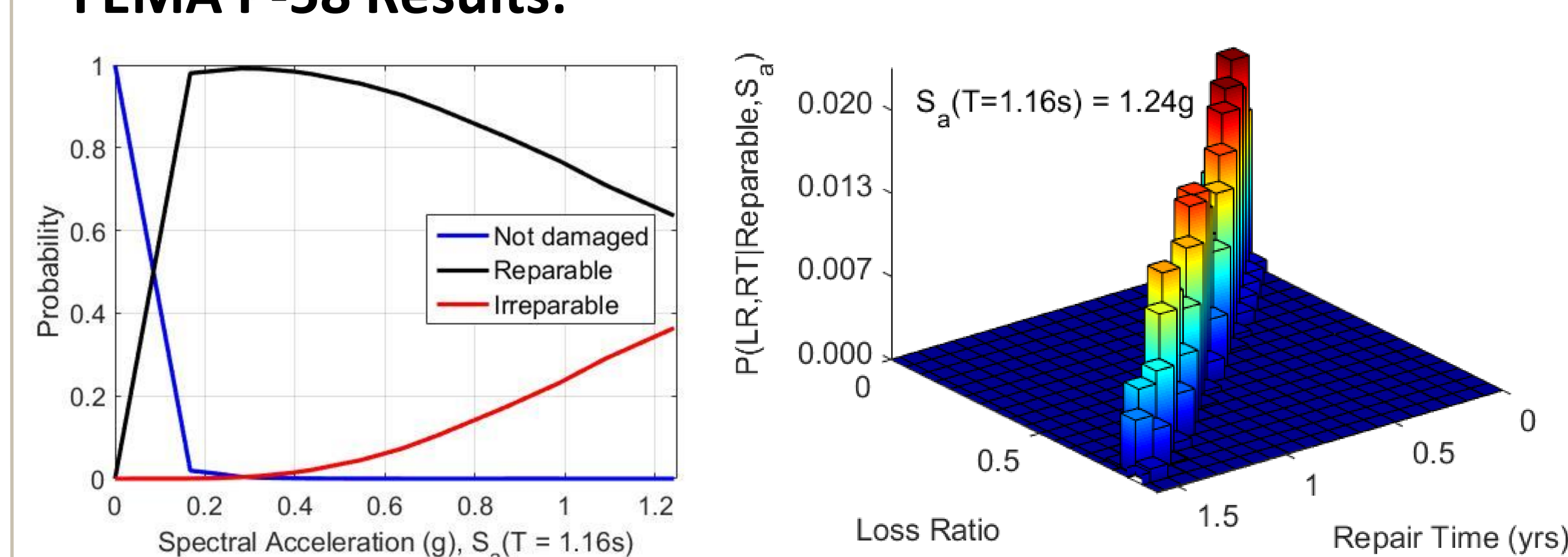


Fig 3. Left: probability a building being in different states conditioned on S_a. Right: joint probability mass function for *LR* and *RT.*

[3] Cook, D., Fitzgerald, K., Chrupalo, T., & Haselton, C. B. (2017). Comparison of FEMA P-58 with other building seismic risk assessment methods.

Investment Model Results:

Sample results for holding period of 5 years, *LR* = 75% and *RT* = 1.4yrs:

	Repair	Replace	ΔPV (Replace-Repair)
$Inv_{t=0}$	$21.0 mil	$31.6 mil	$10.6 mil
PV_{NOI}	$5.8 mil	$7.7 mil	$1.9 mil
PV_{sale}	$23.7 mil	$33.7 mil	$10.1 mil
Total: NPV_D	**$8.4 mil**	**$9.8 mil**	**$1.4 mil**

$\Delta NPV_D > 0$ ∴ Decision = *replace*

The following figures show *PV* of both decisions for a range of *LR's* and *RT's* (left) and *P(Replace|Reparable,S_a)*, which was calculated using a combination of engineering seismic risk analysis (FEMA P-58) and the proposed investment model (right).

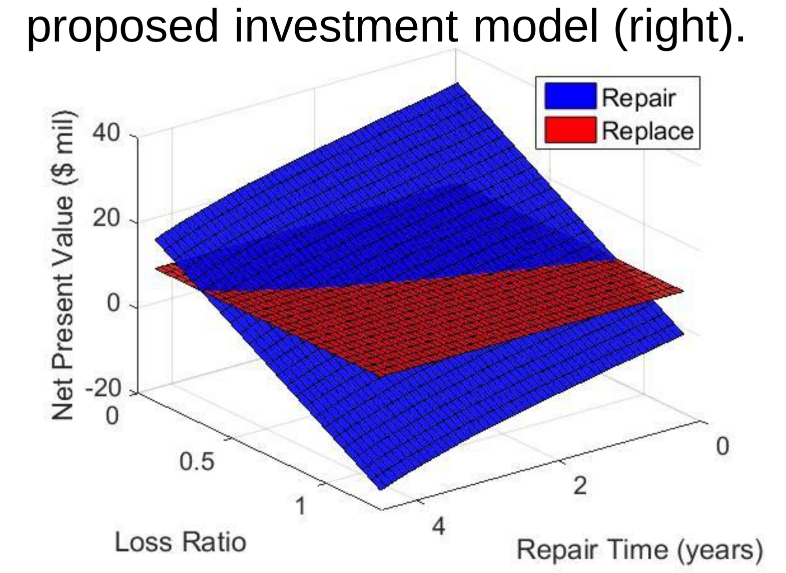


Fig 4: NPV surface for the two decisions

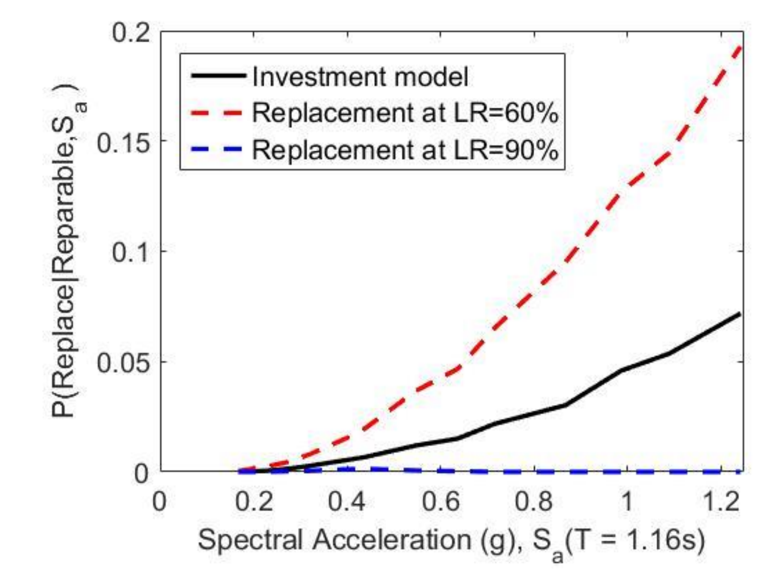


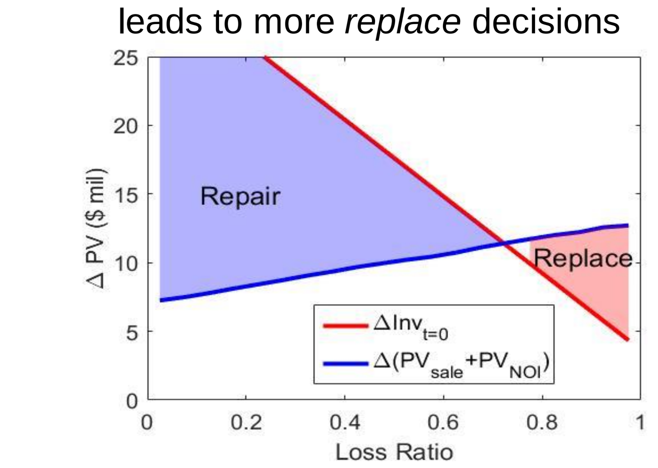
Fig 5: Probability of replacement of a reparable building as a function of S_a

Sensitivity

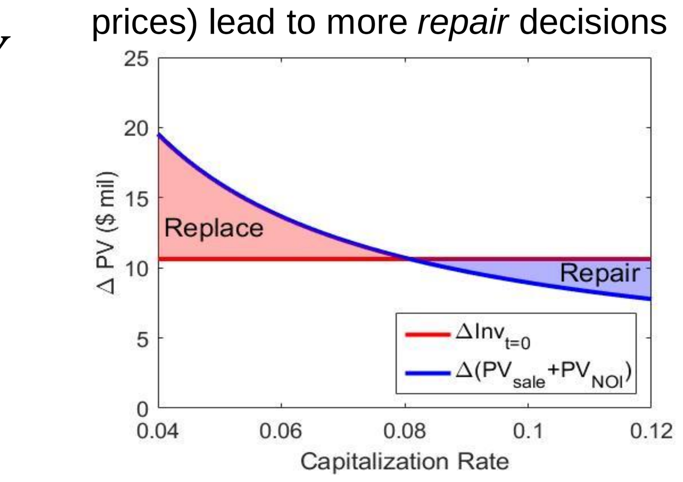
Here we consider the sensitivity of the decision to model parameter values. Changes in ΔPV ($PV_{replace} - PV_{repair}$) of the three *NPV* components as a function of different loss ratios, capitalization rates and rental rates are shown to the right.

Replacement is chosen anytime $\Delta PV_{sale} + \Delta PV_{NOI} > \Delta Inv_{t=0}$. Visually, ΔPV is most sensitive to the amount of building damage (loss ratio), followed by rental and capitalization rates. Future work will consider incorporation of uncertainty and dependency of the market parameters.

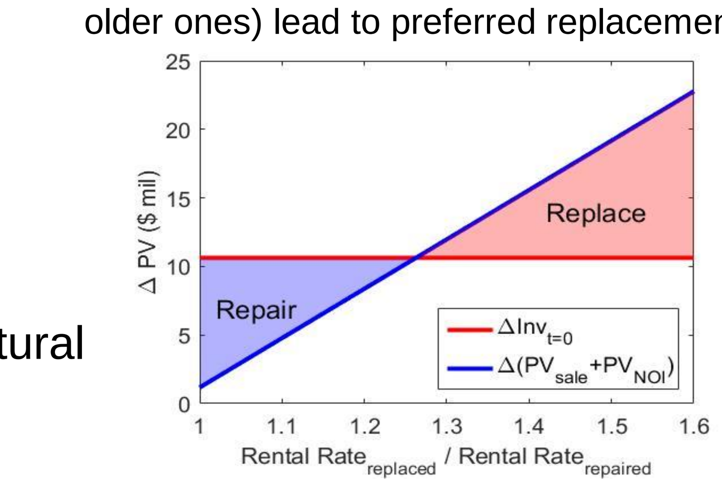
More damage (higher loss ratio) leads to more *replace* decisions



Higher capitalization rates (lower sale prices) lead to more *repair* decisions



Higher rents for new buildings (relative to older ones) lead to preferred replacements



Future Work

- Include uncertainty in parameters describing market conditions
- Consider how capital availability (insurance, credit, reserves) impacts decisions
- Study effect of building age and structural type on the decision

[1] Kim, J. J., Elwood, K. J., Marquis, F., & Chang, S. E. (2017). Factors Influencing Post-Earthquake Decisions on Buildings in Christchurch, New Zealand. *Earthquake Spectra*.

[2] Marquis, F., Kim, J. J., Elwood, K. J., & Chang, S. E. (2017). Understanding post-earthquake decisions on multi-storey concrete buildings in Christchurch, New Zealand. *Bulletin of Earthquake Engineering*, *15*(2), 731-758.

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