

# Evaluating Multiskilling in Residential construction projects Using Regional Industry Simulation

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# Makerhoods

- Newark, NJ, USA
- 66 Residential apartments
- 10 Workshops for “Makers”
- Shopping/Food Court
- Founder w/ Lean Background
- Part of “Newark, NJ, Housing Market Area Central Submarket”



# Research Questions/Goals

- How could Lean-informed production/project management strategies improve project outcomes?
  - Both singly and when multiple improvements used together
- How are the effects moderated by the context of multiple projects in the same market competing for subcontractor labor?



# Main Method: Simulation

## ■ Benefits

- Allows testing of multiple different scenarios
- No exogenous factors

## ■ Agent-Based Modelling (ABM)

- Agents, their attributes and behaviors
- Agent relationships and methods of interaction
- Environment (Macal and North 2010)
- Emergent behavior



# Main Method: Market-wide Simulation

## Reasons

- The negotiation between Subs and GCs over labor-resource allocation can be understood through the lens of game theory (Sacks and Harel 2006)
- Subs are engaged in multiple parallel negotiations with the projects they serve, and their eventual allocation of work crews to any given project is influenced by the contract terms negotiated (Korb 2019)

## Expected Learning

- How will the adoption of a given improvement in a single project among a sea of other traditionally-managed projects affect project outcomes (*early adopter/innovator*)
- What are the effects on a given project if improvements are adopted across the market (*new paradigm*)

# Lean Interventions

Reduce Batch Size



Multiskilled Teams

(Sacks and Goldin 2007)



Contracting with more than one Sub for each trade

(Sacks, Korb, and Duka 2019)

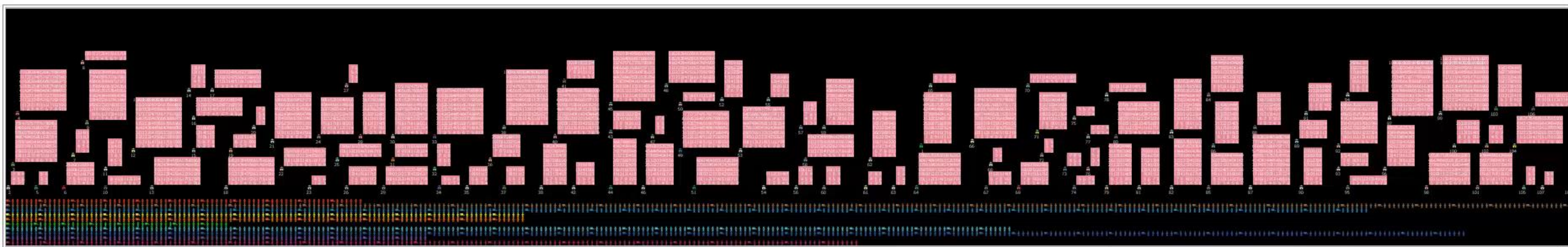


# Research Platform: LeapconX

- Models an entire local construction market
- Addresses broader issues of systemic changes in industry
- First example of multi-project simulation (previously unrepresented in the literature)



# LeapconX



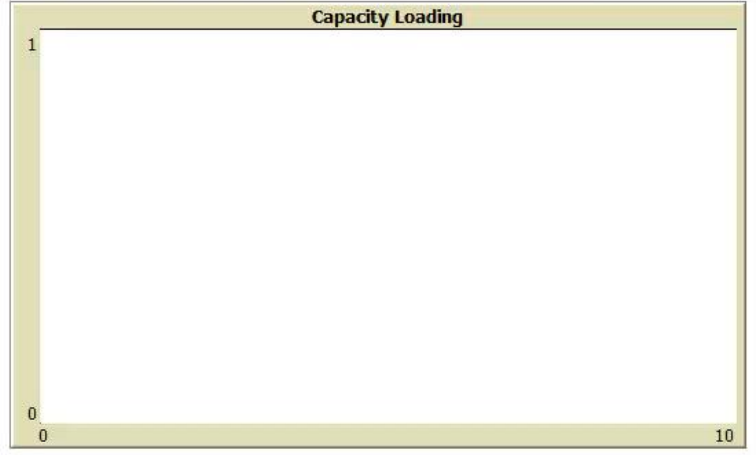
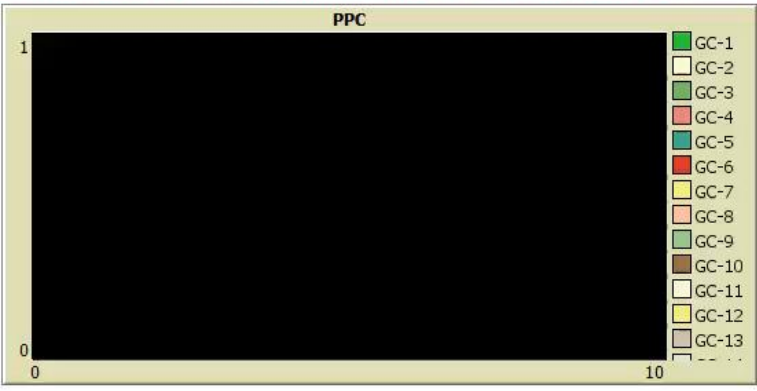
setup    go

On  
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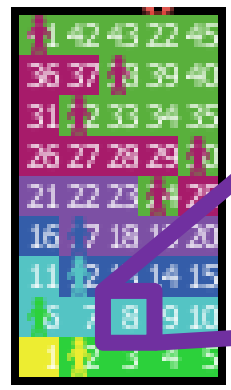
output-durations

LOB of Selected Building



# LeapconX Simulation Components

Agents:



Buildings



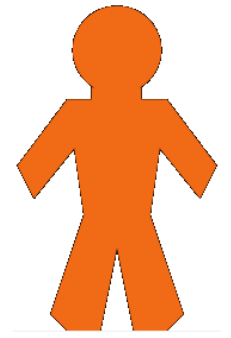
Apartments



GCs

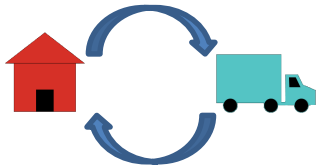


Subs

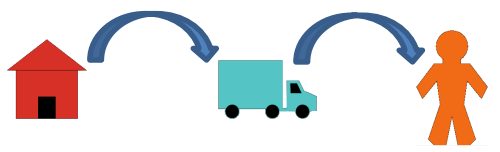


Crews

Main Processes:



Price  
Negotiation



Weekly Work  
Planning



Daily Work  
Processes



Negotiation  
Date

Start  
Date

Project Timeline

# Input Data

- Distribution of buildings and apartments built in a year
- Building sizes
- Trades involved in work
- Work sequence
- Work quantity per apartment
- Customization levels in market
- Work rates by trade/work package

(Makerhoods 2018, U.S. Department of Housing and Urban Development 2015, U.S. Bureau of Labor Statistics 2018, U.S. Census Bureau 2017, RSMeans 2019)



# Experimental Design Scenarios

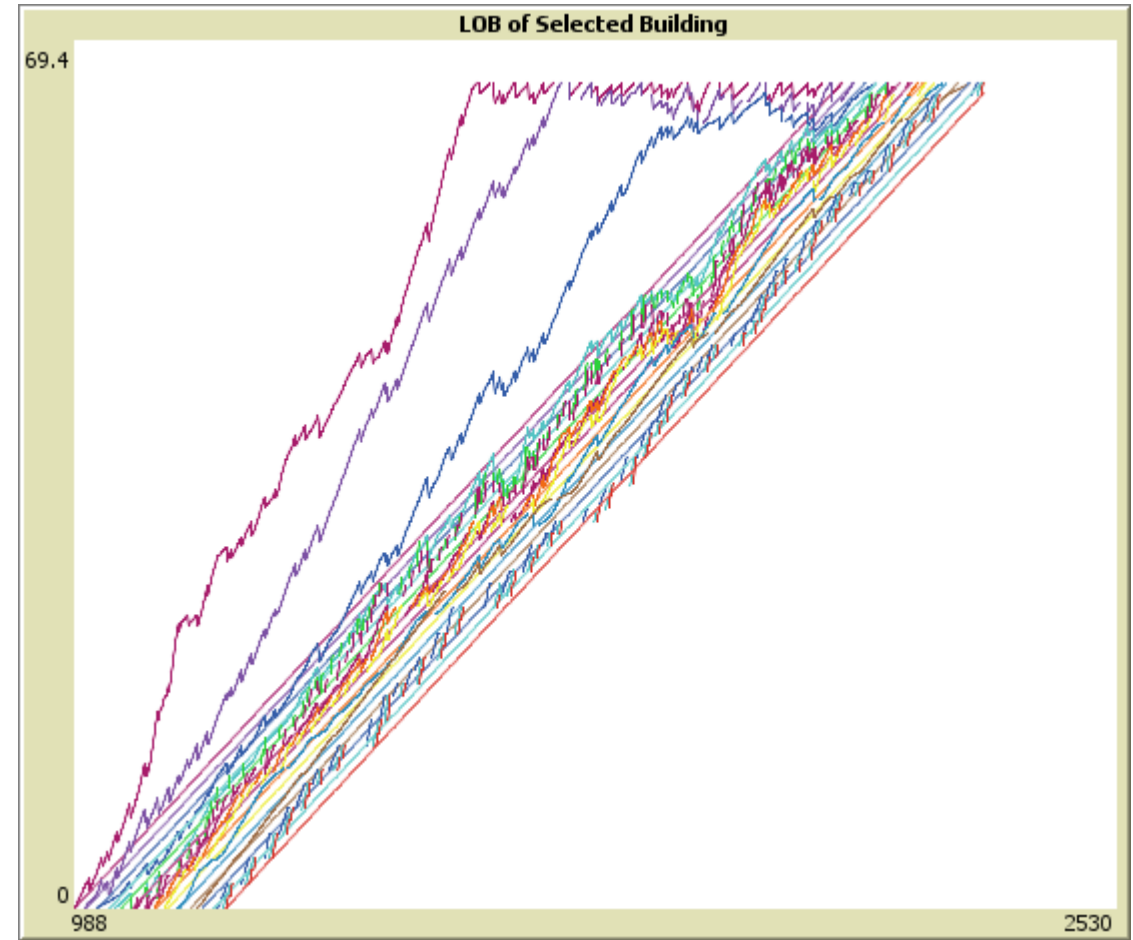
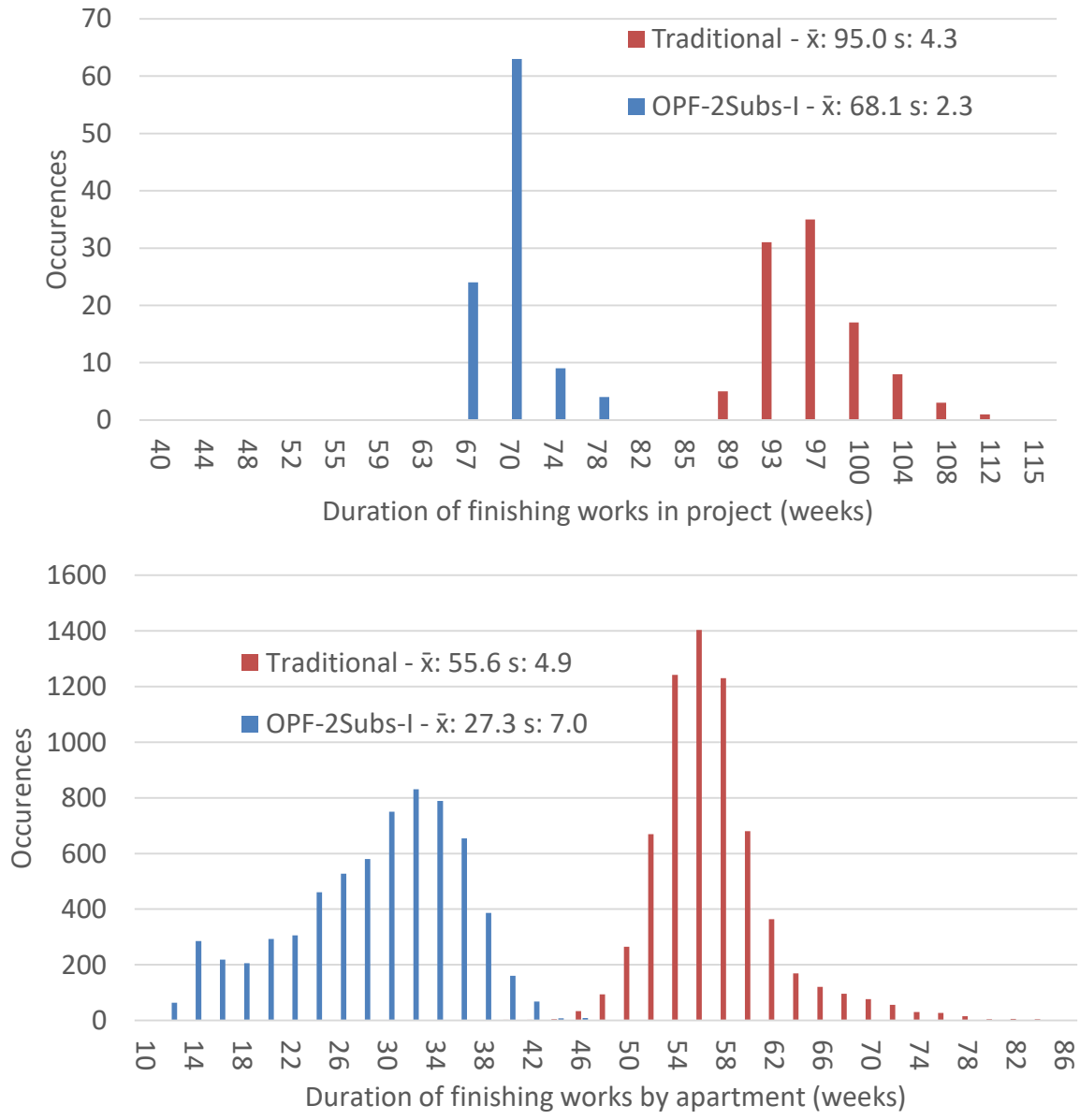
	Scenario		Batch Size	Trade Skills	Contracted Subs
01	Traditional		Floor	Single	1
02	2Subs	Innovator	Floor	Single	2
03		New paradigm	Floor	Single	2
04	OPF	Innovator	Apartment	Single	1
05		New paradigm	Apartment	Single	1
06	OPF & 2Subs	Innovator	Apartment	Single	2
07		New paradigm	Apartment	Single	2
08	Multi	New paradigm	Floor	Multi	2
09	Multi & OPF	New paradigm	Apartment	Multi	2

100 Simulation Runs For Each Scenario

# Duration of Interior Finishing and Systems Works, in weeks

Scenario		Mean	Standard Deviation
Traditional		95.0	4.3
2Subs	Innovator	93.4	2.5
	New paradigm	96.3	5.0
OPF	Innovator	69.3	2.9
	New paradigm	72.7	7.5
OPF & 2Subs	Innovator	68.1	2.3
	New paradigm	71.7	5.9
Multi	New paradigm	90.3	0.2
Multi & OPF	New paradigm	36.7	0.1

# Example Results: OPF and Two Subcontractors, Innovator



# General Tendencies

Scenario	Intervention	Impact on Interior works duration		Impact on Apt. cycle time		Notes
		Mean	Std. Dev.	Mean	Std. Dev.	
2	Reduced Batch Size (OPF)	- 27%	- 32%	- 49%	- 40%	Major improvement
4	Additional Subs	- 2%	- 41%	+ 4%	+ 5%	Improved project reliability
6	OPF and Additional Subs	- 28%	- 45%	- 51%	+ 42%	Minor improvement over OPF alone
8	Multi-skilling	- 5%	- 96%	- 80%	- 52%	Challenging to implement across the industry
9	OPF and Multi-skilling	- 61%	- 99%	- 79%	- 41%	

# Conclusions

## □ OPF:

- Reduces Mean Project Durations, but Increases Variation
- Similar effect on Apartment Durations, expect for those already multiskilling
- Reduces Sub Entrants
- For TP scenarios, improved even the “Traditional” group

## □ 2 Subs:

- Tended to reduce mean durations and standard deviations, though less in the NP scenarios.
- Increased sub entrants
- Some improvements to Traditional group in TP

## □ Multiskilling:

- Reductions in durations of both projects and apartments, and less variation
- Insular improvement – no impact on Traditional group

# Conclusions

## Market wide vs single project simulation

- If GCs are not getting the subcontractor resources they need, it is because they are sending their crews to other projects
- This can be due to over commitment on the part of the sub, or the sub's assessment of the GC's project as less lucrative: less stable (requested work quantities will not match actual work that can be performed), lower work volume offered, lower price
- Results for a given project depend on the level of market penetration of the improvements





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Thanks for Listening!

Questions?