IVORYINNOVATIONS

DRAFT VERSION – NOT FOR PRESENTATION

Lego Blocks and Robots: Turbocharging Housing Production

2024 FHC Affordable Housing Conference

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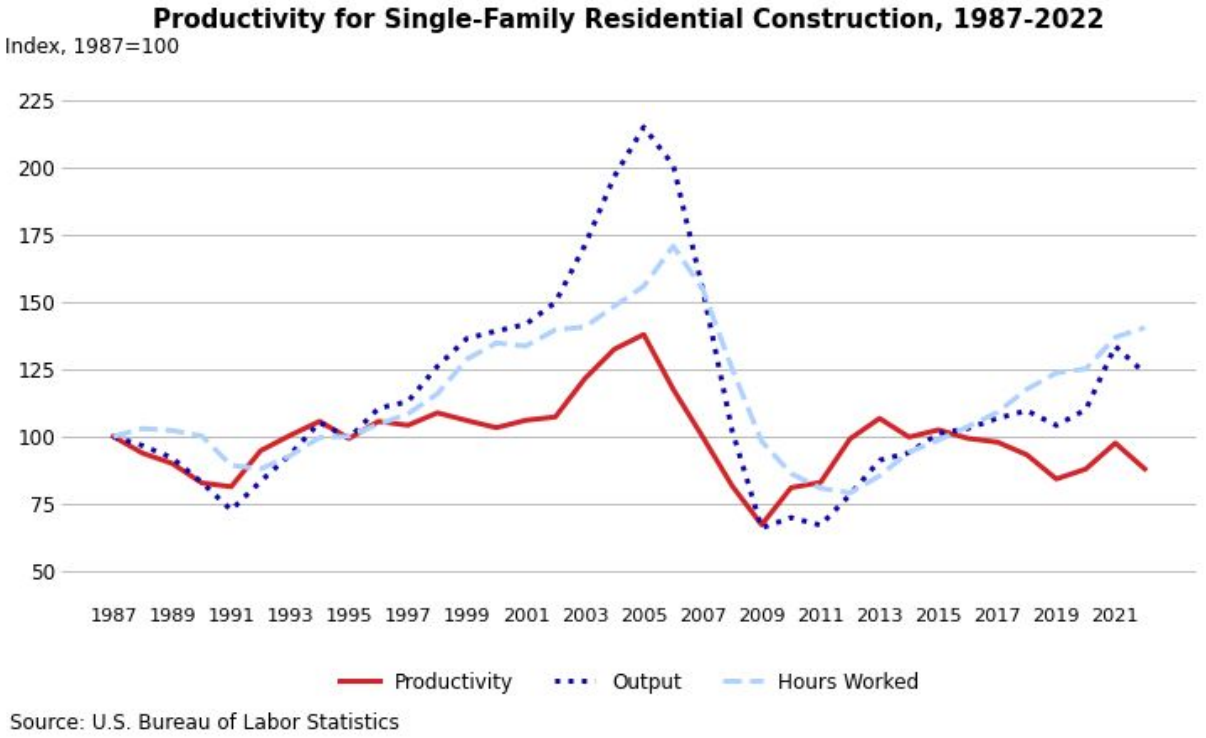
What is construction innovation?

Novel solutions to improve **productivity**

Productivity = *output / hours worked*

Output = number of housing units

Hours worked = time and money



Source: U.S. Bureau of Labor Statistics

Why does productivity matter to housing affordability?

Table 1. SINGLE-FAMILY PRICE AND COST BREAKDOWNS 2022 National Results		
	Average Lot Size:	17,218
	Average Finished Area:	2,561
I. Sale Price Breakdown	**Average**	**Share of Price**
A. Finished Lot Cost (including financing cost)	$114,622	17.8%
B. Total Construction Cost	$392,241	60.8%
C. Financing Cost	$12,192	1.9%
D. Overhead and General Expenses	$32,979	5.1%
E. Marketing Cost	$4,268	0.7%
F. Sales Commission	$23,080	3.6%
G. Profit	$65,369	10.1%
Total Sales Price	$644,750	100.0%

Construction cost = appx. 40% labor, 60% materials

Why does construction innovation matter to housing affordability?

Construction innovation increases productivity

Increased productivity = greater output per hour worked

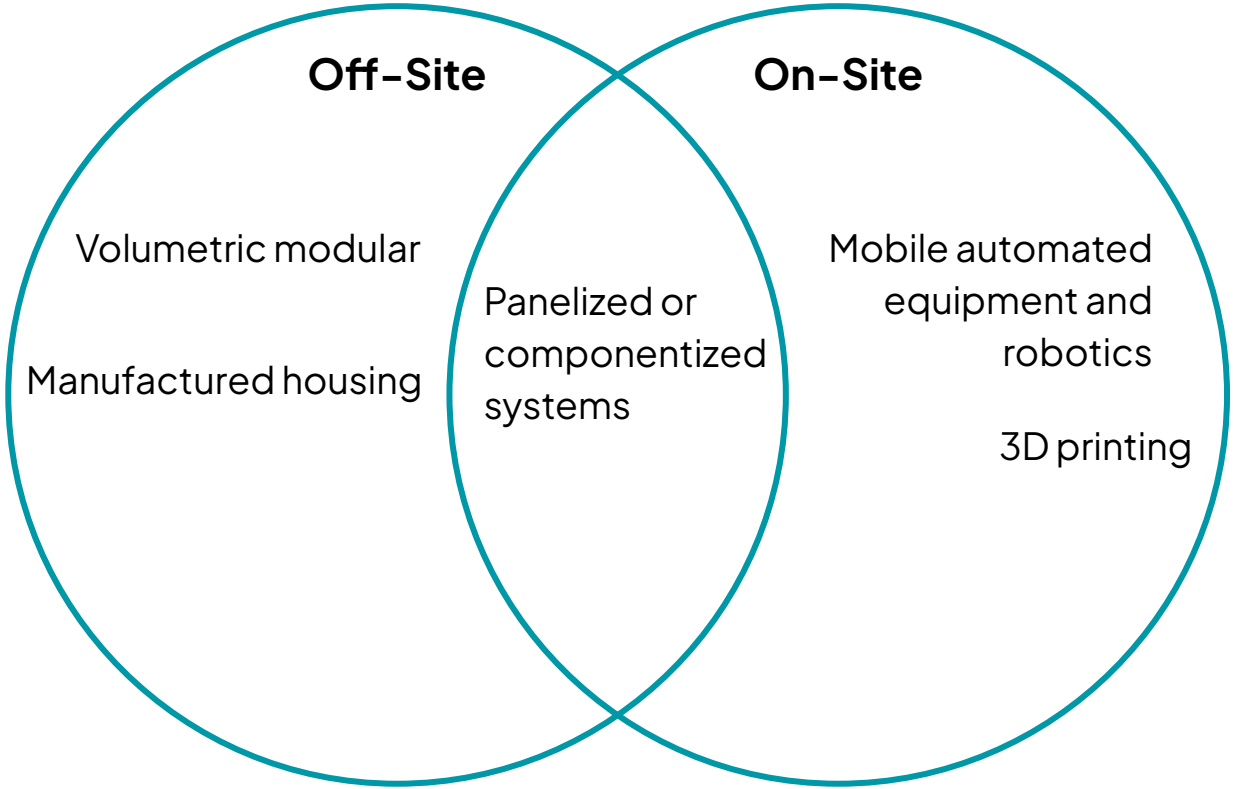
More units of housing for the same amount of time and money

(Material and labor innovations matter too)

Innovative construction methods

- Volumetric modular
- Manufactured housing
- Panelized or componentized systems
- Mobile automated equipment and robotics
- 3D printing

Innovative construction methods



Innovative construction methods: **Manufactured housing**

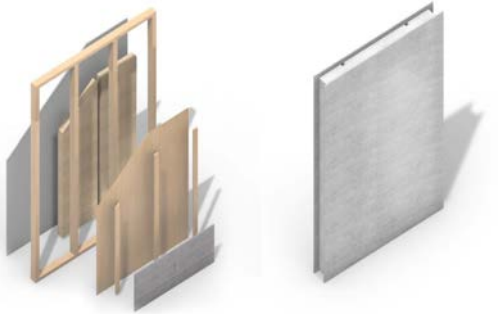
- Built to federal building code (HUD code)
- Usually installed without a crane
- Single-family
- Example: Clayton Homes

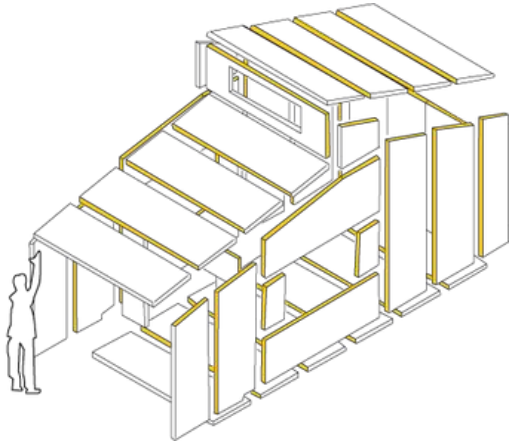
Innovative construction methods: **Volumetric modular**

- Entire rooms or building sections built in a factory
- Crane-set on site
- Single or multifamily
- Example: VBC (Volumetric Building Companies)

Innovative construction methods: **Panelized/componentized systems**

- Varying degrees of prefabrication but less than modular or manufactured
- Can be a single component or a full building system
- Single or multifamily
- Example: Onx or RENCO





Innovative construction methods: **Mobile automated equipment/robotics**

- Small but growing sector
- Usually focused on a single task or trade
- Generally geared towards large multifamily
- Example: Canvas

Innovative construction methods: **3D printing**

- Automated concrete placement
- Two types: robotic arm and gantry system
- Usually single-family
- Example: Apis Cor

Innovative construction methods: **Overview**

- Automated concrete placement
- Two types: robotic arm and gantry system
- Usually single-family
- Example: Apis Cor

Construction Method	Number of trades impacted	Ease of Implementation	Versatility	Other considerations
Manufactured housing			Low	Implicit regulatory barriers, social stigma
Volumetric modular		Low		Easier unit replication for multifamily
Panelized or componentized systems				Compromise between customization and prefab efficiency
Mobile automated equipment and robotics	Low			High upfront cost necessitates large volume of projects
3D printing		Low	Low	Concrete intensive projects only

Conclusion: Lots of good ideas, not a lot of implementation

- Total market share of non-site built single-family homes (modular and panelized) was at 2% of single-family in 2021. **Why?**
  - Code Requirements.
  - Higher upfront costs in multiple locations compared to traditional construction.
  - General contractor's limited knowledge in assembly processes, which adds more cost.
  - New ideas are always risky at first, building knowledge through implementation.