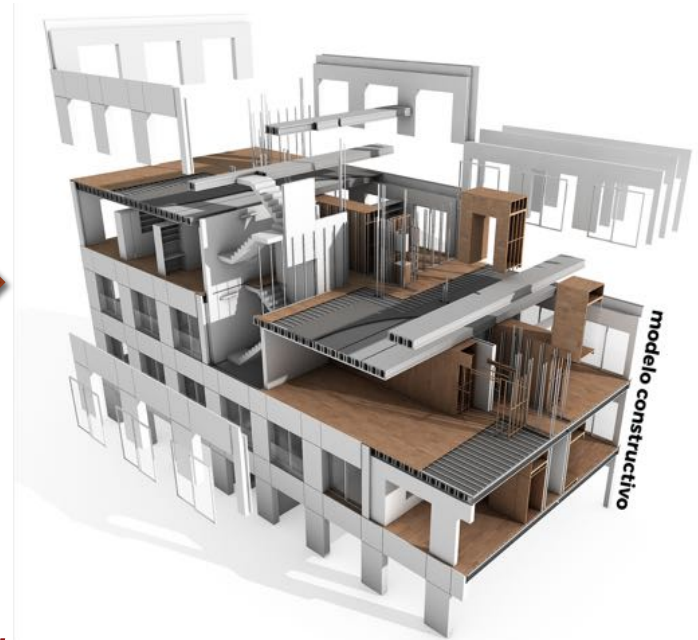
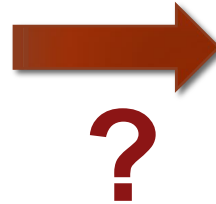


## Principles of “Industry 4.0”: *Application to Industrialized Housing*



*Dr. Raymond Levitt*  
*Kumagai Professor of Engineering, Emeritus*  
*Academic Director, Global Projects Center*

*Operating Partner, Blackhorn Ventures*

# StreetScooter Story



## Principles of Industry 4.0

1. Product developer is a “Capital-light, Digital Systems Integrator”
2. Engages deeply and iteratively with client/s to understand use cases
3. Modularizes product architecture to enable outsourcing of modules
4. Builds and uses digital product models throughout the lifecycle
5. Co-creates module designs with supply chain partners

# Challenges for Industry 4.0 in Industrialized Housing: 1 *Product is Costly for Buyers*

## A CHALLENGE FOR MULTIFAMILY AND SINGLE FAMILY HOUSING

- **B2B:** Capital cost makes multi-family housing sensitive to business cycles
- **B2C:** Need for financing makes all housing highly interest-rate-sensitive

Historically interest rates have been inversely correlated with GDP growth.

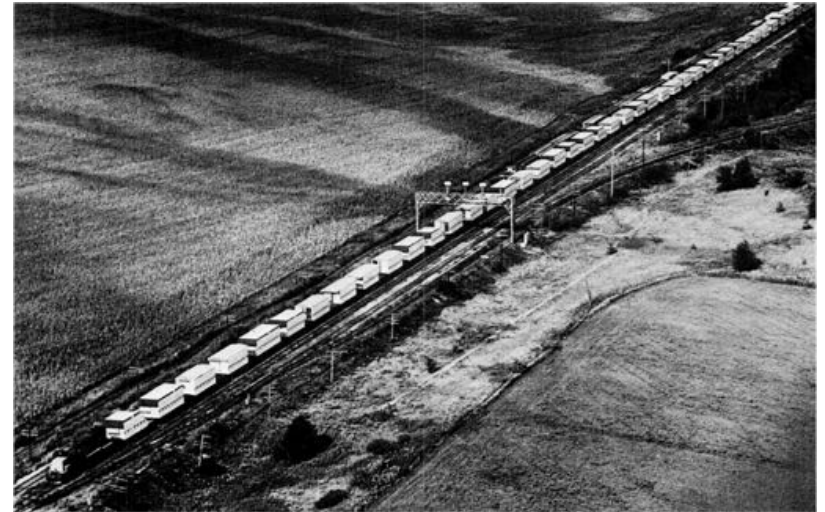
Housing has been viewed as “the balance wheel of the macro-economy” ...

- But “**stagflation**” has sometimes followed overstimulation of the economy with resulting declines in GDP and spiking of interest rates!
- **Can you think of a country that is overstimulating its economy right now?**

So firms tend to stay “Capital-Light!”

## Challenges for Industry 4.0 in Industrialized Housing: 2 *Product is Large, Relative to Available Transportation Modes*

- Road and rail transport limit offsite-made module sizes
- Oceans, rivers and canals are less limiting
- Most prior approaches to prefabricated modules have been systems of 2D wall panels and roof trusses (e.g., *Ryan Homes in 1970s-90s*)
  - › Whole house fits in a single truck
  - › Less shipping of "air"
  - › 250 mile round trip distance from factory



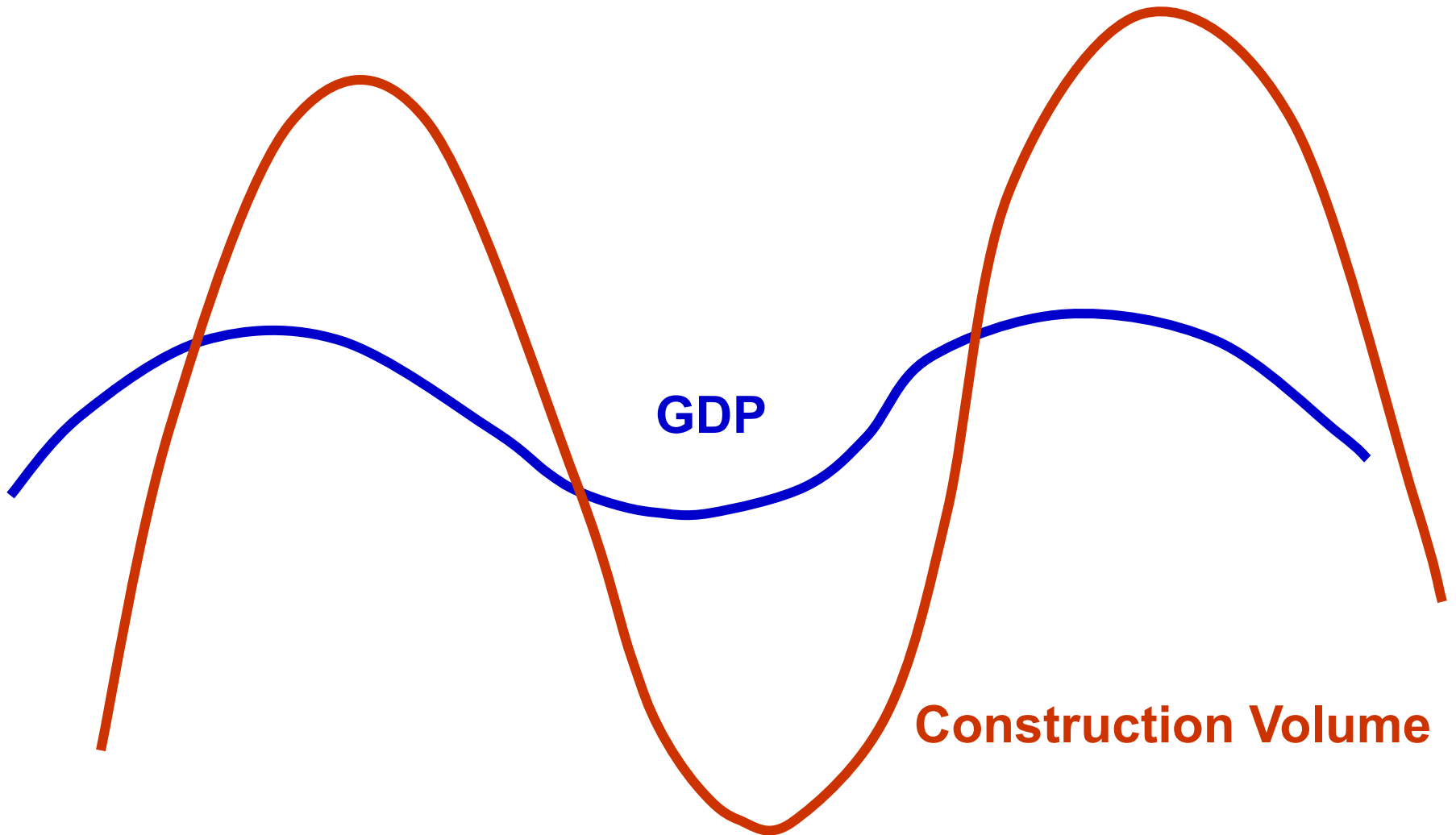
# Challenges for Industry 4.0 in Industrialized Housing: 1

## *Products Tend to be Unique and One-Off*

- Climate and Geological Differences
- Profusion of Local Building Codes
- Client Desires



# Challenges for Industry 4.0 in Industrialized Housing: 4 *Severe Demand Fluctuation*



## Lessons from the Past: Operation Breakthrough



### Prototype Site Locations

Eleven sites were initially chosen as prototypes. Nine of them were developed.



# Outcome of “Operation Breakthrough”

## HOMES BUILT IN SEATTLE AREA:

- Alcoa Construction Systems (86 units)
- Christiana Western Structures (54 units)
- Levitt Technology Corporation (28 units)
- Material Systems Corporation (10 units)

## HOMES BUILT NATIONWIDE

- 2,794 factory-built prototype housing units on 9 test sites throughout the United States, followed by an additional 20,000 or so production units manufactured by the participating firms.

## RESULT:

- O.B. never approached the hundreds of thousands [of units] the endeavor was expected to produce. In their 1976 report to congress the directors of HUD declared this grand and expensive experiment a failure, inasmuch as “it did not create the large, continuous markets necessary for efficient industrialized housing construction.”
- The report cited many problems that contributed, including marketing challenges, conflicting building codes, labor opposition, transportation costs, and so on.

# Some Current Attempts at Industrialized Housing

- Katerra



- Project Frog



- Bone Structures



- Boklok

