

# Very Current Research in Zaragoza

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V Foro International PILOT

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MIT Center for  
Transportation  
& Logistics

**MIT**  **ZARAGOZA**  
**International Logistics Program**

The MIT-Zaragoza logo consists of a globe with two curved arrows forming a circular path around it, positioned between the words 'MIT' and 'ZARAGOZA'.

**ZARAGOZA.**  
**LOGISTICS**  
**center**

The Zaragoza Logistics Center logo features the text 'ZARAGOZA. LOGISTICS center' in a bold, sans-serif font, with a curved line above the word 'center'.

# VERY Current Research in Zaragoza

- With industry partners
  - Bell Labs Ireland
  - Lucent Technologies
  - InBev
  - Metro Group
  - Novartis
  - PLAZA
- Master's student thesis projects
  - Sun Microsystems
  - RFID
  - Analytical outsourcing
  - Flu vaccine supply chain
  - China supply networks
- Professor's individual projects
  - Closed loop supply chains, for example

# Researching the Future



- Supply Chain 2020 is a pioneering project mapping innovations to successful supply chains as far into the future as the year 2020.
  - Create scenarios of the future: technology, regulation, consumer expectations, environmental pressures, etc.
  - Map actions supply chain organizations should take in order to be prepared

## ■ Collaborators

Accenture

Audi

BSH Spain

Borealis Group

C&S Wholesale Grocers

Cisco

CSC Consulting

Dell

DHL

Eli Lilly

ExxonMobil

General Motors

Gillette

Helix

Hewlett-Packard

i2 Technologies

IBM

Intel

ImBev

Johnson & Johnson

Limited Brands

Lucent

Metro Group

Nike

Novartis

P&G

Roche

Scotts

SAP

Staples

Tata Steel

Texas Instruments

TPG

Unilever

UPS

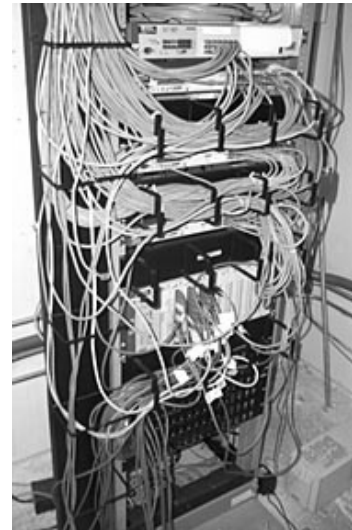
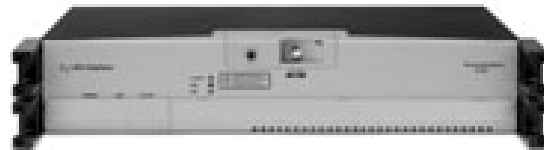


# Research on Reinventing Supply Markets

- Outsourcing
  - 3PL, Logistics Service Providers
  - Contract manufacturers
  - Electronics Manufacturing Services (EMS) providers
- Globalization
  - Companies source from multiple regions
  - Products must satisfy customers in multiple regions
- Supply Chain Coordination
  - OEMs coordinate supply from multiple global partners
  - Continually reinvent each time you change partners

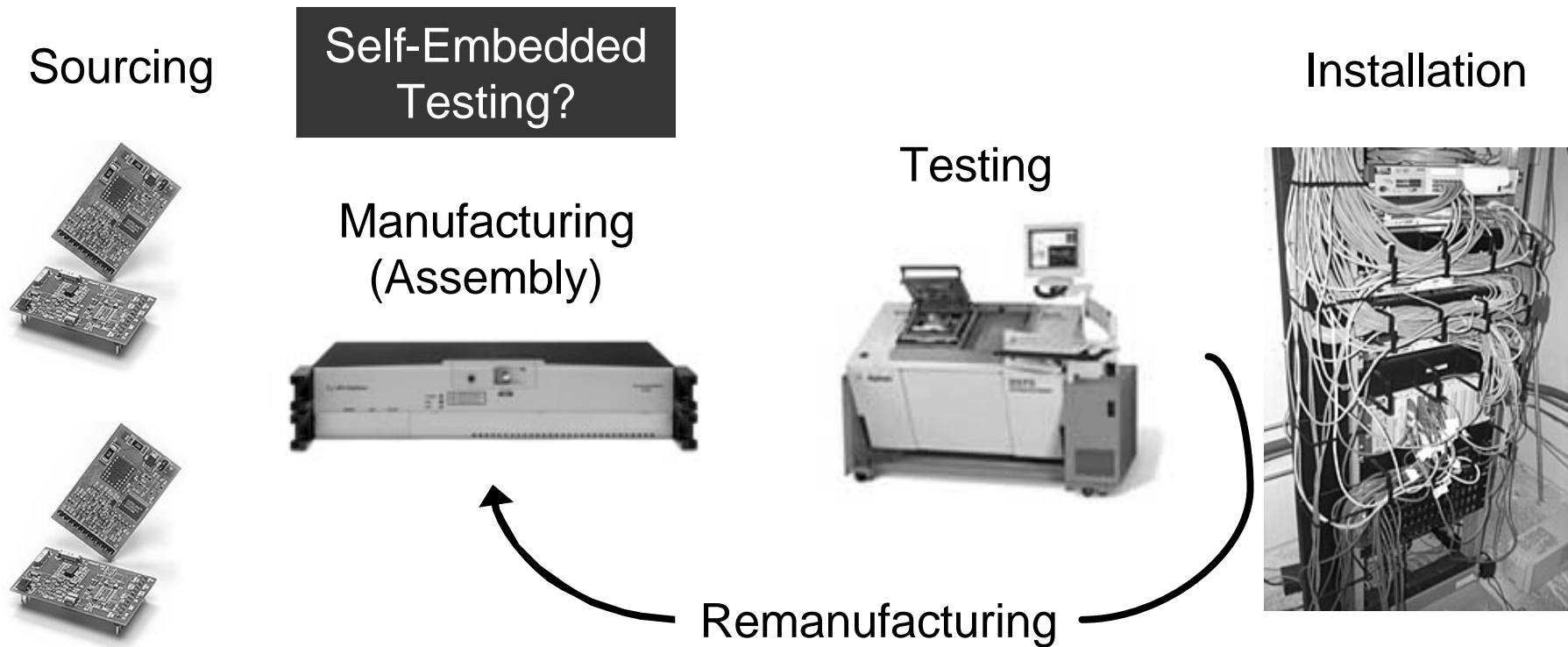
# Case Study: Telecommunications

- How does the OEM strategically invest in and allocate capacities among partners and locations?
- Focus on the circuit pack supply chain

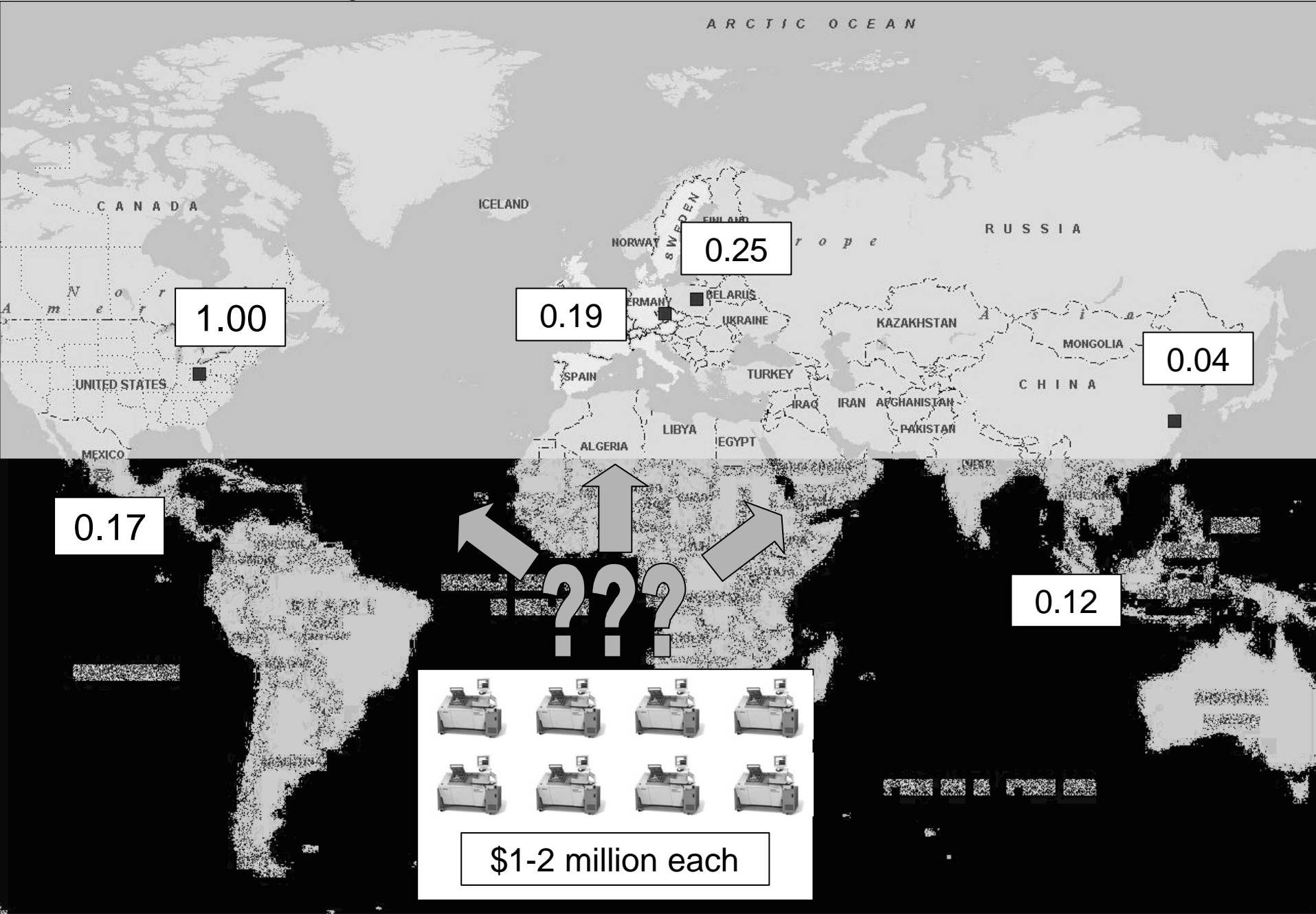


- Research with Bell Labs Ireland

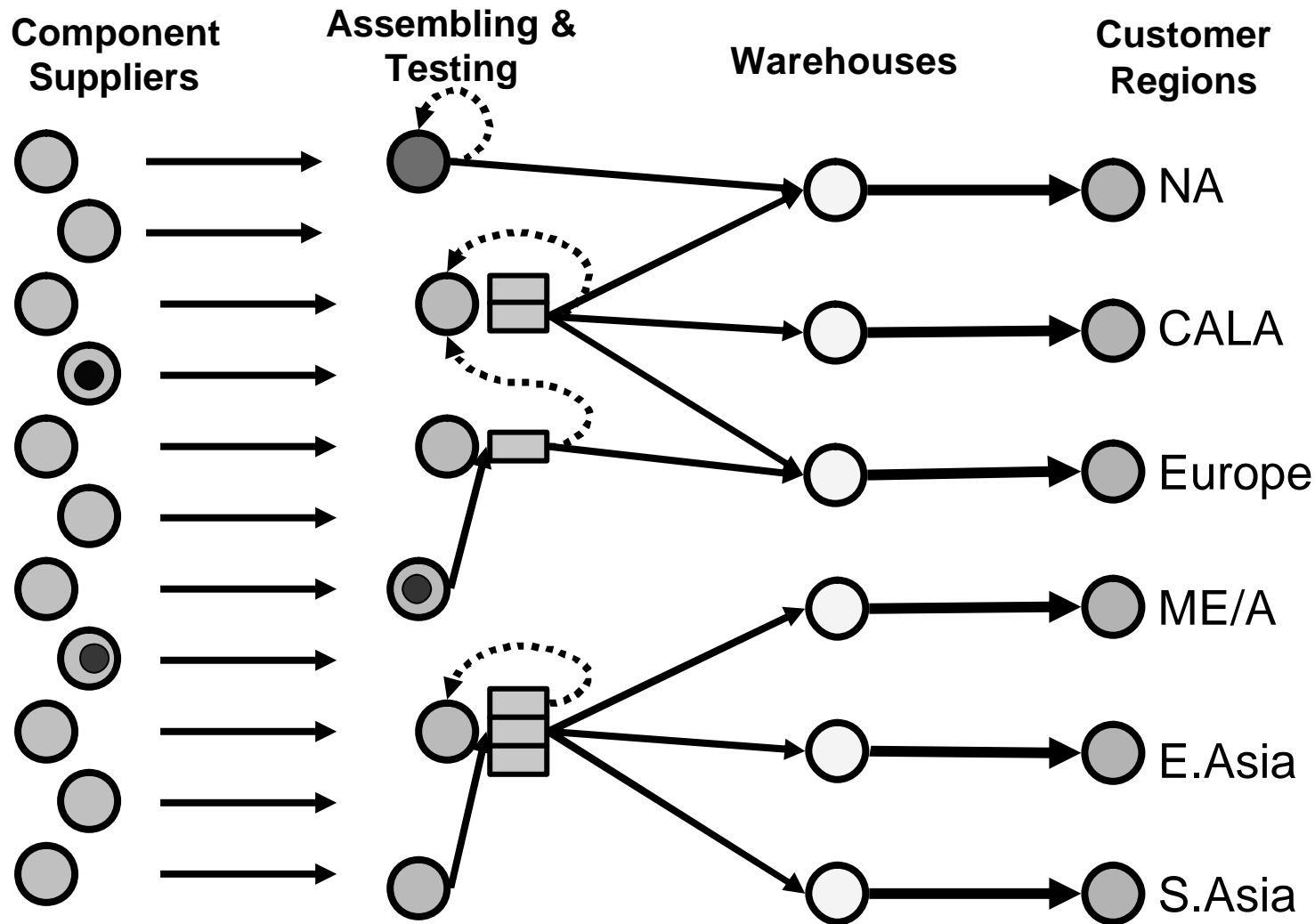
# Case Study: Telecommunications



# How to deploy test sets?

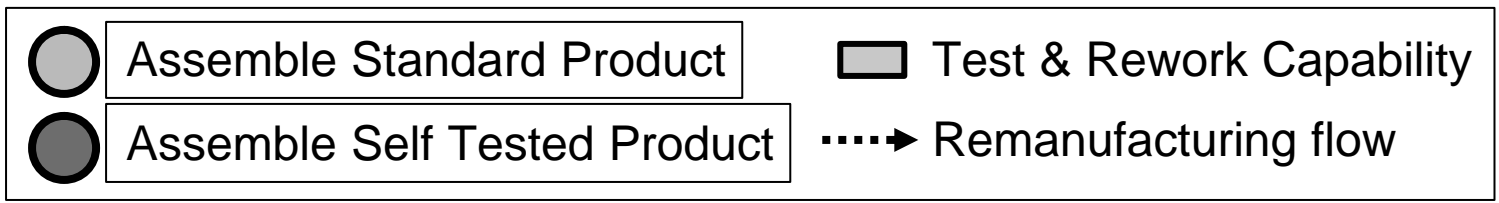


# Example Design



1 2 3 4 5

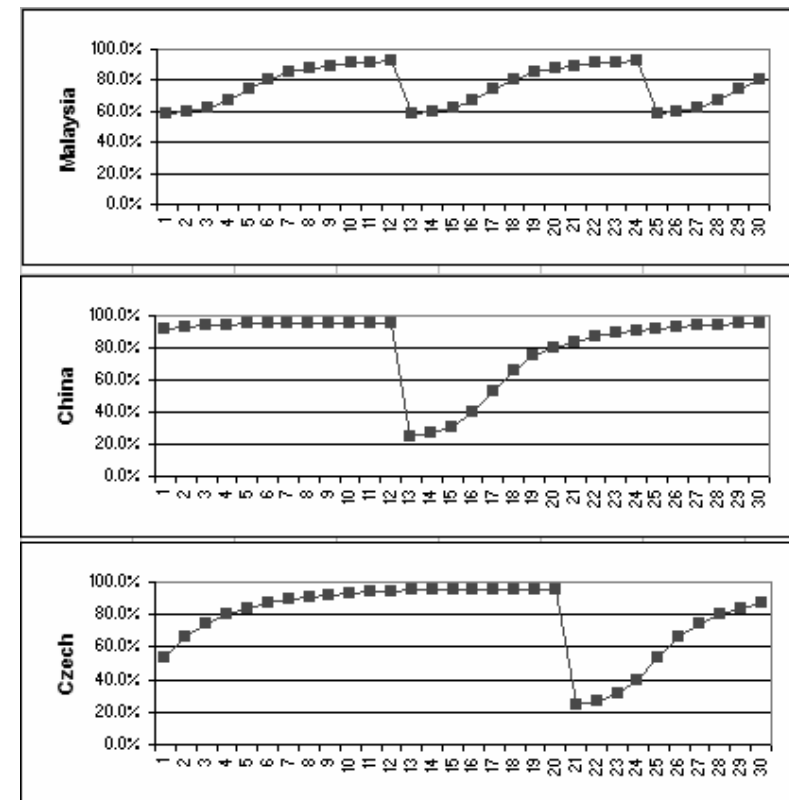
Must consider transportation tradeoffs





# Complications

- Demand can be very volatile, based on a handful of large contracts
- Penalties for production requests above or below a tolerance around the contracted amount
- New products/processes are deployed frequently and the yield of positive tests can drop dramatically



# Analysis

- Optimize using an integer program

To simultaneously determine optimal test set allocation and material flow decisions, we employ the following mixed integer programming formulation:

$$\begin{aligned}
 \min C = & \sum_{t=1}^T \left[ \sum_{j \in J} \sum_{k \in K} \sum_{n \in N} x_{j,k,n,t}^{\text{comp}} \cdot cc_{j,n} \right. & + & \sum_{k \in K} y_{k,t} \cdot ca_k & + & \sum_{i,k \in K} \sum_{p \in \{1,4\}} w_{k,i,p,t} \cdot ct_k \\
 & \text{(Procurement cost)} & & \text{(Assembly cost)} & & \text{(Testing cost)} \\
 & + \sum_{k \in K} v_{k,t} \cdot cr_k & + & \sum_{l \in L} \text{inv}_{l,t} \cdot ch_l & + & \sum_{j \in J} \sum_{k \in K} \sum_{n \in N} x_{j,k,n,t}^{\text{comp}} \cdot cs_{j,k}^{\text{comp}} \\
 & \text{(Remanufacturing cost)} & + & \text{(Holding cost)} & & \text{(Component shipping cost)} \\
 & + \sum_{i,k \in K} \sum_{p \in \{1,3,4\}} x_{k,i,p,t}^{\text{ass}} \cdot cs_{k,i}^{\text{ass}} & + & \sum_{k \in K} \sum_{l \in L} x_{k,l,p,t}^{\text{wh}} \cdot cs_{k,l}^{\text{wh}} & + & \left. \sum_{l \in L} \sum_{m \in M} x_{l,m,t}^{\text{cust}} \cdot cs_{l,m}^{\text{cust}} \right] \\
 & \text{(Transshipment cost)} & + & \text{(To warehouse shipping cost)} & & \text{(Final product shipping cost)} \\
 & + \sum_{k \in K} c \cdot z_k & & & & \\
 & \text{(Fixed test set cost)} & & & & \tag{1}
 \end{aligned}$$

- Model decisions for each of 30 months
- Use realistic cost data and demand scenarios

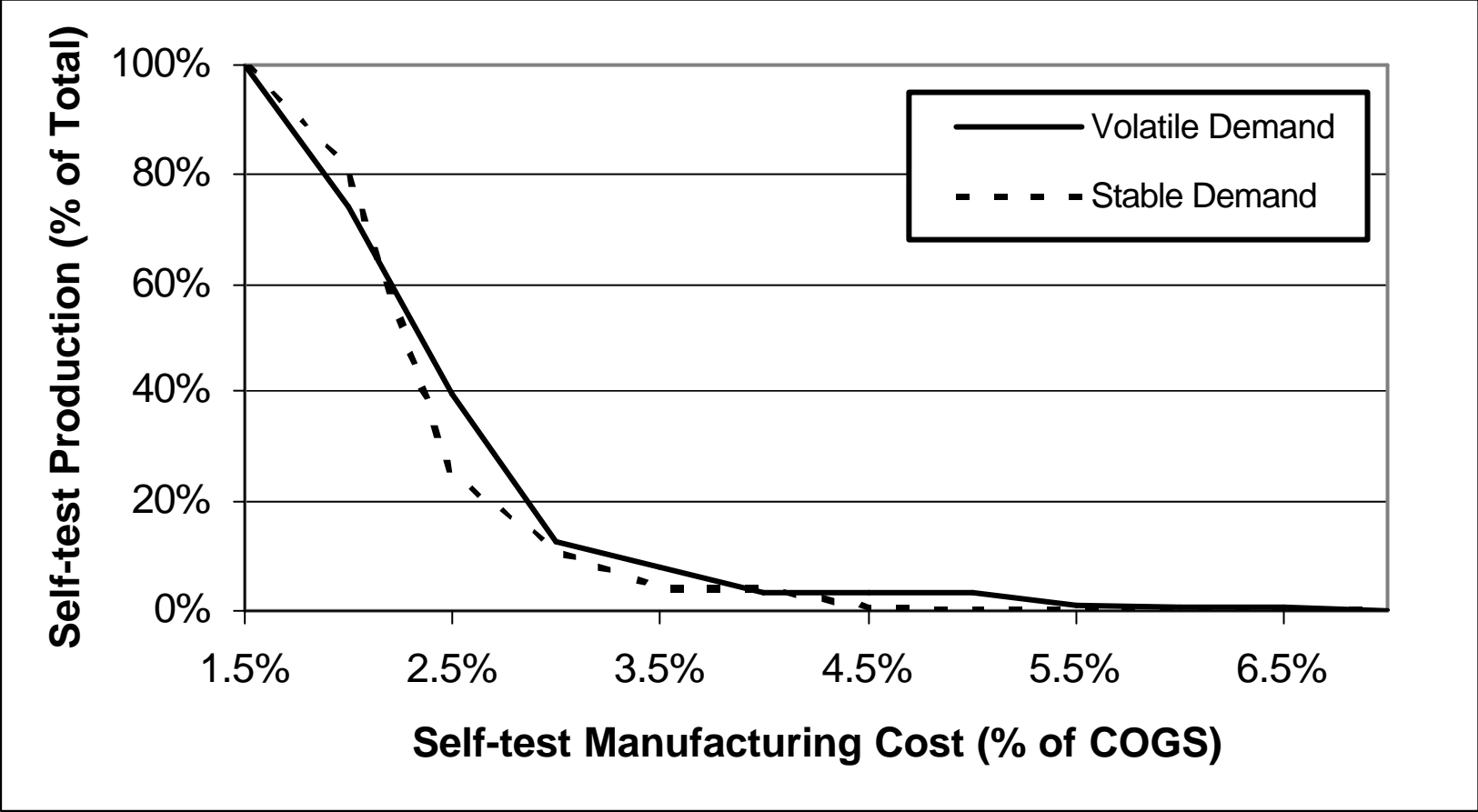
# Results

- It is not optimal to deploy test sets at each location
- Cost of complete centralization of testing and remanufacturing is 11-12% above the optimal
- Sites without testing ship to the nearest testing location, not the one with the cheapest labor cost.
- If defects are found, products are then shipped to low cost locations for remanufacturing.
- Testing of remanufactured products is always conducted at the site of remanufacture.

# Results

- Remanufacturing work chases the lowest variable cost with over 90% occurring in China
- Mexico, at four times the cost of China, does handle the rework when yield rates are below 80% in U.S. or Mexico

# Evaluate Self-Embedded Testing



To request a copy of the paper

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**STRATEGIC DEPLOYMENT OF SPECIALIZED TESTING AND  
REMANUFACTURING IN A GLOBAL NETWORK OF CONTRACT  
MANUFACTURERS**

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**ABSTRACT**

Most research on supply chain network design has been addressed from an intra-organizational perspective. Increasingly, however, companies are outsourcing key manufacturing, assembly, and testing functions to contract manufacturers around the globe. Companies must determine how to

# Zaragoza Supply Chain Summit

[www.zaragozalogistics.com/summit2005](http://www.zaragozalogistics.com/summit2005)

- *Beyond Offshoring: The Road to Globalization*
- May 31 – June 1 in Zaragoza
- Keynote Addresses
  - David Abney, President, UPS International
  - John Allan, CEO, Exel
  - Janice Hammond, Sr. Assoc. Dean, Harvard Bus. School
  - Nicky Hartery, VP of Manufacturing (EMEA), Dell
  - Tom Malone, Professor, MIT Sloan
  - Lou Manzione, Executive Director, Bell Labs Ireland
  - Edouard Michelin, CEO, Michelin
  - Yossi Sheffi, CTL Director, MIT
  - B.G. Srinivas, Head of Infosys, Europe

	SC		SR		VC		VR	
	Total Cost	Above "ALL"	Total Cost	Above "ALL"	Total Cost	Above "ALL"	Total Cost	Above "ALL"
<b>ALL</b>	69.7		68.2		74.2		72.6	
<b>3 Location</b>	75.8	8.6%	74.2	8.8%	80.1	8.0%	78.6	8.2%
<b>2 Location</b>	84.1	20.7%	82.8	21.3%	88.5	19.4%	87.1	19.9%
<b>Centralized</b>	77.9	11.7%	76.5	12.1%	82.4	11.2%	81.0	11.6%

		SC			SR			VC			VR		
		Test Sets	Testing Flow	ReMfg Flow	Test Sets	Testing Flow	ReMfg Flow	Test Sets	Testing Flow	ReMfg Flow	Test Sets	Testing Flow	ReMfg Flow
<b>ALL</b>	China	9	57%	91%	9	57%	91%	8	48%	94%	9	53%	94%
	Malaysia	3	19%	0%	3	19%	0%	5	28%	0%	4	22%	0%
	Czech	1	6%	0%	1	6%	0%	1	6%	0%	1	6%	0%
	Mexico	3	18%	9%	3	18%	9%	3	19%	6%	3	19%	6%
<b>3 Location</b>	China	12	75%	100%	12	75%	100%	12	74%	100%	12	74%	100%
	Malaysia	4	25%	0%	4	25%	0%	4	23%	0%	4	23%	0%
	USA	4	0%	0%	4	0%	0%	4	3%	0%	4	3%	0%
<b>2 Location</b>	China	0	0%	2%	0	0%	2%	0	0%	3%	0	0%	3%
	Malaysia	15	96%	98%	15	96%	98%	16	96%	97%	16	96%	97%
	USA	6	4%	0%	6	4%	0%	6	4%	0%	6	4%	0%
<b>Centralized</b>	Malaysia	16	100%	100%	16	100%	100%	17	100%	100%	17	100%	100%