

# **The Impact of Manufacturing Offshore on Technology Trajectories in the Automotive and Optoelectronics Industries**

**Erica R.H. Fuchs**

**Post-Doctoral Fellow**

**M.I.T. Microphotonics Center**

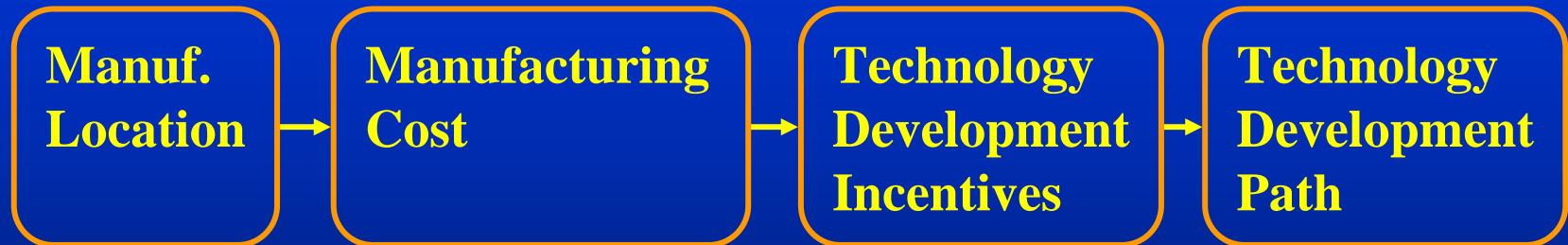
**M.I.T. Industrial Performance Center**

# Background: Gains From Trade?

- **Trade may not advantage U.S. economy**
  - Real wages will fall (Samuleson 2004)
- **Gains enough to compensate losers**
  - Short term, developing countries' skills won't compete
  - By the time skills improve, U.S. further ahead (Bhagwati 2004)
- **Does everyone win?**
  - Net job growth, not disappearance (Berger 2000)
  - Middle-wage and low-end jobs being lost (Berger 2000)
- **Key for U.S. to stay ahead: Innovation** (Grossman & Helpman 1991)
  - Imitation to Innovation (Kim 1997, Amsden 2001, Breznitz 2005, Arora 2005)
  - Innovation increases in the U.S. (Grossman & Helpman 1991)
  - Manufacturing matters (Cohen & Zysman 1987, Macher and Mowery 2004)
  - Geography constrains knowledge flows (Teece 1977, Mansfield 1982, Levy 2005)
  - Differentiate: life cycle (Vernon 1966), knowledge type (VonHippel 1994), design (Baldwin 2000, Sturgeon 2002, Sturgeon 2005)

# Research Question

**Are firms' manufacturing location decisions changing their technology development incentives, and thereby the technology development path of these industries?**



# Methods: Two-Case Study (Glasner and Strauss 1967, Eisenhardt 1989, Yin 1994)

## Two Cases:

- **Automotive: FR Polymer Composite Unibody**
- **Optoelectronic: Integrated Optoelectronic Components**

## Both Cases: Emerging Technologies

- **In early stages of development, implementation**
- **Substitute for products on today's market**
- **Physical properties associated with demand preferences expected in long term**

## Both Cases: Moving Manufacturing Offshore

- **Auto: Market Proximity** (Humphrey 2001)
- **Opto: Cost Reduction**

# Methods: For Each Case

- **Technology Development Incentives: PBCM**

(Kirchain & Field 2000)

## Technology Description

Device Description  
Material Properties  
Operating Conditions  
Factor Prices



Process-based Cost Model

Production  
Cost

## **Data Collection** (Jick 1979)

- **Design: current, emerging alternatives**
- **Production: current, new requirements**
- **Location: differences in production variables**

23 companies  
>50% market  
5 of the 7 companies w/  
dominant share of market  
Over 100 interviews

- **Technology Development Path: Semi-structured interviews** (Glasner and Strauss 1967, Eisenhardt 1989)

- **Design decisions in the U.S. vs. offshore**
- **Explanation or logic behind decisions**

# Findings: In Both Cases...

## Modeling

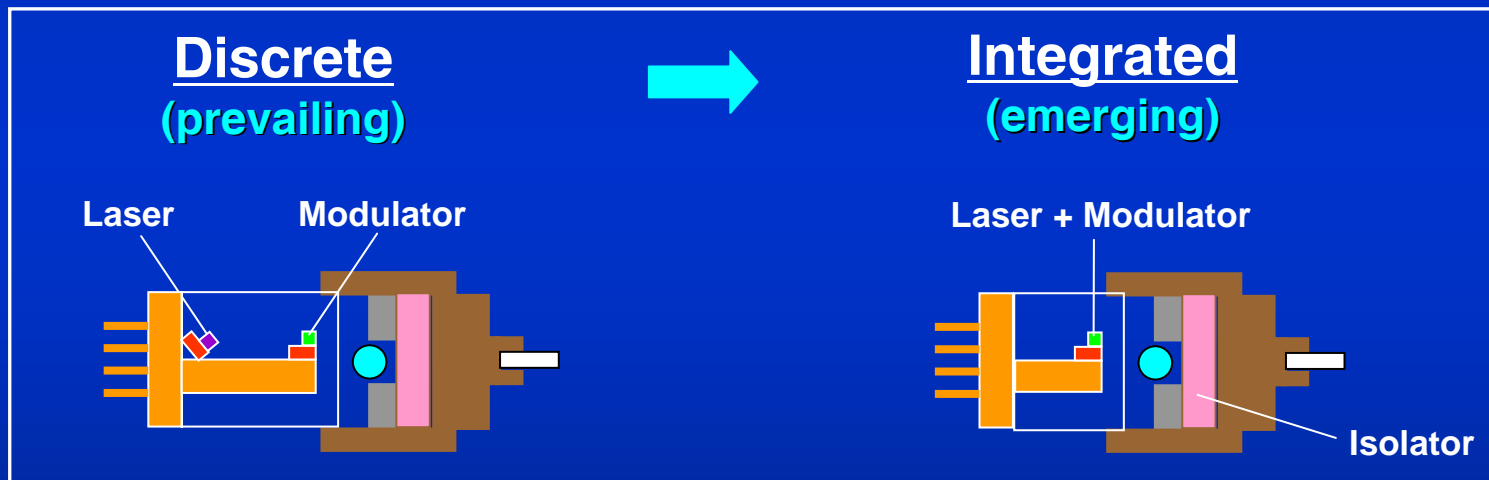
- Manufacturing offshore (developing E. Asia) *shifts* relative economic position of emerging design and prevailing design
- Emerging design more cost competitive in U.S. production structure; prevailing design more cost competitive in developing East Asia

## Interviews

- Firms produce prevailing design offshore
- Decisions economically advantageous in short-term, may overlook long-term consequences

# Case: Integration in Optoelectronic Transmitters

- Produce multiple functions on a single chip
- Originally, driven by telecom market
  - Improve network performance; reduce size, cost



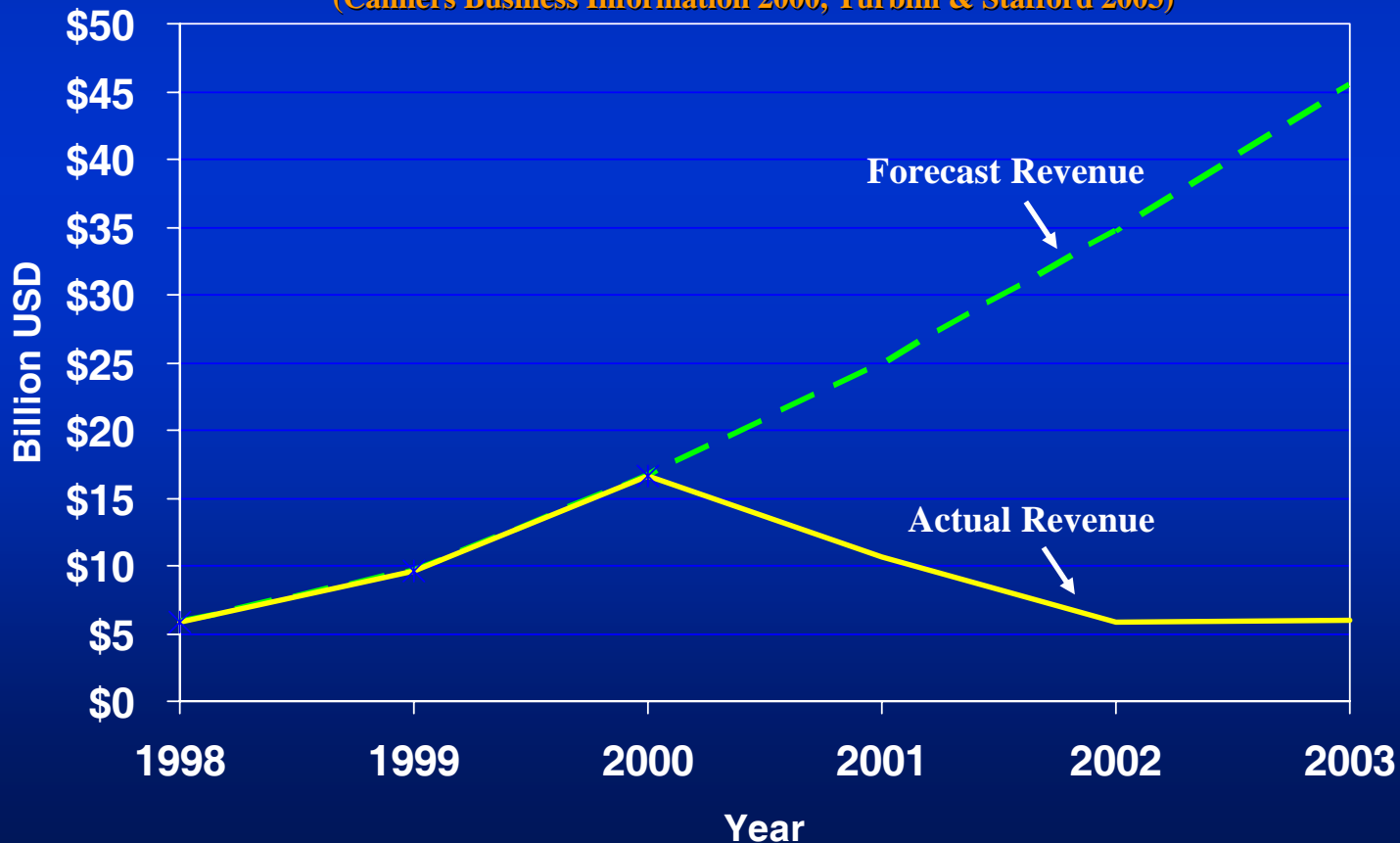
- Long term, computing (Moore's Law)
  - Interconnect bottleneck, multi-core paradigm
  - Computer optical bus: integration seven functions

# Dramatic Shift in the Telecom Market

Industry driver: performance innovation ➡ efficiency & cost

## Actual vs. Forecast U.S. Fiber-Optic Market Sizes

(Cahners Business Information 2000, Turbini & Stafford 2003)





# Options to Reduce Cost

Pressure  
To Drive  
Down Costs

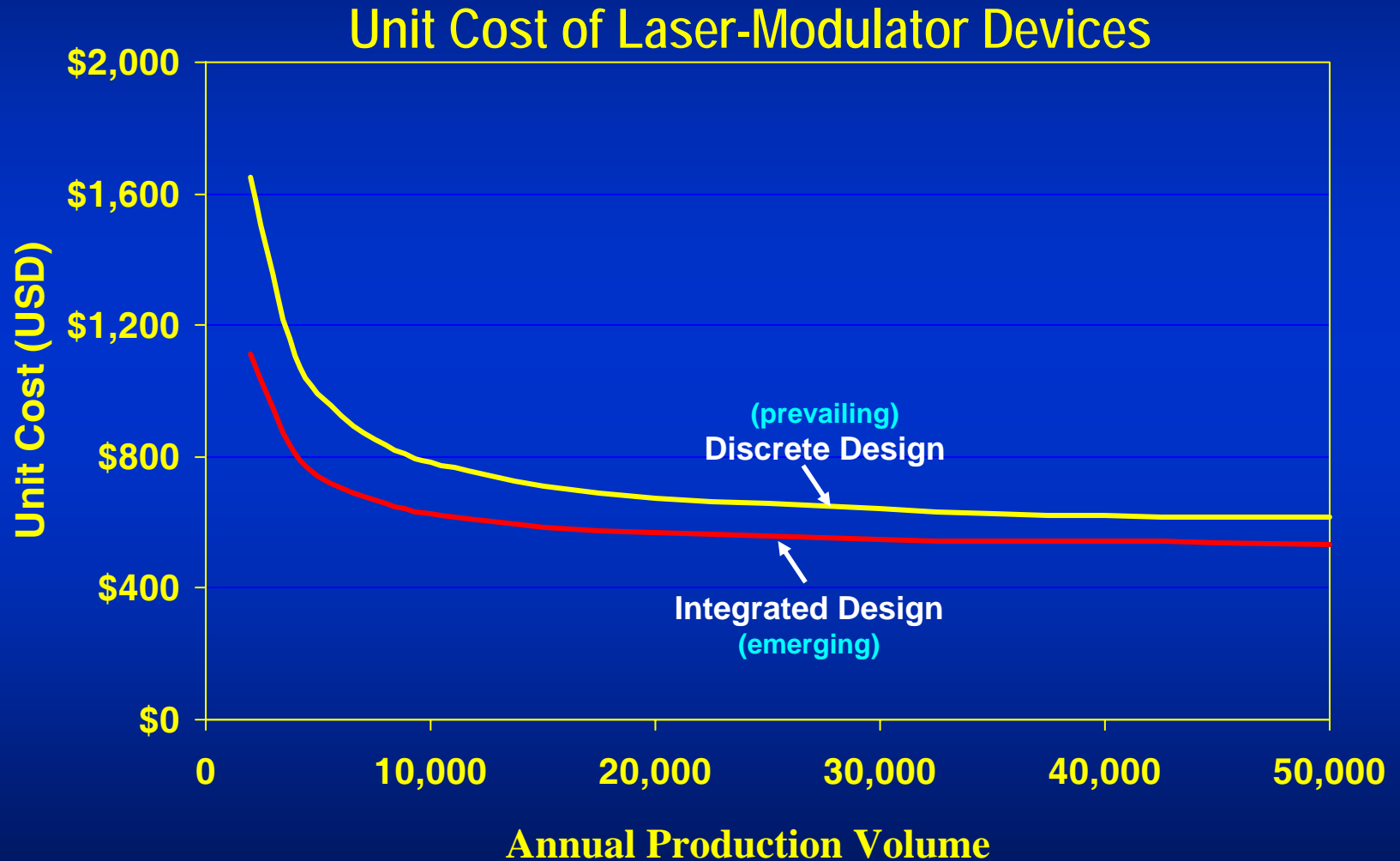
?

Technology Solution:  
Integration

Location Solution:  
Low Wage Environment

- **Major cost driver: packaging, assembly, test**
  - Material- and labor-intensive, back-end processes
- **Two ways to reduce back-end costs**
  - Production in low-wage environment (prevailing design)
  - Technology development: integration
- **15 of 16 firms moved offshore**

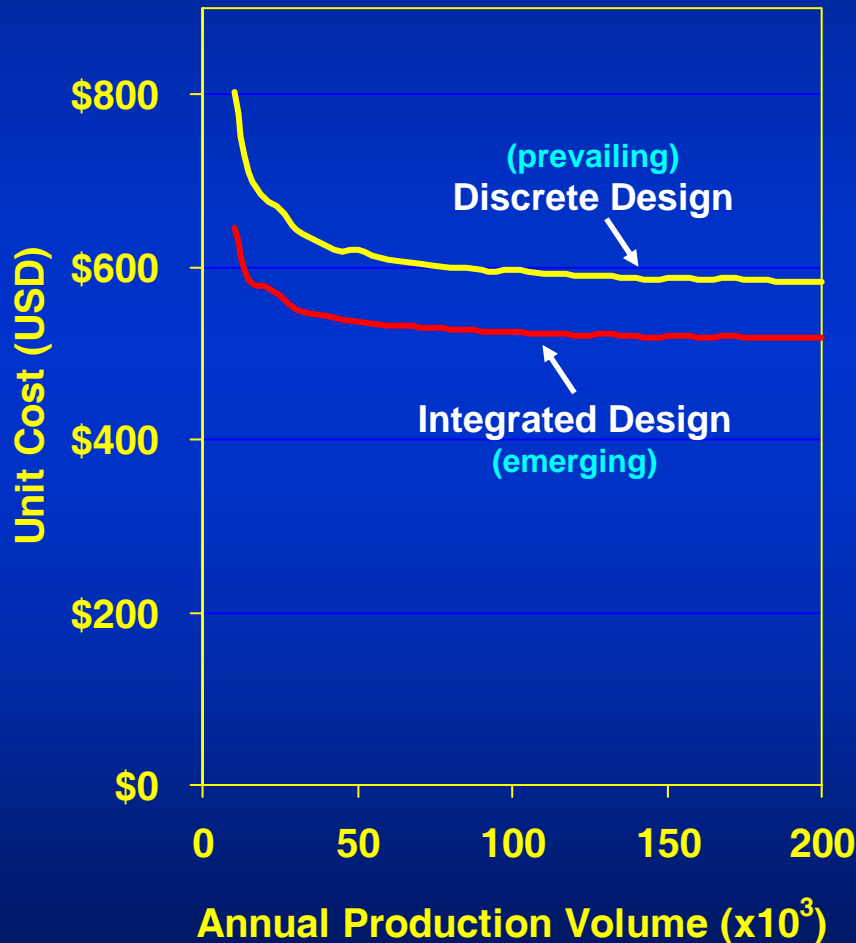
# Model Results: U.S.-Based Production



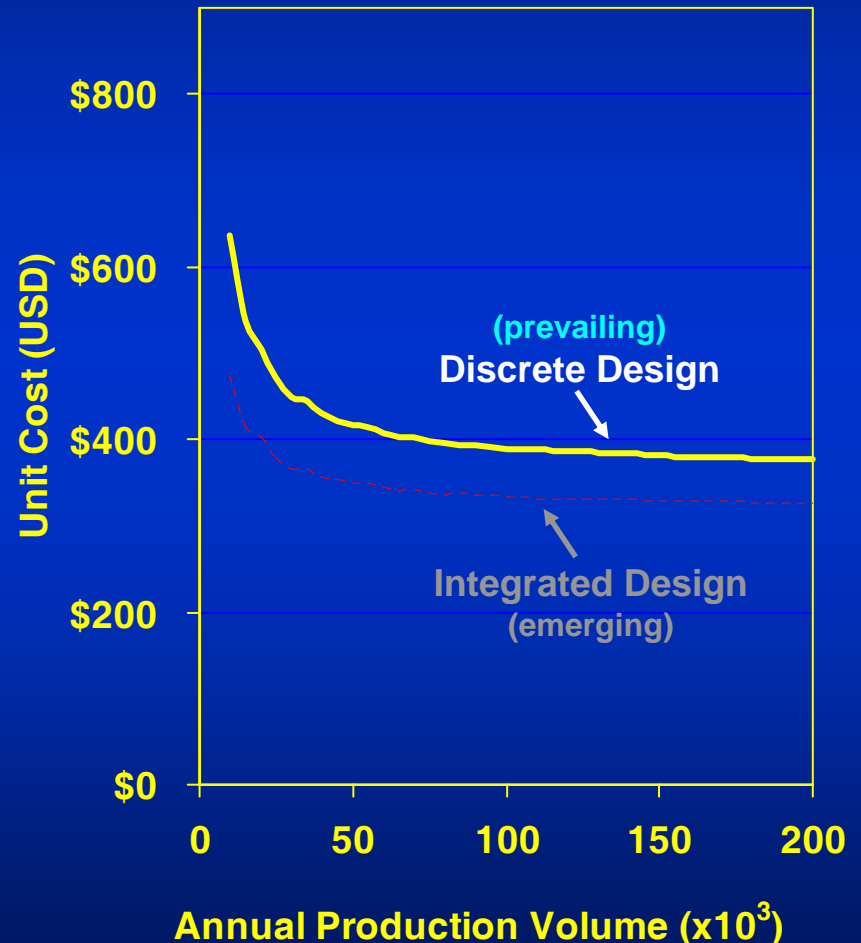
(Source: Fuchs, Bruce, Ram, Kirchain (2006) Process-Based Cost Modeling of Photonics Manufacture *Journal of Lightwave Technology*. 24(8): 3175-3186.)

# Integration Unable to Compete Against Developing East Asia Cost Reductions

## U.S. Production Scenario



## E. Asia Production Scenario



(Source: Fuchs, E. and Kirchain, R. (2005) Changing Paths: The Impact of Manufacturing Offshore on Technology Development Incentives in the Optoelectronics Industry. Proceedings of the Annual Meeting of the Academy of Management. August 2005.)

# Results: Barriers to Pursuing Path of Integration

## Barriers to transferring knowledge

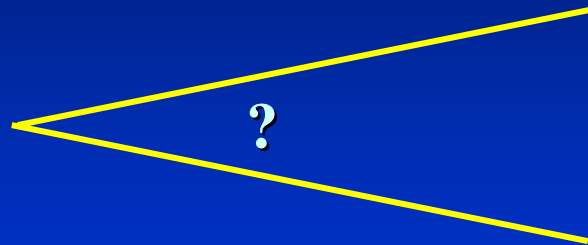
- **Constant design engineer attention required on production line**
- **Lack of skilled local design engineers, back-end assembly workers**

## Barriers to producing in both locations

- **Current market size doesn't support multiple plant sites** (Fuchs & Kirchain 2005, Schabel 2005)

# A Dilemma for Firm Strategy?

Pressure  
To Drive  
Down Costs



Technology Solution:  
Integration

Location Solution:  
Low-Wage Environment

## Case

- **Short-term markets: lower costs, long-term markets: innovation**

## Results

- **Offshore manufacturing:**
  - **Reduces cost-competitiveness of emerging design**
  - **Reduces viability of pursuing integrated technology**

**By moving production, are firms reducing their incentives and ability to “stay ahead?”**

# Changing Paths?

## U.S. Firms...

- **15 of 16 moved offshore (15 → 8)**
  - Not producing emerging technology
  - No R&D efforts on integration
  - Dominating telecom market
- **Small firm in U.S. manufacturing emerging tech**
  - Unclear if going to survive

**Slow path, change path, or change institutions?**

# Cross-Case Findings: Similarities

In two very different cases...

- **Manufacturing offshore *shifts* relative economic position of emerging design and prevailing design**
- **Emerging design more cost competitive in U.S. production structure; prevailing design more cost competitive in developing East Asia**
- **Firms produce prevailing design offshore**
- **Decisions economically advantageous in short-term, may overlook long-term consequences**

# What can we learn from these two cases?

- **Manufacturing location matters for design competitiveness.**
  - As engineers, should we be designing for manufacturing location?
  - Should we be forcing firms to manufacture in the U.S.?
- **Optoelectronics Case: Extremely Constrained!**
  - Difficulty separating manufacturing from R&D
  - Small market, only able to afford one manufacturing facility
  - **Typical of small, high-tech firms?** (Holbrook 2000, Pisano 1997, Bohn 2005)



# Implications of Manufacturing Offshore for Firm Strategy Development

