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

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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)
  – Manufacturing matters (Cohen & Zysman 1987, Macher and Mowery 2004)
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  

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**
  
  Technology Description
  - Device Description
  - Material Properties
  - Operating Conditions
  - Factor Prices

  Data Collection (Jick 1979)
  - Design: current, emerging alternatives
  - Production: current, new requirements
  - Location: differences in production variables

  Process-based Cost Model

  Production Cost

  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)

![Graph showing actual vs. forecast revenue from 1998 to 2003.](image)
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

Unit Cost of Laser-Modulator Devices

- Discrete Design (prevailing)
- Integrated Design (emerging)

Integration Unable to Compete Against Developing East Asia Cost Reductions

U.S. Production Scenario

E. Asia Production Scenario

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
Implications of Manufacturing Offshore for Firm Strategy and Development

Scenario

Most Constrained

Manufacturing offshore requires path of technology change

Least Constrained

Manufacturing offshore does not change path of technology development