Building Supply Chain Excellence in Emerging Economies

Hau L. Lee
Stanford University

POMS-Vancouver 2010
Global Trade Growth

Growth in the volume of world merchandise trade and GDP, 1997-2007

(Annual percentage change)

Source: WTO Secretariat.
Globalization Trends

Selling to and Sourcing from Outside of Home Market

- Growing middle class:
  - 1.5 billion in 52 developing nations
  - 300 million in China, with 1% annual growth
  - Tripled in India since 1985

- Emergence of BRICs (Brazil, Russia, India, China):
  - 15% of G6 today
  - Half of G6 by 2025
  - Surpass G6 in less than 40 years

Source: Accenture Global Operations Survey, 2005
Supply Chain Trends

- Increasing trend of outsourcing and offshoring to emerging economies.
- Challenges of underdeveloped infrastructures in emerging economies.
- Complexity and diversity of cultures and needs.
- Emerging economies are not just a source of supply and manufacturing, but could become markets and sources of innovation.
- But trade barriers, tariffs, special agreements, regulations are also on the rise.
- Rising importance of sustainability and social responsibility.
Key Considerations in Supply Chain Research with Emerging Economies

- Data availability and accuracy
- Rapid dynamic changes
- Complexity of inter-country trade flows and cultural differences
- Different incentives and objectives of different stakeholders other than profit maximization
- Need to understand the details of all process steps
Examples of Research Topics

- Supply chain design
- Product design for diverse market needs
- Process efficiency improvements
- Business model re-engineering
- Socially responsible supply chains
- Environmentally sound businesses
- Logistics coordination
- Innovations and new product development
- …
Examples of Research Topics

• Supply chain design
  • Product design for diverse market needs
  • Process efficiency improvements
  • Business model re-engineering
  • Socially responsible supply chains
  • Environmentally sound businesses
  • Logistics coordination
  • Innovations and new product development
  • …
Network Design

Value chain design  Location & deployment  Product configuration

Total Landed Cost Analysis

<table>
<thead>
<tr>
<th>Variable cost</th>
<th>Setup cost</th>
<th>Safety stocks</th>
<th>Transit stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>WIP</td>
<td>Custom duties</td>
<td>Taxes</td>
<td>Freight</td>
</tr>
<tr>
<td>Market presence</td>
<td>Sourcing</td>
<td>Compliance</td>
<td>Security</td>
</tr>
</tbody>
</table>
Increasing Regional Trade Agreements

Source - WTO
Renault’s Logan Car

2006 Sales

- Romania
- Russia
- Columbia
- Germany
- Spain
- Turkey
- Algeria
- Morocco
- France
- Ukraine

Sales (100000)
Network of Agreements

- Turkey
- E. Europe
- EU
- Suppliers
- Russia
- Brazil
- Columbia
- India
- Morocco
- Russia, Ukraine
- Columbia, Ecuador, Venezuela
- Maghreb region, Egypt, Tunisia, Jordan

CBU
CKD
Parts
Implications for Research

• Supply chain design still a very hard problem, in addition to the usual NP-hard nature of mixed-integer programming optimization.
• Standard, linear cost of customs and duties may not be sufficient for supply chain design.
• Need to integrate the network of trade agreements with the bill of materials (the DNA) of products in the design problem.
• But trade agreements and government policies change rapidly, so need to develop dynamic models for supply chain design.
Examples of Research Topics

- Supply chain design
- **Product design for diverse market needs**
- Process efficiency improvements
- Business model re-engineering
- Socially responsible supply chains
- Environmentally sound businesses
- Logistics coordination
- Innovations and new product development
- …
Workstation Postponement Boundary

Manufacturing

Build-to-Stock (Push)

Distribution

Build-to-Order (Pull)

Postponement Boundary
Model

- One factory, multiple DCs
- Factory builds intermediate products and stocks at DCs
- DCs configures products to order
- Promised response time to customers
- $I$ modules, fixed assembly sequence

Objective: $\min_{P} \text{Total Cost}$
Complications with Emerging Economies

- Customs duty rates vary greatly.
- Classification of product may result in vastly different duty rates.
- Availability of local component supply sources vary.
- Labor cost and efficiency vary greatly for final customization process steps.
- Additional testing sometimes necessary.
- Quality and reliability concerns.
Base Case Analysis

Supply Chain Cost ($10M per Year)

Postponement Boundary

- **All at DC**
- **Backplane**
- **Processor**
- **Graphics**
- **Store & Mem**
- **All at Factory**

<table>
<thead>
<tr>
<th>Sourcing</th>
<th>Differential</th>
<th>Processing</th>
<th>Differential</th>
<th>Test</th>
<th>Trans.</th>
<th>Duty</th>
<th>Inventory</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Evolution of Postponement

**Suppliers**

Pre-Postponement:
- Suppliers
- Factory: Core assembly, customization

Market DC Postponement:
- Market DC: Distribution
- Factory: Core assembly

Offshoring:
- Offshore Postponement
- Market DC: Customization, distribution
- Factory in LCC: Core assembly

New Postponement:
- Near-Market DC: Customization, distribution
- Factory in LCC: Core assembly
## Supply Chain Evolution

<table>
<thead>
<tr>
<th>Drivers</th>
<th>Mfg Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>70’s Capability &amp; control</td>
<td>W. Europe</td>
</tr>
<tr>
<td>80’s Cost reduction</td>
<td>E. Europe</td>
</tr>
<tr>
<td>90’s Cost &amp; supply network</td>
<td>China</td>
</tr>
<tr>
<td>Today Service pressure, China</td>
<td>Dual-Response</td>
</tr>
<tr>
<td>cost, oil prices</td>
<td></td>
</tr>
</tbody>
</table>
Implications for Research

• Optimal product design and postponement strategies increasingly valuable as more emerging markets become part of demand points.

• Again, need to examine product classification and duty implications for partially assembled product.

• Complete considerations of cost and risk components necessary.

• Need to consider dynamic, not static, strategies, as market conditions change more rapidly in emerging economies.
Examples of Research Topics

- Supply chain design
- Product design for diverse market needs
- **Process efficiency improvements**
- Business model re-engineering
- Socially responsible supply chains
- Environmentally sound businesses
- Logistics coordination
- Innovations and new product development
- ...
Stanford Trade Process Model*

* Joint research with Warren Hausman, sponsored by Tradebeam
## Information-Based Innovations

### Process Excellence

**Focus**
- Faster
- More accurate
- More reliable

**Values**
- Shorter cycle time
- Less delays & reworks
- Lower capital tied up
- Faster cash cycle
- Less penalties from errors
- Accurate duty payment and refunds

### Process Redesign

- Re-sequencing
- Parallel processing
- Elimination
IT-Enabled Benefits

* Joint research with Warren Hausman, China-US apparel trade lane
Implications for Research

• Process improvement must be grounded on deep understanding of how the process works, but there are much greater complexity and diversity of process flows in emerging economies.

• Data is a big challenge: needs to do more empirical work (interviews, ethnographical methods, secondary data, etc.).

• Powerful link of IT and process improvements.

• Since some investments are necessary, it is worthwhile to do research on the values of process improvements.
Examples of Research Topics

• Supply chain design
• Product design for diverse market needs
• Process efficiency improvements
• Business model re-engineering
• Socially responsible supply chains
• Environmentally sound businesses
• Logistics coordination
• Innovations and new product development
• ...
Soy Bean Supply Chain in India

Farmers

- Inbound logistics in bulk

Mandis

- Display & visual inspection
- Auction (spot market)

Outbound logistics & payment

ITC

Other Buyers

- Congestion at Mandis can hold up farmers for days.
- Price uncertainty faced by farmers – material flow must precede price information discovery.
- Farmers rely on word of mouth or localized previous prices.
- Farmers vulnerable to delayed payments.

Source: Anupindi & Suvakumar, 2007
ITC e-Choupal

Selected farmers (Sanchalak) maintain computers and inspect products.
Price transparency provided to farmers.
Direct sales to ITC enabled.
Material flows occur only after sales to ITC or price discovery to Mandis.

Source: Anupindi & Suvakumar, 2007
Win-Win Value Proposition

Transaction Costs in Rupees per metric ton

Source: Anupindi & Suvakumar, 2007
ITC e-Choupal

- 6,000 e-Choupals & more than 120 hubs in 9 states, 36,000 villages; empowering 3.5 million e-farmers. 6,000 e-Choupal installations
- Started with soya bean, now covering wheat, coffee, shrimp and other aqua products.
- Reverse flow of fertilizers, household goods, seeds, etc. back to farmers.
- Aims at extending to 100,000 villages and 10 million e-farmers in next decade.
Modeling ITC and Farmers Incentives*

- ITC e-Choupal investments helped reduced production costs of farmers.
- Farmers in network benefit directly, and can sell directly to ITC (implicit agreement) or to mandis.
- Farmers outside of network can also benefit, based on e-Choupal’s investment, but have to sell to mandis.
- Would farmers honor implicit agreement, and is it worthwhile for ITC to provide training to non-network farmers?

Decisions by Players

In-Network Farmers

Training Investments for Non-Network Farmers

ITC

Out-of-Network Farmers

Quantity Produced for ITC and Mandis

Quantity Produced for Mandis

Also, need to model prices (endogenous or exogenous) and capacity of ITC.

Some Results

• Implicit agreement between farmers and ITC behaves like a formal agreement – farmers always give priority to sell directly to ITC.

• It is also optimal for ITC to provide the best training investment to out-of-network farmers, since ITC also needs to purchase from open market (mandis).

Implications for Research

• Emerging economies offer great opportunity for business model re-engineering that can directly improve business results and serving the mass.
• Analyzing differential values to different direct and indirect stakeholders of such changes important.
• Fertile ground for incentive alignment research.
• Parallel research on cost efficiency & agility of ultra-low cost products for extreme affordability (e.g., one lap-top per child, Tata Nano cars, D.Light, and Shanzhai cell phones, etc.)
Examples of Research Topics

• Supply chain design
• Product design for diverse market needs
• Process efficiency improvements
• Business model re-engineering
• **Socially responsible supply chains**
• Environmentally sound businesses
• Logistics coordination
• Innovations and new product development
• …
Causes of Deaths in 2002

* Cancer, diabetes, neuropsychiatric disorders, cardiovascular diseases and respiratory diseases, etc.
Maternal Mortality Ratio
(per 100,000 livebirths, 2008)

Hogan et al., *Lancelot*, 2010
Health Care in Africa

- Short life expectancy: 49 years vs 77 in the US.
- 6% of population, or 25 million, had HIV/AIDS.
- Infrastructure and logistics challenges:
  - No integrated road, transportation and logistics network
  - Rural communities (with 62% of population) accessible only by single-lane sand or dirt paths.
  - Only 20-30% lived within 2 km of a road.
- Big problem of “the last mile” to deliver medicine and health care to the bulk of the population.
Motorcycle as Solution

- Ability to access terrain inaccessible by four-wheel vehicles.
- Lower cost to purchase and operate.
- Fewer and less complicated tools to maintain.
- Lower carbon emissions than four-wheel vehicles.
- Less subject to abuse by corrupt officials.
Transport Resource Management

• Standardization of vehicle fleets.
• Preventive maintenance practices:
  • Self pre-ride checks by health workers
  • Monthly service by Riders-trained technician.
  • Extend useful life of motorcycles from 20,000 km to 80,000 km.
• Hub-and-spokes model for service support.
• Spare parts inventory management.
• Fixed service cost per km model to cover local hub, service parts, gas, protective gear, training and logistics management.

Based on Stanford case, 2008
Impact (2001-2002)

% of population indicating increased visits

<table>
<thead>
<tr>
<th></th>
<th>Gokwe</th>
<th>Binga</th>
</tr>
</thead>
<tbody>
<tr>
<td>8%</td>
<td></td>
<td>100%</td>
</tr>
</tbody>
</table>

% change in malarial deaths

<table>
<thead>
<tr>
<th></th>
<th>Gokwe</th>
<th>Binga</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-0.21</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Frequency of health worker visits

<table>
<thead>
<tr>
<th></th>
<th>Gokwe</th>
<th>Binga</th>
</tr>
</thead>
<tbody>
<tr>
<td>5%</td>
<td></td>
<td>3%</td>
</tr>
<tr>
<td>68%</td>
<td></td>
<td>35%</td>
</tr>
<tr>
<td>5%</td>
<td></td>
<td>49%</td>
</tr>
<tr>
<td>22%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Based on Stanford case, 2008
Research Problems*

• How to measure effectiveness of program
  – Logistics improvements
  – Health workers productivity improvements
  – Public health improvements

• Incentive issues and resulting performance under different business models

• Predictive models of performances
  – Different geographies, needs and terrains
  – Different business models

* Research grant to Stanford University from Gates Foundation
Business Models with Governments

• Business models used and proposed:
  – On-demand service
  – Managed care based on mileage
  – Total ownership model.

• Incentives create different behaviors on:
  – Maintenance and service schedule
  – Inventory and stocking depot control
  – Vehicle retirement decisions
A Vehicle Replacement Model*

• Used field data to 4×4 vehicle replacements at IFRC relative to stated IFRC policy (5 year or 150,000 km).

• Developed optimal replacement policy and analyzed current policy’s effectiveness.

• Data from 2002-6 for Afghanistan, Ethiopia, Georgia and Sudan, covering 449 vehicles.

• Significance of problem due to IFRC policy being used by many other NGOs.

* Martinez and Van Wassenhove, working paper, 2009
Data is the Beast

• Field data includes: procurement cost, vehicle operation mileage, accident records, maintenance costs (preventive & others), and salvage values.
• Data in records not totally reliable.
• Internal data migration errors.
• Personal usage not captured.

* Martinez and Van Wassenhove, working paper, 2009
Stated Policy Not Followed

<table>
<thead>
<tr>
<th>Odometer (‘000 km)</th>
<th>No. of Retired Vehicles and Their Ages and Odometers</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 150</td>
<td>5 110</td>
</tr>
<tr>
<td>&lt; 150</td>
<td>16 84</td>
</tr>
</tbody>
</table>

• HQ purchased vehicles, National Delegation (ND) responsible for operational & maintenance costs, and paid depreciation cost to HQ up to 5 years.
• Revenue from sale of retired vehicle went to HQ.
• Interesting incentive problem arose.

* Martinez and Van Wassenhove, working paper, 2009
Optimal Replacement Policy

• Develop analytical models of operational cost and salvage value as a function of age and odometer.
• Formulate dynamic program for optimal replacement policy.
• Optimal replacement odometer found at 100,000 km.
• Average savings of 8.7% can be achieved.

* Martinez and Van Wassenhove, working paper, 2009
Riders for Health Project*

• Pilot to start in 20 counties of Gambia (with variations of business models), eventually rolling out to whole country & other countries.

• Measurement systems are to be put in place: daily log records, GPS devices on vehicles, and on-site manual audits, etc.

• Predictive model building.

• Vehicle operational and replacement modeling based on different business models.

* Research grant to Stanford University from Gates Foundation
Implications for Research

• Data is still the beast – need more creative methods to collect data, or ways to use coarse data in research.
• Performance measurement research – what is the right measure that would link to efficient use of resources for social good?
• Big incentive alignment problem, but stakeholders can include operators, government, NGOs, donors, and the general mass.
• Implications for regular commercial supply chain management.
## Key Issues of Research Topics

<table>
<thead>
<tr>
<th></th>
<th>Data</th>
<th>Inter-Flow</th>
<th>Dynamics</th>
<th>Incentives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply chain network design</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Product design for diverse market needs</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Process efficiency improvements</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Business model re-engineering</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Socially responsible supply chains</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Final Remarks

• Great opportunities exist for OM research involving emerging economies.
• Use detailed field/teaching cases to build right models.
• Data is the challenge, but sometimes support for collaborations is there.
• Beware of the dynamics – both complicates but also enriches your problem.
• Incentive issues are BIG but exciting research problems.