

# Building Supply Chain Excellence in Emerging Economies

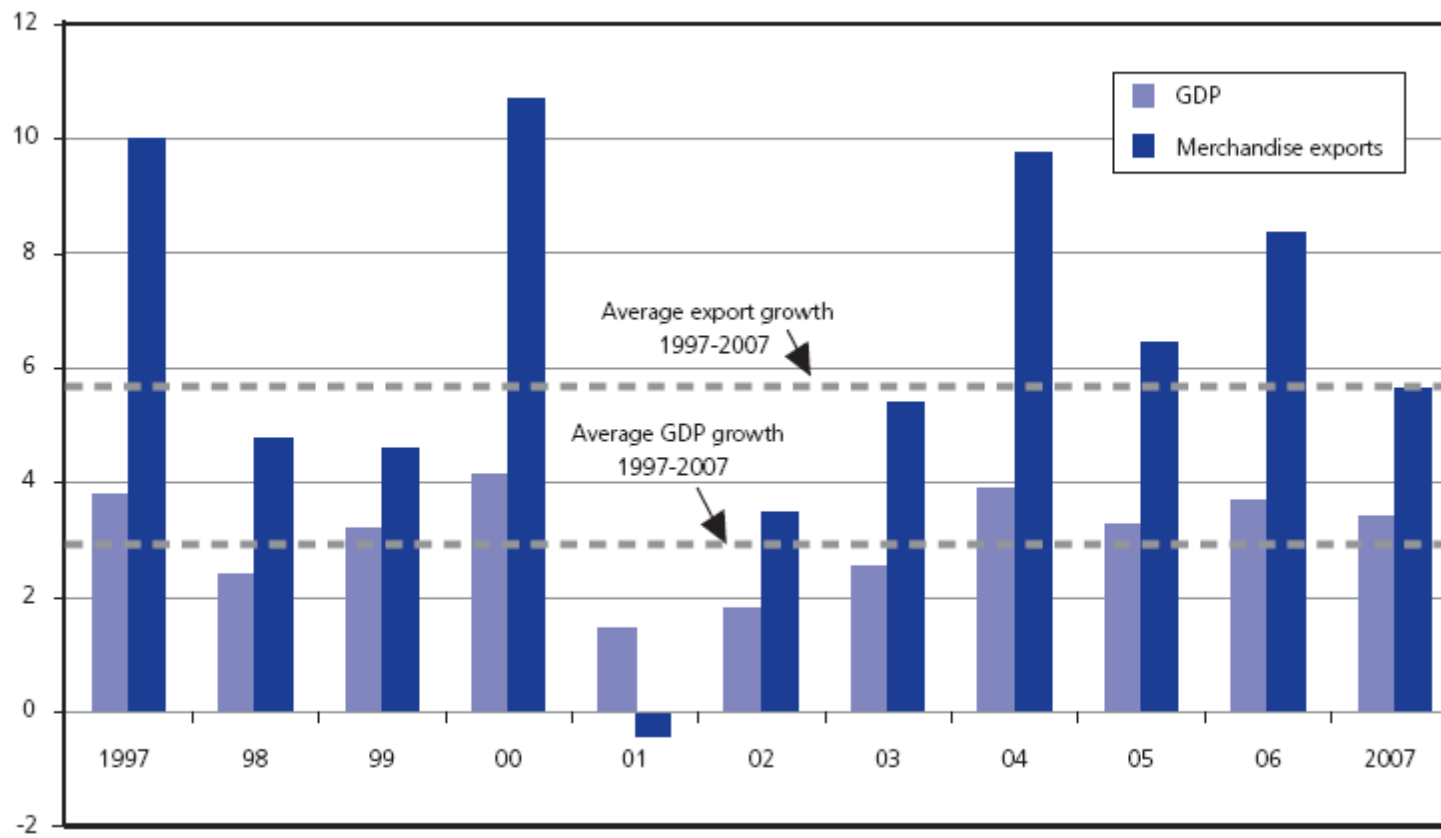
Hau L. Lee  
Stanford University

POMS-Vancouver 2010

# Global Trade Growth

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

(Annual percentage change)

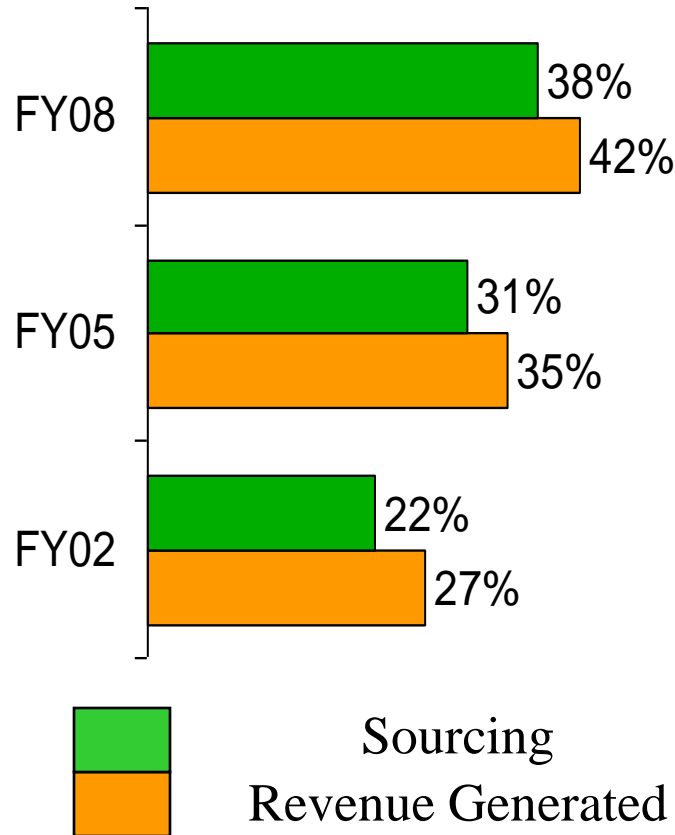


Source: WTO Secretariat.

Source: WTO Report, 2008

# 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

# 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

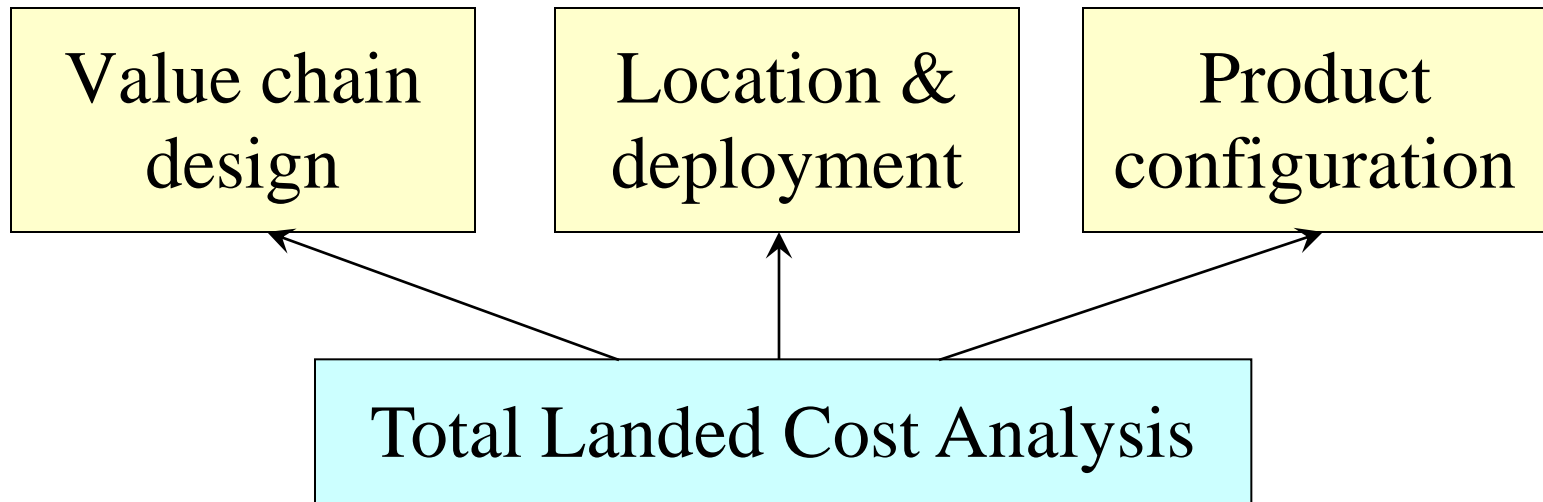
# Examples of Research Topics

- 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

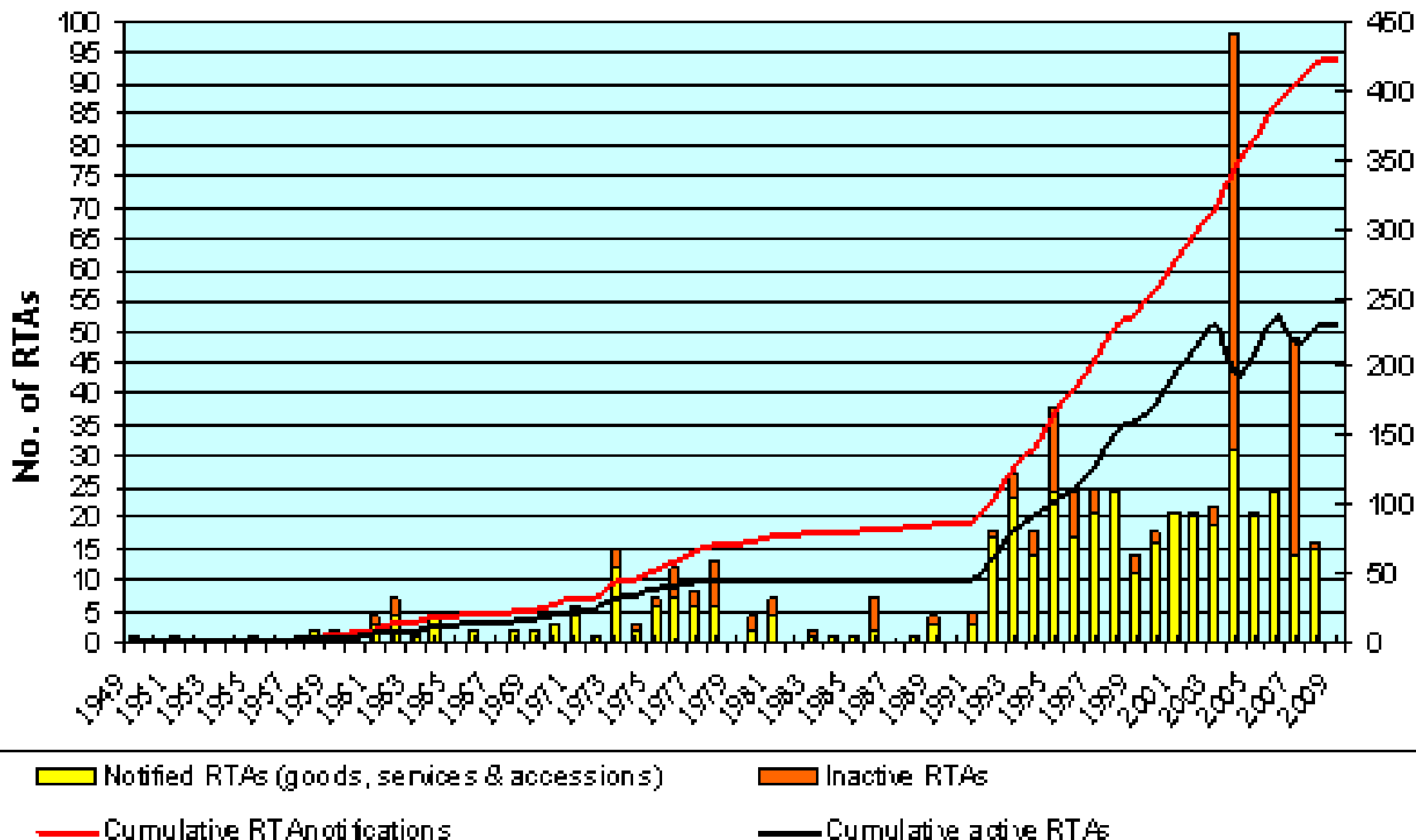
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# Network Design

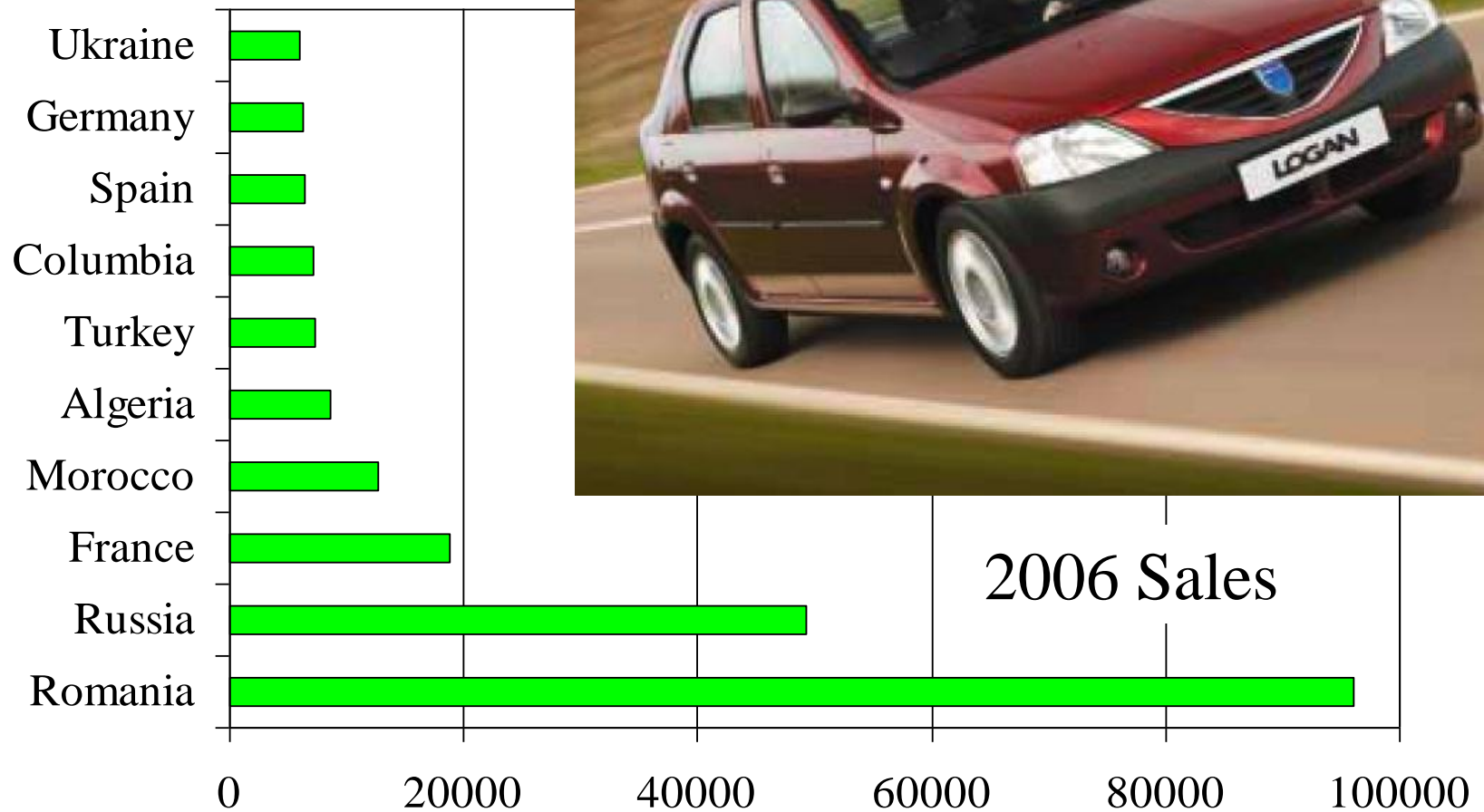


Variable cost	Setup cost	Safety stocks	Transit stock
WIP	Custom duties	Taxes	Freight
Market presence	Sourcing	Compliance	Security

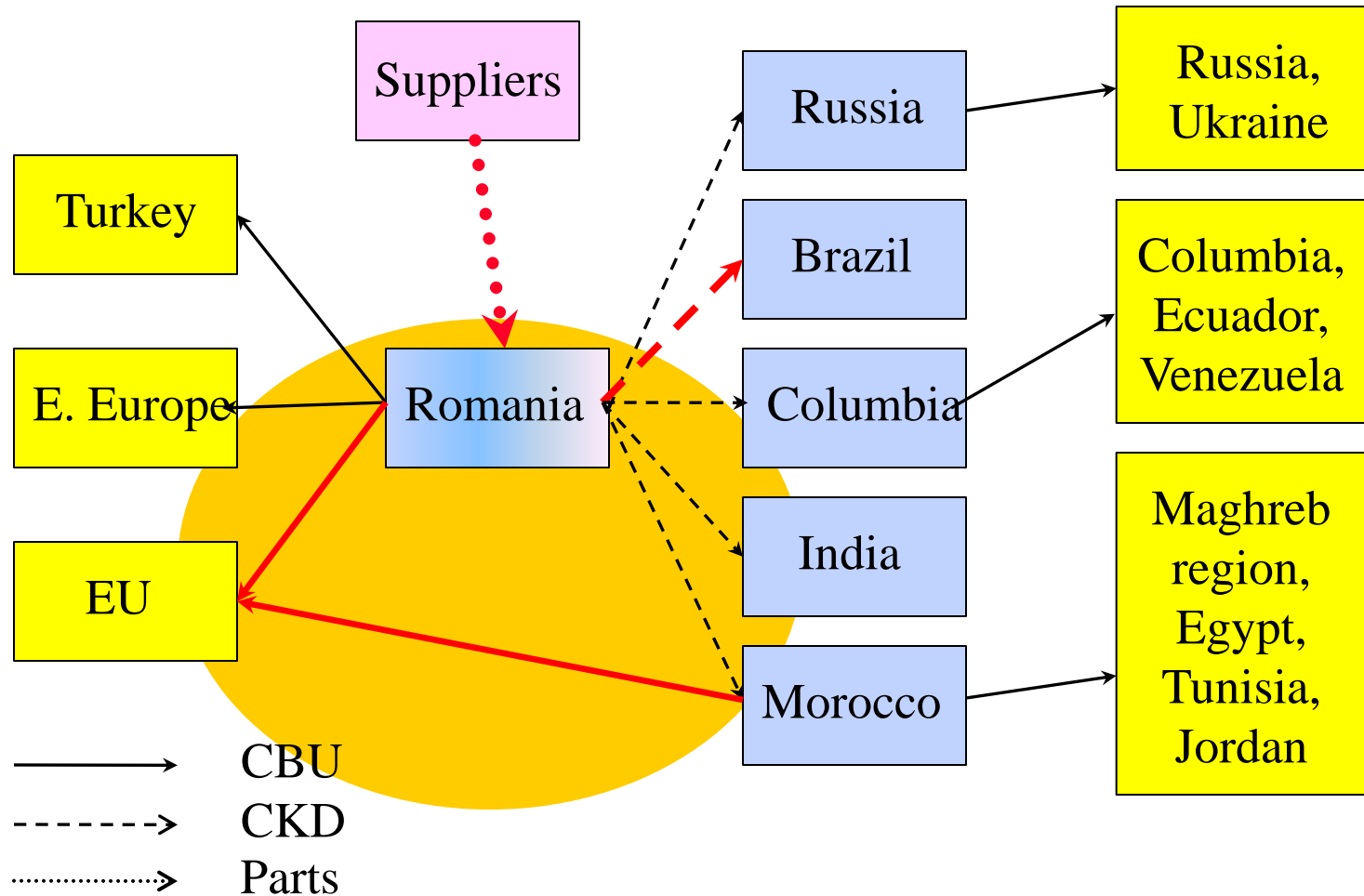
# Increasing Regional Trade Agreements



# Renault's Logan Car



# Network of Agreements



# 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

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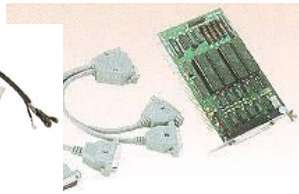
# Workstation Postponement Boundary



Chassis



Power  
Supply



Backplane  
&  
I/O Card



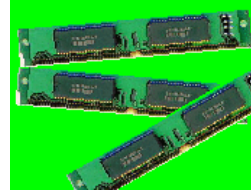
Processor  
Board



Graphics  
Board



Hard  
Disk



Memory

Manufacturing

Distribution

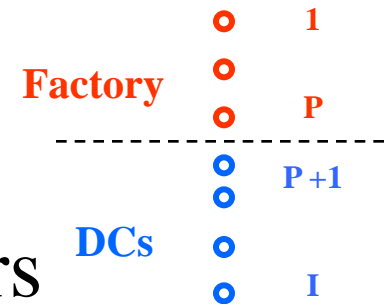
Build-to-Stock (Push)

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

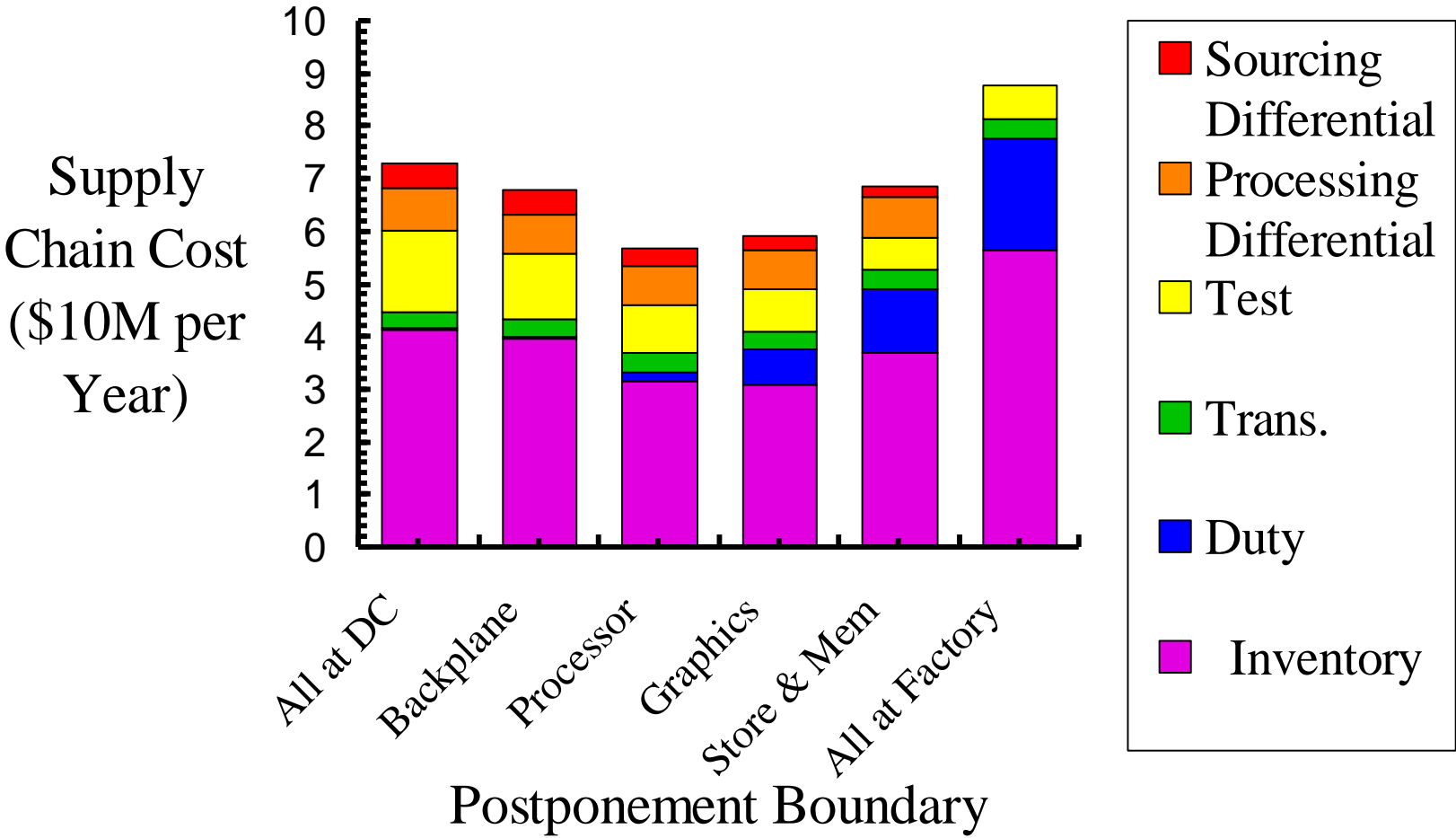


*Objective: Min Total Cost*  
 $P$

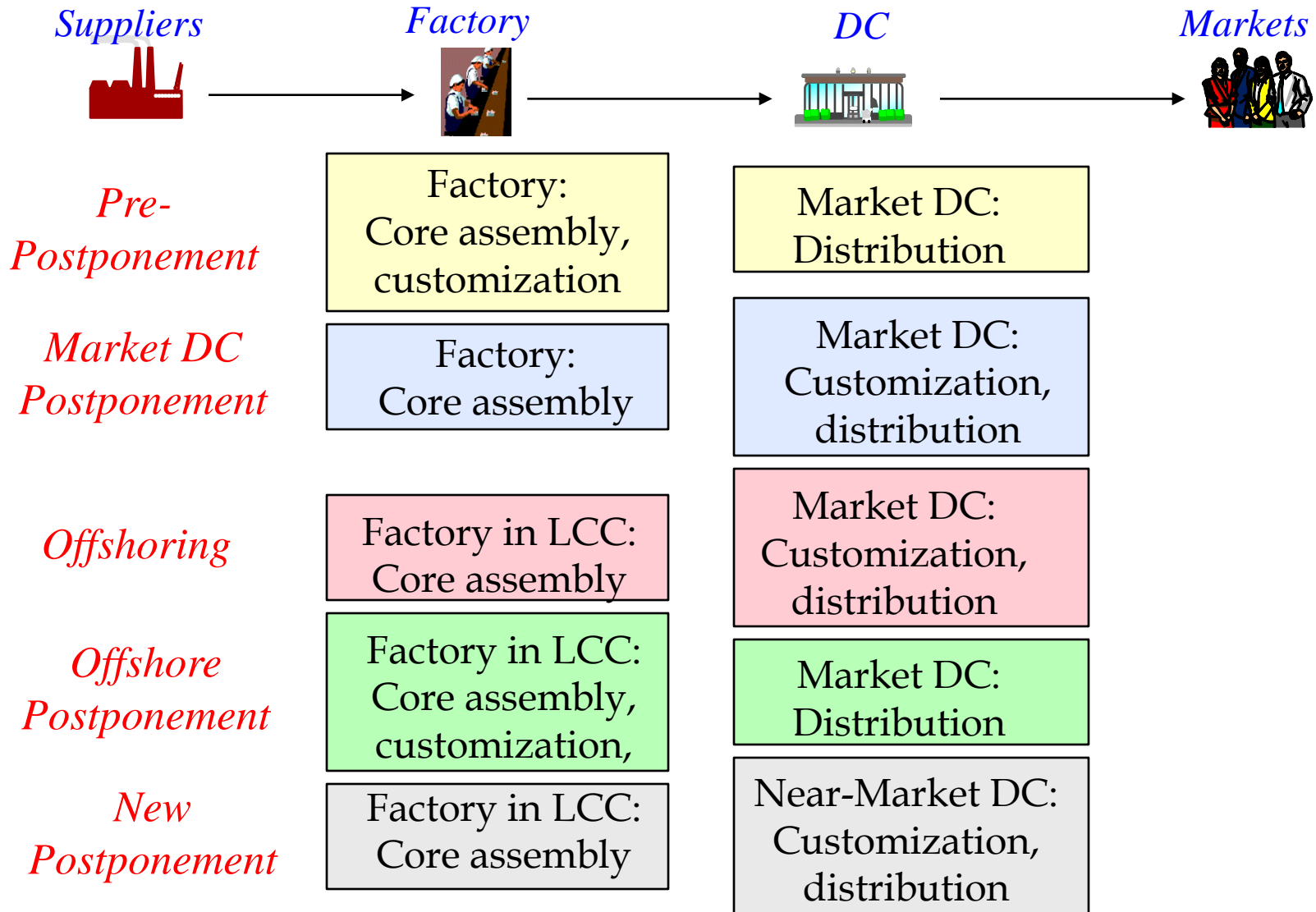
# Complications with Emerging Economies

- 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



# Evolution of Postponement



# Supply Chain Evolution

*Drivers*

*Mfg Strategy*

70's	Capability & control	W. Europe
80's	Cost reduction	E. Europe
90's	Cost & supply network	China
Today	Service pressure, China cost, oil prices	Dual-Response

# 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.

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# Stanford Trade Process Model\*



\* Joint research with Warren Hausman, sponsored by Tradebeam

# Information-Based Innovations

*Focus*

*Values*

Process  
Excellence

- Faster
- More accurate
- More reliable

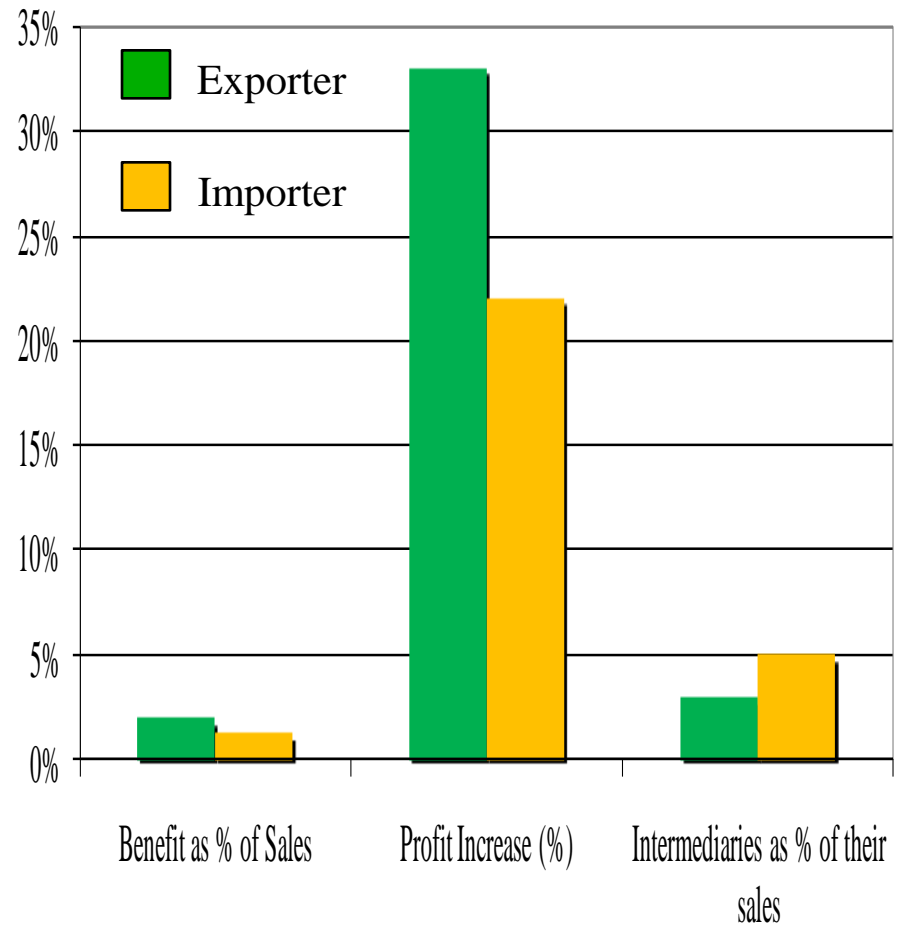
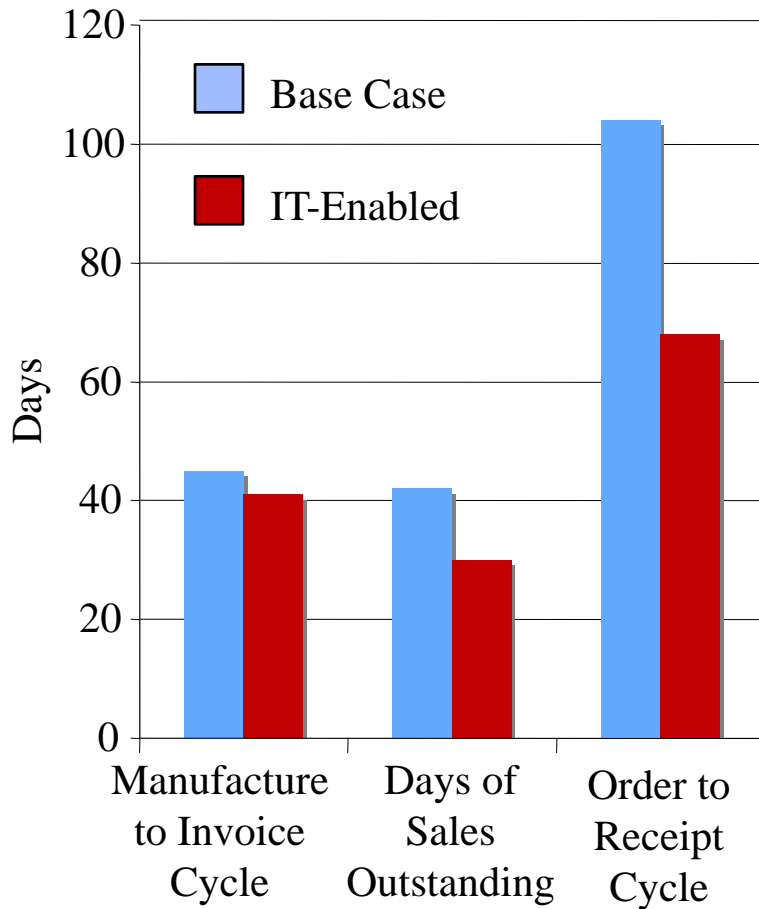
- Shorter cycle time
- Less delays & reworks
- Lower capital tied up
- Faster cash cycle

Process  
Redesign

- Re-sequencing
- Parallel processing
- Elimination

- Less penalties from errors
- Accurate duty payment and refunds

# IT-Enabled Benefits



\* Joint research with Warren Hausman, China-US apparel trade lane

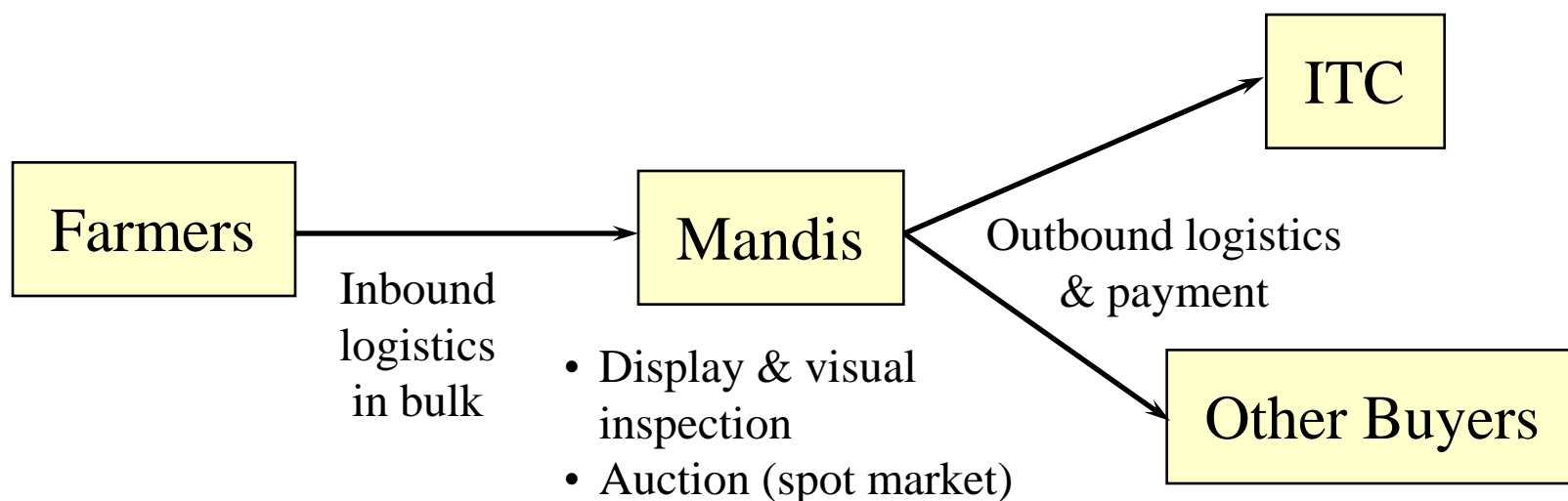
# Implications for Research

- 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

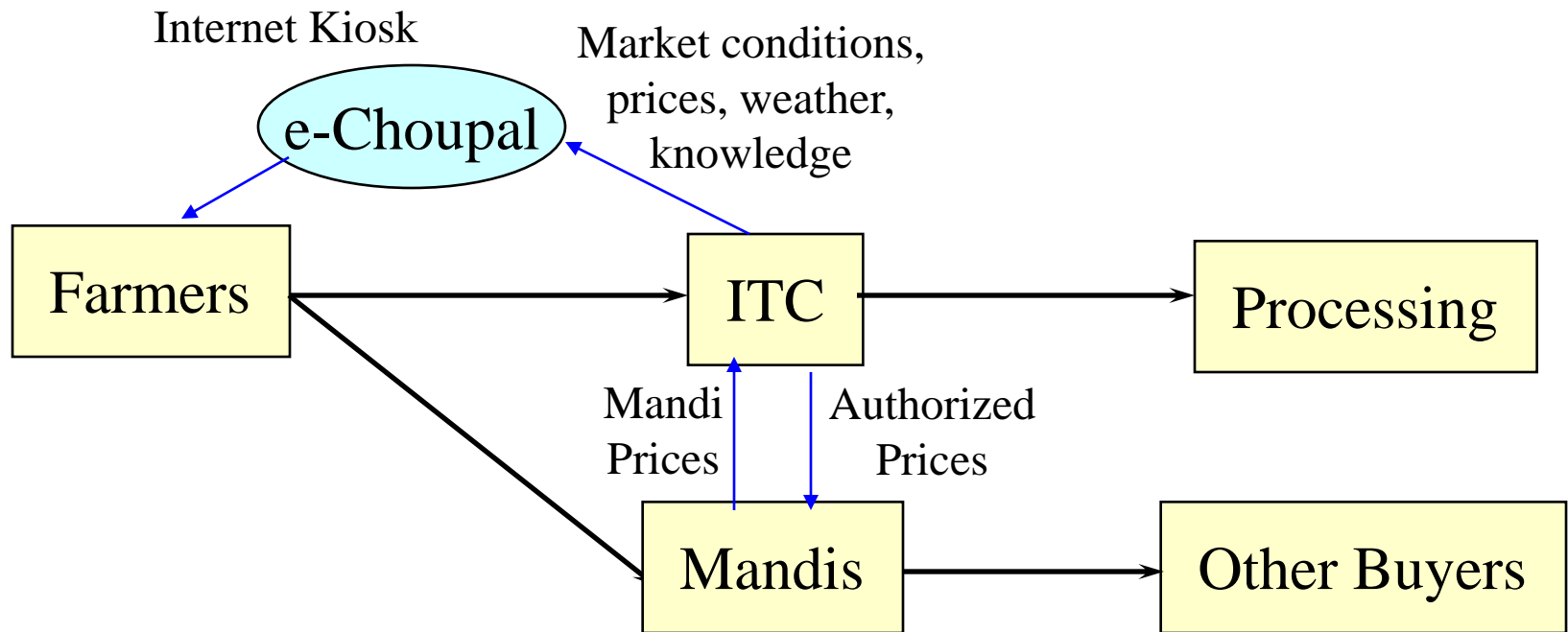
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# Soy Bean Supply Chain in India



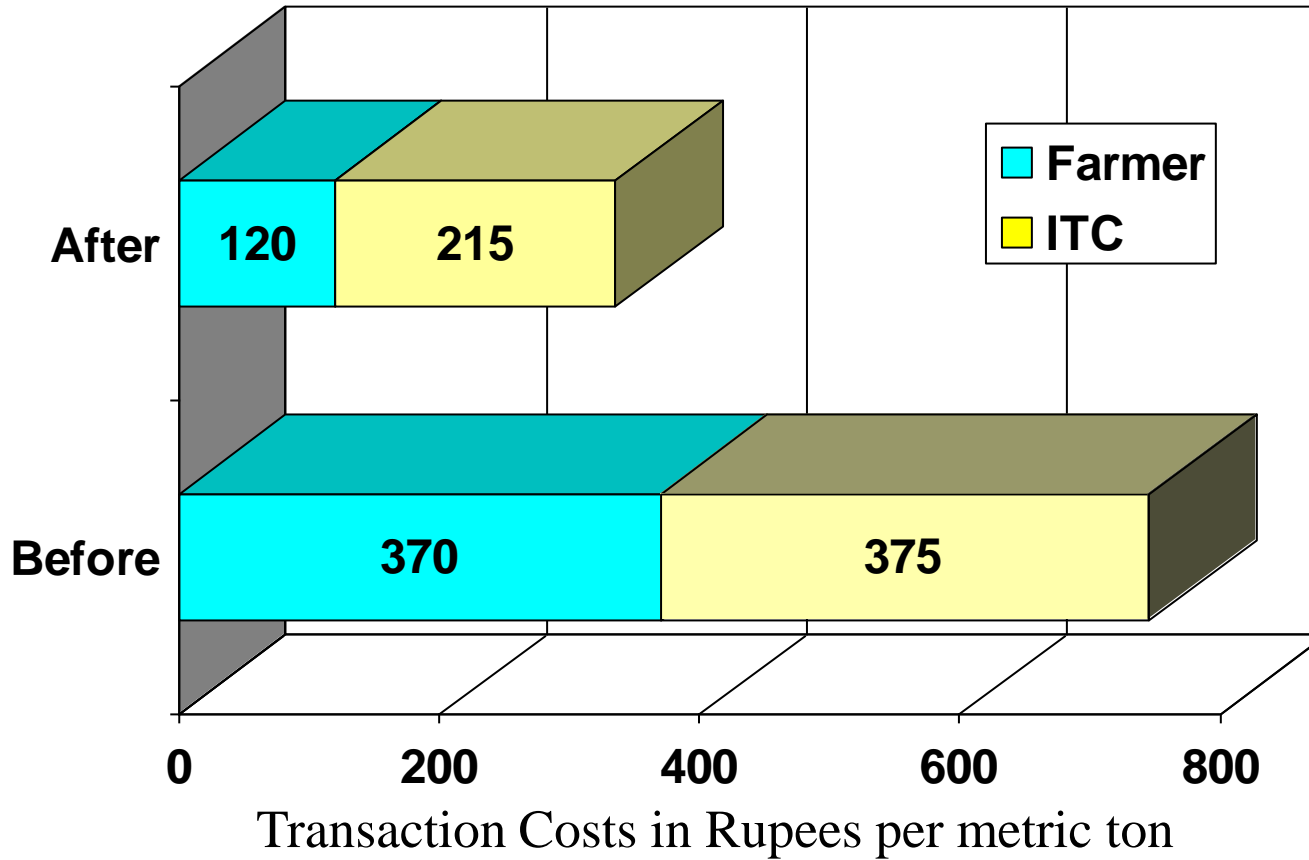
- Congestion at Mandis can hold up farmers for days.
- Price uncertainty faced by farmers – material flow must precede price information discovery.
- Farmers rely on word of mouth or localized previous prices.
- Farmers vulnerable to delayed payments.

# 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.

# Win-Win Value Proposition



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.

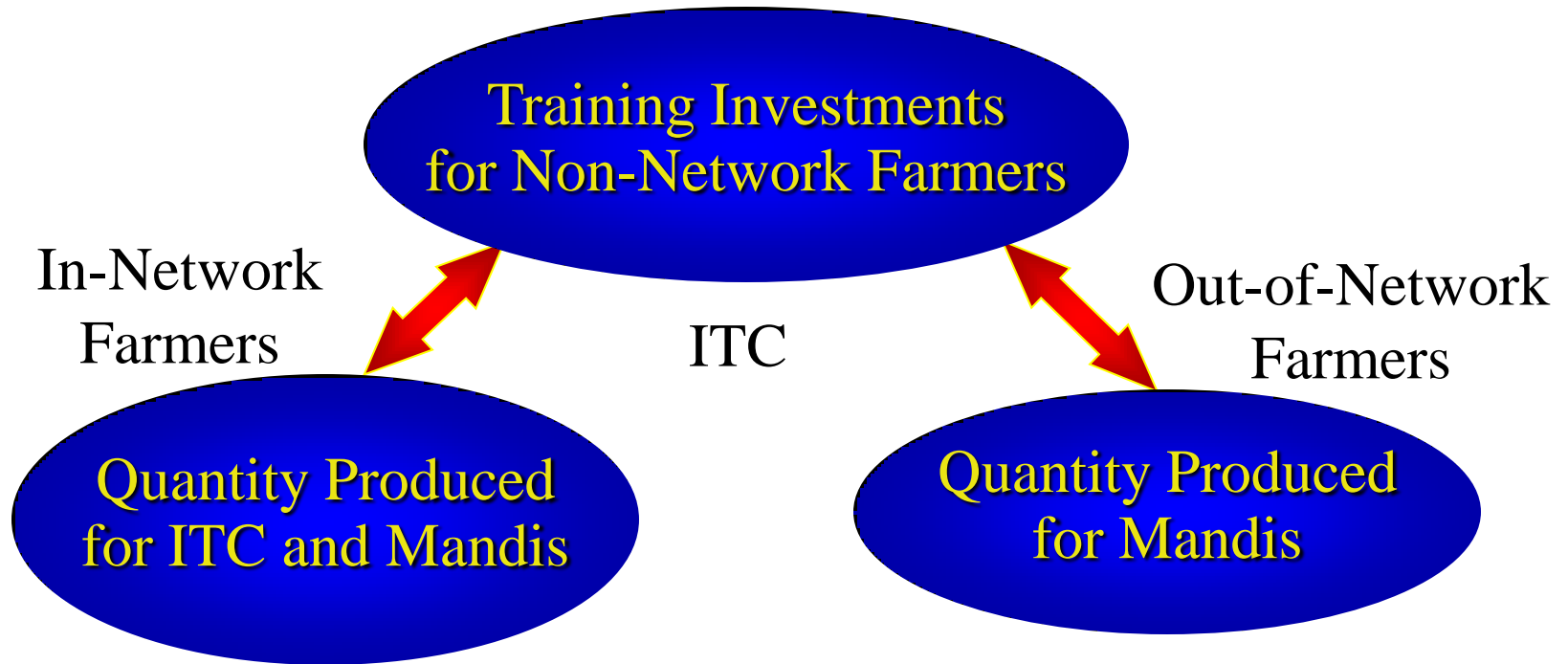


# Modeling ITC and Farmers Incentives\*

- 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?

\* Chen et al., Working Paper, 2008.

# Decisions by Players



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).

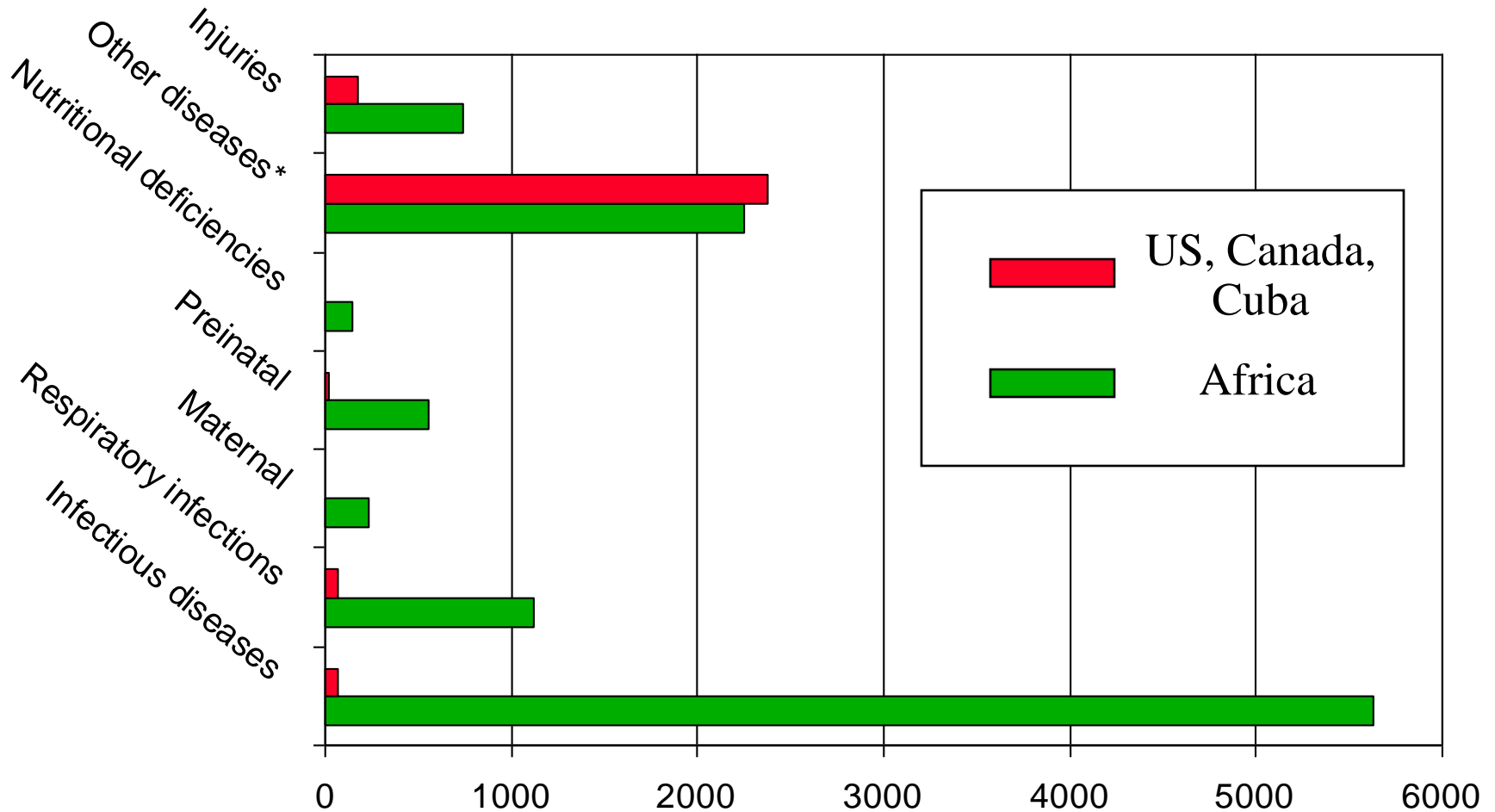
# Implications for Research

- 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

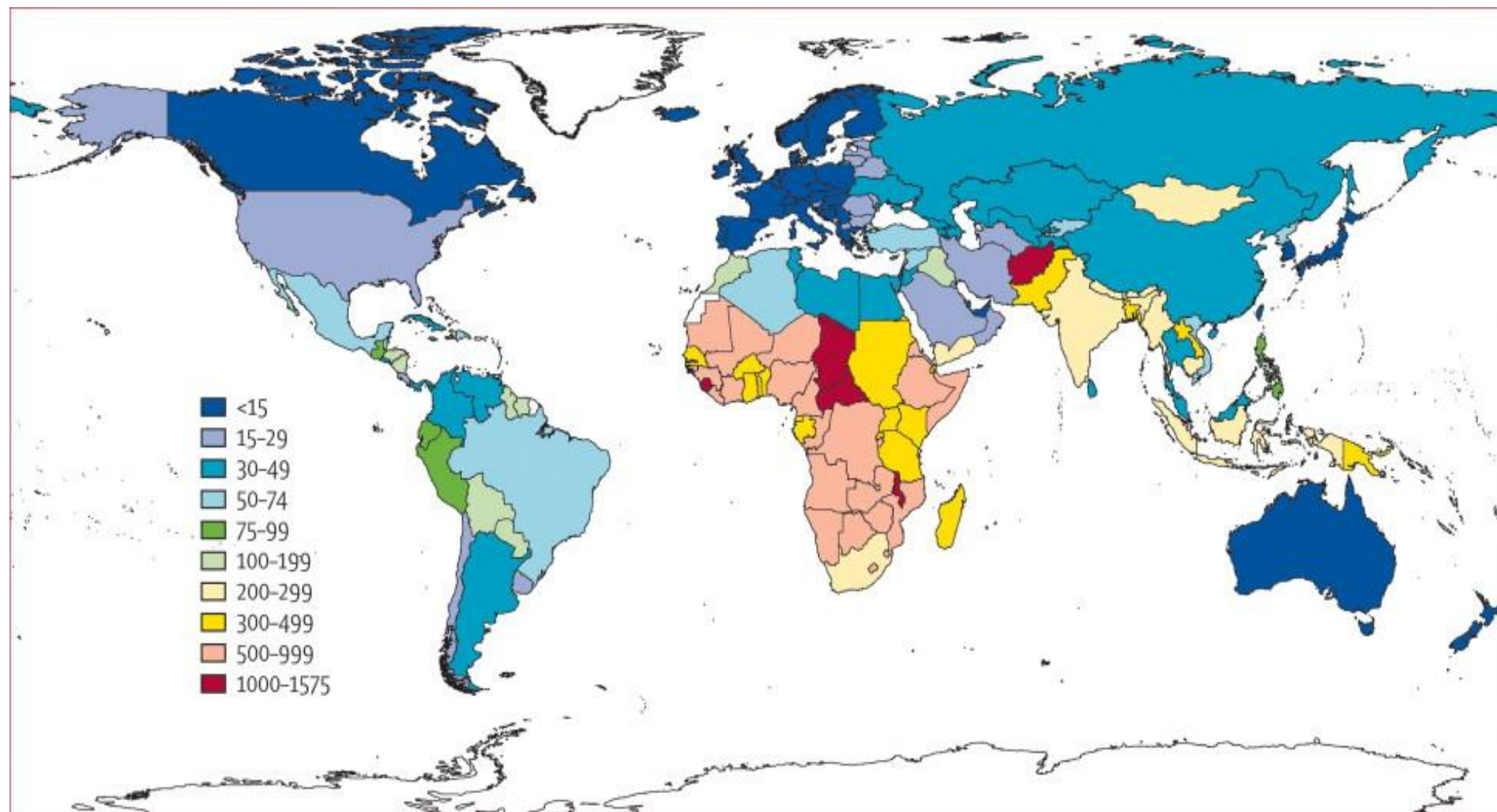
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# Causes of Deaths in 2002



\* Cancer, diabetes, neuropsychiatric disorders, cardiovascular diseases and respiratory diseases, etc.

# Maternal Mortality Ratio (per 100,000 livebirths, 2008)



Hogan et al., *Lancet*, 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

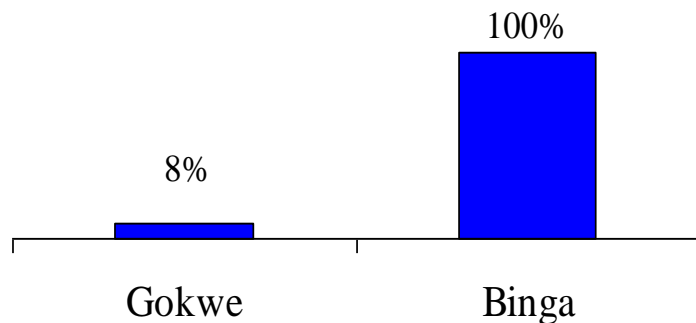
- Standardization of vehicle fleets.
- Preventive maintenance practices:
  - Self pre-ride checks by health workers
  - Monthly service by Riders-trained technician.
  - Extend useful life of motorcycles from 20,000 km to 80,000 km.
- Hub-and-spokes model for service support.
- Spare parts inventory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



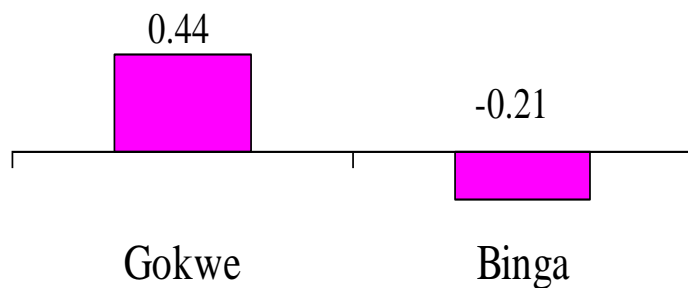
# Impact (2001-2002)



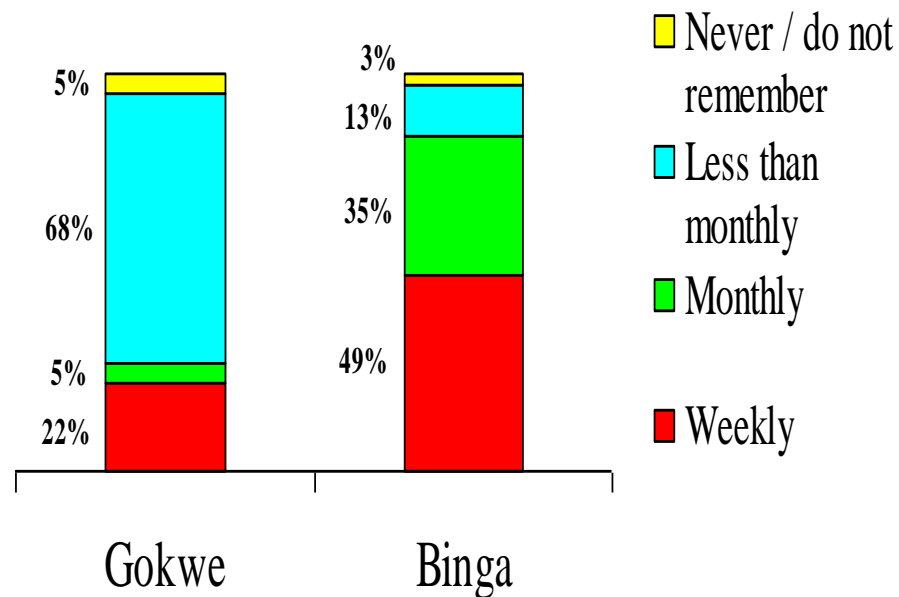
% of population indicating increased visits



% change in malarial deaths



Frequency of health worker visits



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.

# Stated Policy Not Followed

No. of Retired Vehicles and Their Ages and Odometers

Odometer ( '000 km)	> 150	5	110
	< 150	16	84
		<i>Below 5</i>	<i>Above 5</i>
		Age in Years	

- 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.

# 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

	Data	Inter-Flow Complexity	Dynamics	Incentives
Supply chain network design		✓	✓	
Product design for diverse market needs		✓	✓	
Process efficiency improvements	✓	✓		
Business model re-engineering		✓		✓
Socially responsible supply chains	✓			✓

# 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.