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Global Sourcing and Economic Integration

Professor N. Viswanadham
Center for Global Logistics and Manufacturing Strategies
Indian School of Business
Hyderabad
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n_viswanadham@isb.edu

Global Supply Chain

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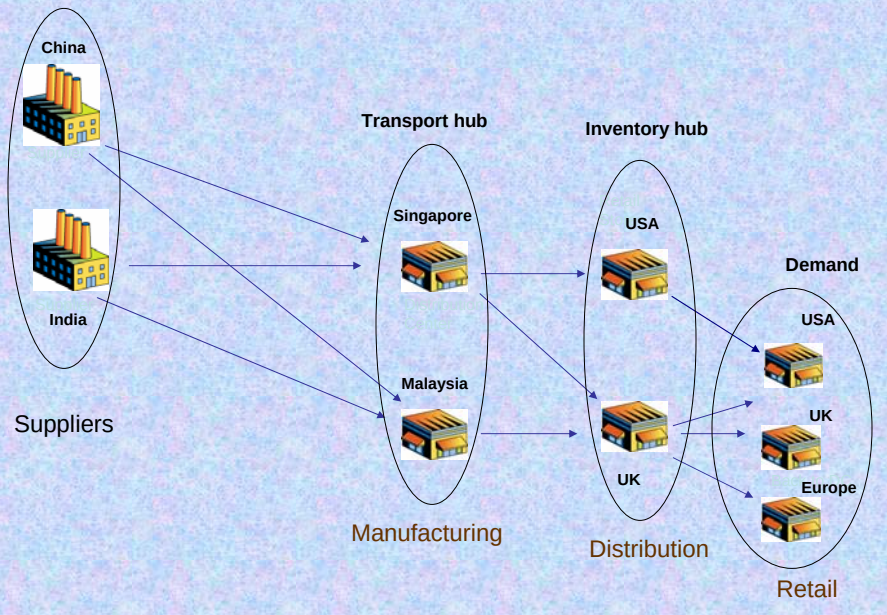
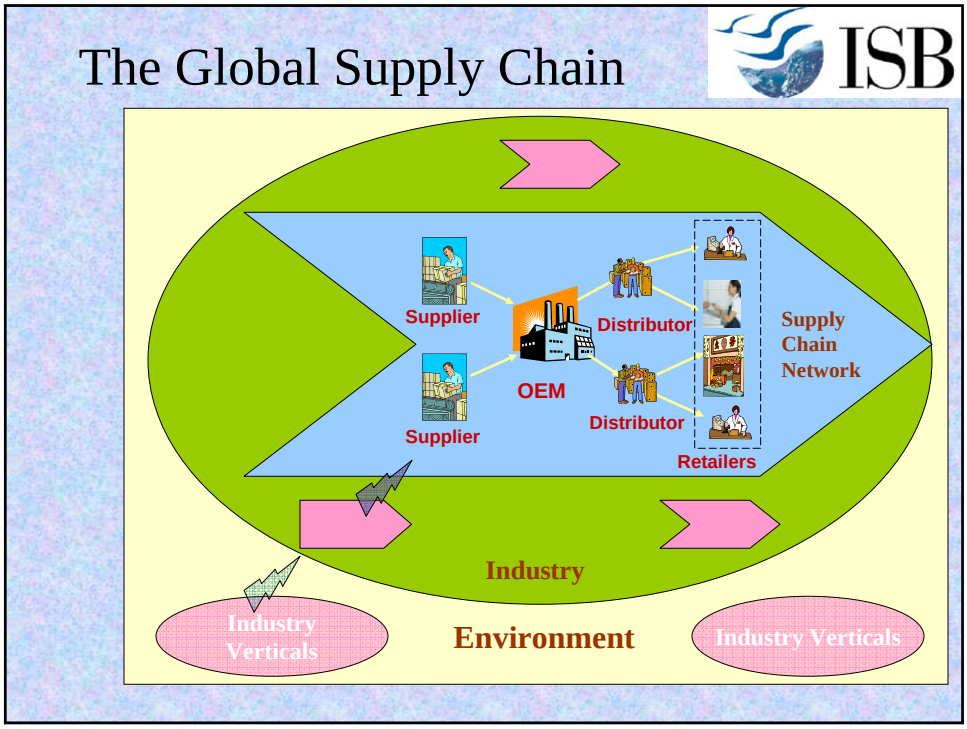
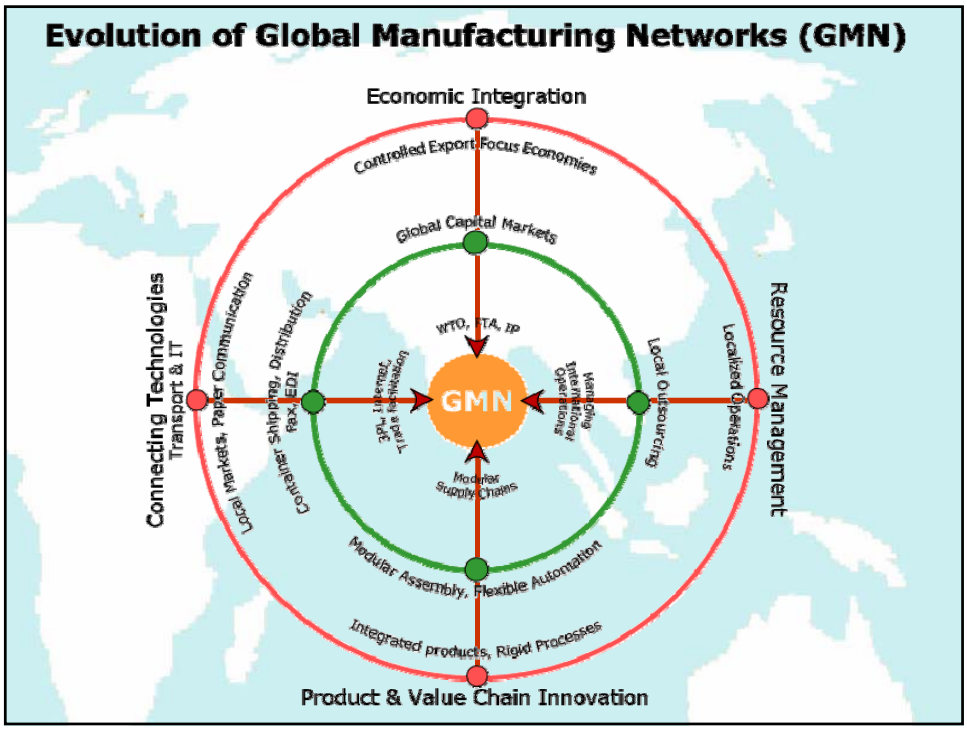



The Global Supply Chain
ISB
Supplier
Supplier
OEM
Distributor
Distributor
Retailers
Supply Chain Network
Industry
Industry Verticals
Environment
Industry Verticals


Evolution of Global Manufacturing Networks (GMN)
Economic Integration
Controlled Export Focus Economies
Global Capital Markets
WTO, FTA, IP
GMN
Modular Supply Chains
Modular Assembly, Flexible Automation
Integrated products, Rigid Processes
Product & Value Chain Innovation
Connecting Technologies
Transport & IT
Local Markets, Paper Communication
Containerisation, Shipping, Distribution
EDI, Fax
3rd / 4th party logistics, Internet, Trade e-business
Managing International Operations
Local Outsourcing
Localized Operations
Resource Management

Country Issues

- Economic policy and trade issues
- Generation of Resources that give a comparative advantage
- Infrastructure creation
- Industry Policy

Company Issues

- Product life cycle management
- Value chain
- Resource management
- Logistics and IT management

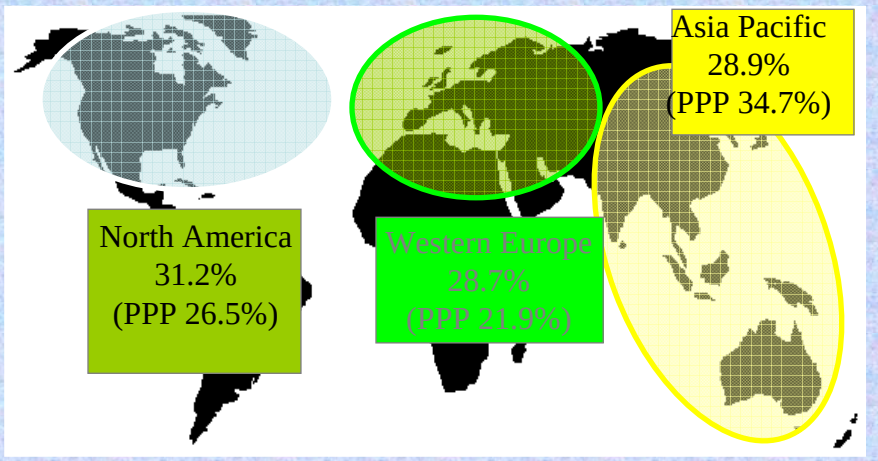
Agenda

- International Trade- Issues
- Regional Integration
- FDI vs Outsourcing
- Global sourcing

International Trade- Issues

The Three Great Circles

Shares of World GDP, 2004



International Trade

- International logistics flows are substantially more complex, with as many as 25-30 hands-off points within a complex global move.
- Lead times are substantially longer (measured in weeks, unless expensive air freight is used) – total transit times of 21-35 days from Asia are common.
- There is substantially more documentation required (commercial invoices, customs paperwork, etc.).
- There are as many as 7 times the number of cost elements to consider, including duties, tariffs, freight forwarding costs, etc.
- Security issues in the global sourcing process require a new level of intelligent logistics software capable or higher levels of tracking and notification,

Standardization, Integration of Trade Flows

- Trade flows are facilitated by harmonization of information, material & financial flows.
  - Need to define standards for each of these flows to ensure hand-off from one country to another
  - Trading Blocs achieve this harmonization enhancing intra-Bloc trade
  - Forrester says that countries e-ready countries will benefit from enhanced trading activity between themselves.

Customs plays a key role in International Trade.

- The liberalization and globalization of trade in the 21st Century, has brought about a paradigm shift,
  - The conventional and traditional role of customs as a regulatory and revenue collecting agency, has been complemented with that of trade facilitation.
- Customs has substantial impact on the movement of goods across international borders
  - The Every international trade transaction involves at least two Customs intervention; one at the import level and the other is at the export level.
- Trade document automation is common in south east Asian countries
  - Singapore saves 1bn USD a year on use of Trade net

Efficient Global Logistics is more than Brick and Mortar Infrastructure

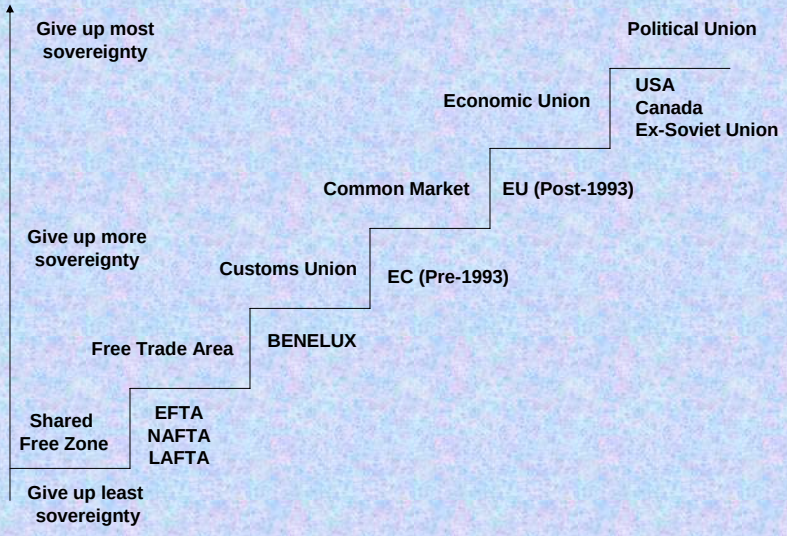
- Most developing nations have a single-minded devotion to expanding their hard infrastructure such as airports, highways, and shipping ports
- They Overlook other network components — such as efficient customs clearance and quality trucking services — that can have a strong impact on GDP.
- There is a tremendous need to understand the balance between brick-and-mortar projects and policies, regulations, and enforcement measures.
  - Speeding up customs clearance, automating the trade documentation process and making processing times more consistent, would allow companies to reduce inventory levels

Indirect and Direct Costs

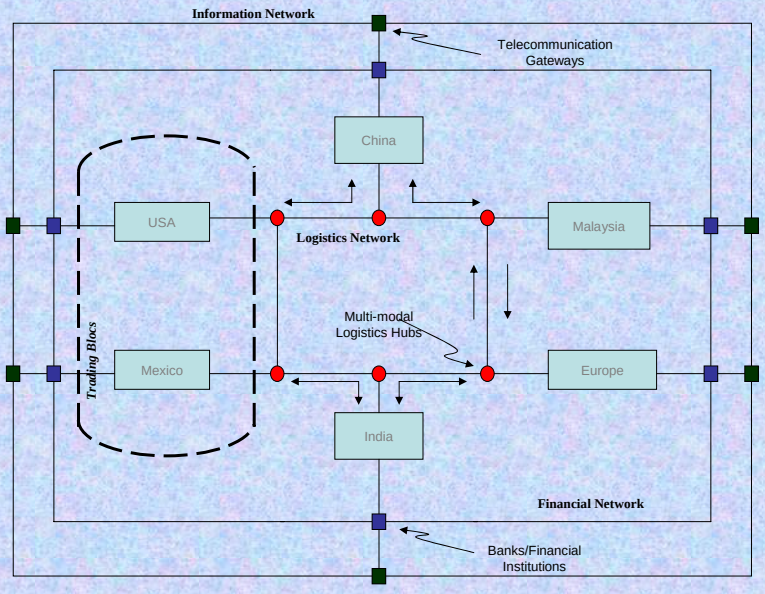
- In any economy, the logistics industry bears substantial direct and indirect costs.
  - Direct costs such as transportation, warehousing, and handling, are more transparent.
  - Indirect costs such as stock-outs, unnecessary high inventories, and obsolescence, are much less visible
- Efficient logistics can increase the cost competitiveness of nations

Regional Integration

Hierarchy of Economic Integration



Integrated Trading Blocs



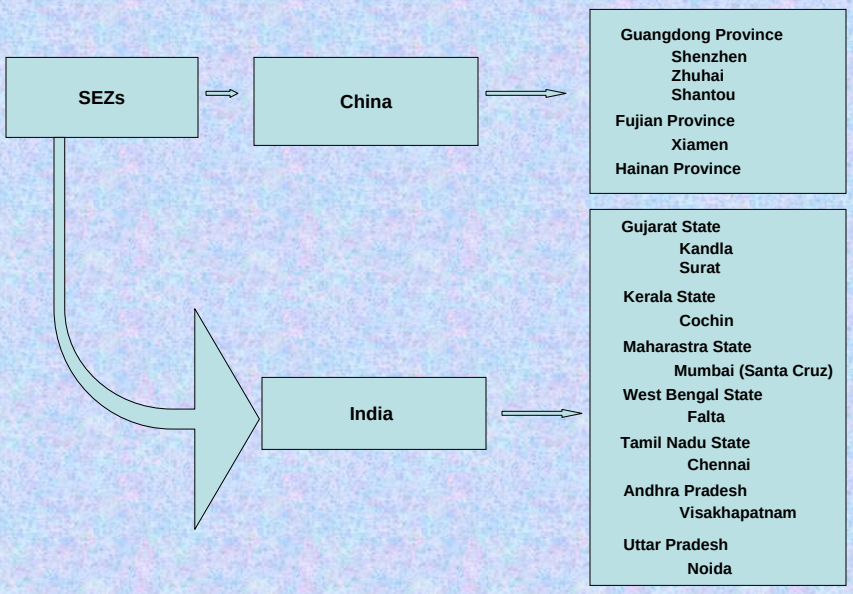
Free Trade Zones (FTZ s)

- Special Economic Zones
- Export bound goods can enjoy tax-holidays
- Deemed to be a foreign territory for export bound trade operations

Special Economic Zones (SEZ s)

- SEZ is a geographical region that has economic laws different from the country's typical economic laws.
- The purpose of SEZs in a country is to boost its foreign investments.
- SEZs have been established in many countries – China, India, Jordan, Poland, Kazakhastan, Philippines, Russia, and, North Korea.

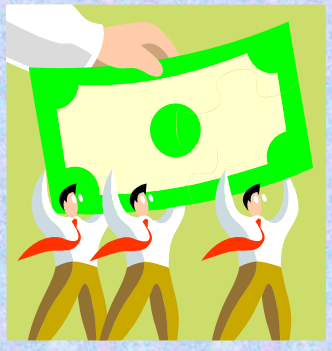
SEZs – China and India



FDI vs Outsourcing

Foreign Direct Investment (FDI)

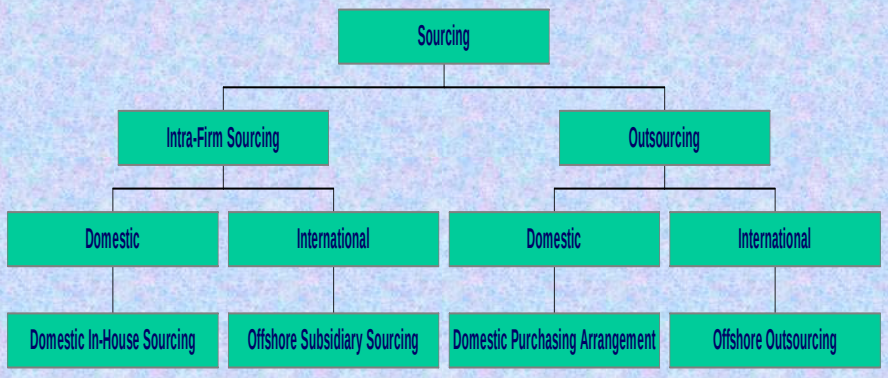
- Movement of capital across national borders in a manner that grants investor control over the acquired asset.
- Management control is with the investing company even though the operations are carried out at Low Cost Centers (LCCs).



Outsourcing

- Delegation of non-core operations or jobs from an internal production to an external entity that specializes in that operation.
- Significant amount of management control is delegated to the supplier.

Global Sourcing Alternatives



A company procures major components in-house by procuring them domestically

A company procures major components from its foreign subsidiary

A company buys major components from independent suppliers at home

A company buys major components from independent suppliers internationally

Source: Kotabe (2000)

FDI-Outsourcing Alternatives

- FDI-Outsourcing alternatives that are considered for North and South bound demand.
  - Alternative-1 : Outsourced to a low cost country in South - Outsource South.
  - Alternative-2 : Outsourced to a low cost country in North (other than the home country) – Outsource North.
  - Alternative-3 : Outsourced to a low cost supplier at home – Outsource Home.
  - Alternative-4 : FDI in a low cost country in South – FDI South.
  - Alternative-5 : FDI in a low cost country in North (other than the home country) – FDI North.
  - Alternative-6 : Manufacturing/assembling at home (in-house production) – In-house.
- Corporate headquarters (home) of a multinational company under consideration is assumed to be North.

Problem Addressed ?

- Supply chain winners are those who identify and successfully implement the best strategies.
- We address the problem of designing an efficient global supply chain by taking into account the various sourcing alternatives, regulatory factors and risks.

Problem Statement and Modeling

Problem Statement

- Let $S_1, S_2, \ldots, S_N$, be N stages of a supply chain.
- Let $A_1, A_2, \ldots, A_K$, be K different FDI/outsourcing alternatives associated with each stage.
- A 0-1 FDI-outsourcing strategy is obtained by choosing exactly one alternative for each stage.

Problem Statement (continued)

- A 0-1 FDI-outsourcing strategy S can be represented as (s_{il}), where $s_{il} = 1$ if for stage i, alternative l is chosen, $s_{il} = 0$, otherwise.
- Cost associated with a strategy S is defined as,

$$\sum_{i=1}^{N} \sum_{l=1}^{K} c_{il} s_{il},$$

where c_{il} is the cost associated with the l^{th} alternative of the i^{th} stage.

- An optimal 0-1 FDI-outsourcing strategy would have the minimum cost.
- The problem of determining optimal FDI-outsourcing strategy is referred as FDI-outsourcing decision problem.

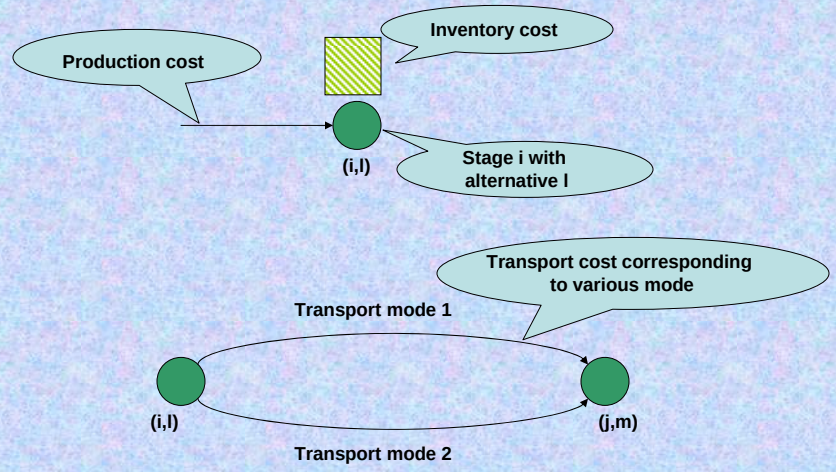
Problem Statement (continued)

- Relaxed version of 0-1 FDI-outsourcing strategy, S, would have $0 \leq s_{il} \leq 1$.
- In the relaxed context, 0-1 FDI-outsourcing strategy and 0-1 FDI-outsourcing decision problem are referred as FDI-outsourcing strategy and FDI-outsourcing decision problem, respectively.

Modeling

- The problem is modeled as MINLP by taking different scenarios into consideration
- Models
  - Single-product case (Base model)
  - Multi-product case
  - Incorporating duty
  - Incorporating risk

Costs considered in the Base Model



Model for Single Product Scenario (Base Model)

$$\text{MINLP1}: \min \sum_{i=1}^{N}\sum_{l=1}^{K} PC_{il}\lceil\frac{D_i x_{il}}{PLS_{il}}\rceil + \sum_{i=1}^{N}\sum_{l=1}^{K}\sum_{j:(i,j)\in A(G)}\sum_{m=1}^{K}\sum_{r=1}^{n_{mode}} TC_{iljmr}\lceil\frac{D_j y_{iljmr} x_{il} x_{jm}}{TLS_{iljmr}}\rceil + \sum_{i=1}^{N}\sum_{l=1}^{K} IHC_{il}\lceil\frac{D_i x_{il}}{IHLS_{il}}\rceil(ILT_{il}+PLT_{il}-OLT_{il})x_{il}$$

$$\text{subject to } \sum_{l=1}^{K} x_{il} = 1, \forall 1 \le i \le N,$$

$$\sum_{r=1}^{n_{mode}} y_{iljmr} = 1, \forall i,l,j,m, \text{ such that } (i,j)\in A(G),$$

$$OLT_{il}x_{il} + TT_{iljmr}y_{iljmr}x_{il}x_{jm} - ILT_{jm}x_{jm} \le 0, \forall i,l,j,m,r, \text{ such that } (i,j)\in A(G),$$

$$0 \le x_{il} \le 1, y_{iljmr} = 0 \text{ or } 1, ILT_{jm} \ge 0.$$

Number of days of inventory that need to be held

Sum of % of demand sourced through various alternatives equals 100%

Exactly one mode of transport is chosen

Inbound lead time of alternative m for stage j is at least the outbound lead time of alternatives and stages that it is dependent on and transport time from them

G - Supply chain G, A(G) - Arcs (dependencies), D – demand, PLS – Production lot size, TLS – Transport lot size, IHLS – Inventory holding lot size, PC – Production cost per lot, TC – Transport cost per lot, IHC- Inventory holding cost per lot, PLT – Production lead time, OLT – Outbound lead time, ILT -Inbound lead time, TT – Transport time, $\lceil Q \rceil$ - smallest integer greater than Q
x, y, ILT – Decision variables. PLS is equal for all stages and divides IHLS and TLS.

Tax Integrated Model (TIM)

$$\text{MINLP (Tax Integrated Model)}: \text{minimize } w_{PC}(\sum_{i=1}^{N}\sum_{l=1}^{K} PC_{il}\lceil\frac{D_i x_{il}}{PLS_{il}}\rceil) + w_{TC}(\sum_{i=1}^{N}\sum_{l=1}^{K}\sum_{j:(i,j)\in A(G)}\sum_{m=1}^{K}\sum_{r=1}^{n_{mode}} TC_{iljmr}\lceil\frac{D_j y_{iljmr} x_{il} x_{jm}}{TLS_{iljmr}}\rceil) + w_{TAX}(\sum_{i=1}^{N}\sum_{l=1}^{K}\sum_{j:(i,j)\in A(G)}\sum_{m=1}^{K}\sum_{r=1}^{n_{mode}} TAX_{iljmr}\lceil\frac{D_j y_{iljmr} x_{il} x_{jm}}{TXLS_{iljmr}}\rceil) + w_{IHC}(\sum_{i=1}^{N}\sum_{l=1}^{K} IHC_{il}\lceil\frac{D_i x_{il}}{IHLS_{il}}\rceil(ILT_{il}+PLT_{il}-OLT_{il}))$$

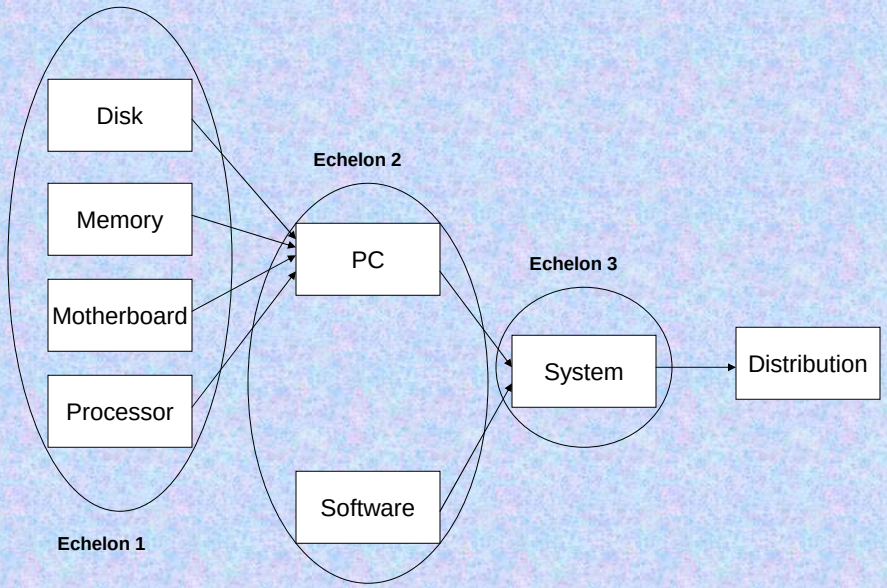
$$\text{subject to } \sum_{l=1}^{K} x_{il} = 1, \forall 1 \le i \le N,$$

$$\sum_{r=1}^{n_{mode}} y_{iljmr} = 1, \forall i,l,j,m, \text{ such that } (i,j)\in A(G),$$

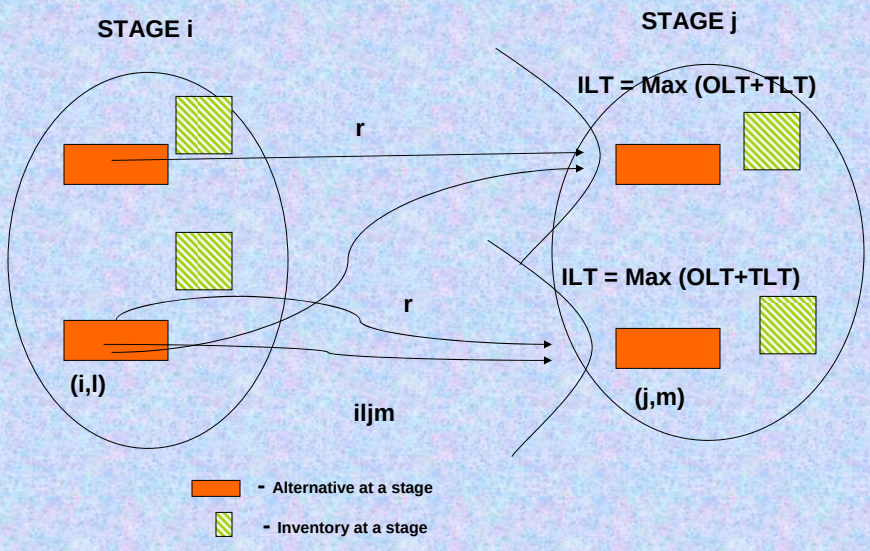
$$OLT_{il} + TT_{iljmr} - ILT_{jm} \le 0, \forall i,l,j,m,r, \text{ such that } (i,j)\in A(G),$$

$$0 \le x_{il} \le 1, y_{iljmr} = 0 \text{ or } 1, ILT_{jm} \ge 0.$$

A 8-stage Supply Chain



Base Model Details



Model Incorporating Duty

$$\text{MINLP3}: \min \sum_{i=1}^{N}\sum_{l=1}^{K} PC_{il}\lceil\frac{D_i x_{il}}{PLS_{il}}\rceil$$
$$+\sum_{i=1}^{N}\sum_{l=1}^{K}\sum_{j:(i,j)\in A(G)}\sum_{m=1}^{K}\sum_{r=1}^{n_{mode}} TC_{iljmr}\lceil\frac{D_j y_{iljmr} x_{il} x_{jm}}{TLS_{iljmr}}\rceil$$
$$+\sum_{i=1}^{N}\sum_{l=1}^{K}\sum_{j:(i,j)\in A(G)}\sum_{m=1}^{K}\sum_{r=1}^{n_{mode}} DUTY_{iljmr} D_j x_{iljmr} x_{il} x_{jm}$$
$$+\sum_{i=1}^{N}\sum_{l=1}^{K} IHC_{il}\lceil\frac{D_i x_{il}}{IHLS_{il}}\rceil(ILT_{il}+PLT_{il}-OLT_{il})x_{il}$$
$$\text{subject to } \sum_{l=1}^{K} x_{il}=1, \forall 1\le i\le N,$$
$$\sum_{r=1}^{n_{mode}} y_{iljmr}=1, \forall i,l,j,m, \text{ such that } (i,j)\in A(G),$$
$$OLT_{il}x_{il}+TT_{iljmr}y_{iljmr}x_{il}x_{jm}-ILT_{jm}x_{jm}\le 0, \forall i,l,j,m,r,$$
$$\text{such that } (i,j)\in A(G),$$
$$0\le x_{il}\le 1, y_{iljmr}=0 \text{ or } 1, ILT_{jm}\ge 0.$$

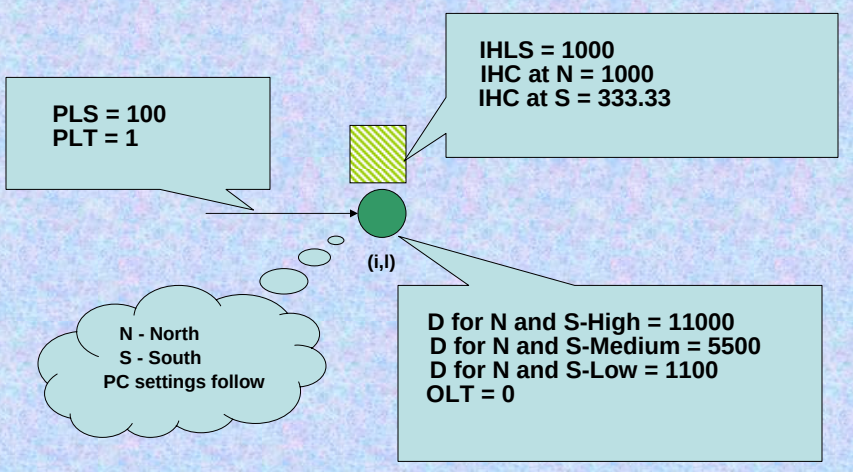
DUTY - Duty (import tax) incurred per unit

Analysis of the Base Model

FDI-Outsourcing Alternatives

- FDI-Outsourcing alternatives that are considered for North and South bound demand.
  - Alternative-1 : Outsourced to a low cost country in South - Outsource South.
  - Alternative-2 : Outsourced to a low cost country in North (other than the home country) – Outsource North.
  - Alternative-3 : Outsourced to a low cost supplier at home – Outsource Home.
  - Alternative-4 : FDI in a low cost country in South – FDI South.
  - Alternative-5 : FDI in a low cost country in North (other than the home country) – FDI North.
  - Alternative-6 : Manufacturing/assembling at home (in-house production) – In-house.
- Corporate headquarters (home) of a multinational company under consideration is assumed to be North.

Parameters Setting - Nodes



Production Cost - North

- Production cost for all stages in the case of North bound demand

Production cost at stage-i, i=1,2,…,8.

Alternative/Demand Type	High	Medium	Low
Alternative-1	150	200	250
Alternative-2	100	150	200
Alternative-3	50	100	150
Alternative-4	200	250	300
Alternative-5	150	200	250
Alternative-6	100	150	200

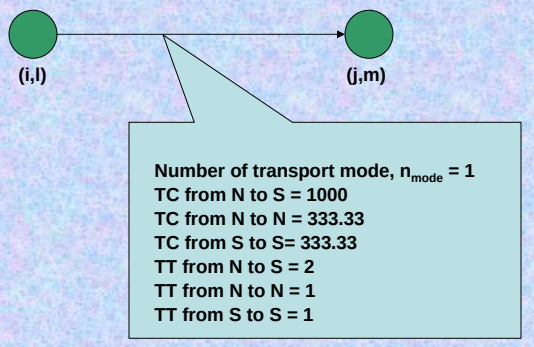
Production Cost - South

- Production cost for all stages in the case of South bound demand

Production cost at stage-i, i=1,2,…,8.

Alternative/Demand Type	High	Medium	Low
Alternative-1	50	100	150
Alternative-2	100	150	200
Alternative-3	150	200	250
Alternative-4	100	150	200
Alternative-5	150	200	250
Alternative-6	200	250	300

Parameters Setting - Arcs



Output of the Model

- The model was analyzed for high, medium and low demand cases, for the demand at North and South, individually.
  - For North, North-high, North-medium, North-low, correspond to, High, Medium and low demand cases.
  - For South, South-high, South-medium, South-low, correspond to, High, Medium and low demand cases.
- The output of the model for these various cases follow.

North-High Strategy

	Echelon		
	1	2	3
Outsource South	0	0	0
Outsource North	38	36	26
Outsource Home	38	36	26
FDI South	0	0	0
FDI North	0	8	22
In-house	24	20	26

North-Medium Strategy

	Echelon		
	1	2	3
Outsource South	0	0	0
Outsource North	37	35	26
Outsource Home	37	35	25
FDI South	0	0	0
FDI North	3	10	24
In-house	23	20	25

North-Low Strategy

	Echelon		
	1	2	3
Outsource South	0	0	0
Outsource North	32	32	25
Outsource Home	32	30	25
FDI North	0	0	0
FDI South	15	18	25
In-house	21	20	25

South-High Strategy

	Echelon		
	1	2	3
Outsource South	71	67	56
Outsource North	0	0	0
Outsource Home	0	0	0
FDI South	29	33	44
FDI North	0	0	0
In-house	0	0	0

South-Medium Strategy

	Echelon		
	1	2	3
Outsource South	69	66	55
Outsource North	0	0	0
Outsource Home	0	0	0
FDI South	32	34	45
FDI North	0	0	0
In-house	0	0	0

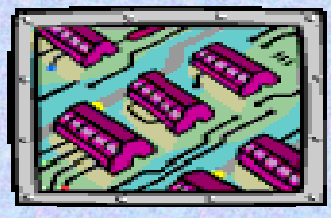
South-Low Strategy

	Echelon		
	1	2	3
Outsource South	59	60	50
Outsource North	0	0	0
Outsource Home	0	0	0
FDI South	41	40	50
FDI North	0	0	0
In-house	0	0	0

Insights from the output

- Optimal strategy is to produce in North and South for the North and South bound demand, respectively.
- Cost effective strategy -
  - Outsource when the demand is high
  - FDI or manufacture in-house when the demand is low
- The echelons which are closer to the end customers should be substantially owned by the company, even though the echelons which are farther away from the end customers could be outsourced.

Future Directions



Challenge

- The challenge for the managers
  - Meet the demand at the various global locations
  - Optimally manage manufacturing, inventory, and assembling, for the global demand by taking into account the tax and tariff structure at FTZs and DTA s

Other Topics of Research

- Analyzing the tax-integrated FDI-outsource problem by taking into account the tax and other government policies of various developing economies such as India and China.
- Analyzing the problem under various capacity restrictions that may be posed by various entities in the supply chain.

Model for Multi-Product Scenario

$$\text{MINLP2}: \min \sum_{i=1}^{N}\sum_{l=1}^{K}\sum_{P\in\mathcal{P}_{il}} PC_{ilP}\lceil\frac{D_{jP}x_{ilP}}{PLS_{ilP}}\rceil$$
$$+\sum_{i=1}^{N}\sum_{l=1}^{K}\sum_{j:(i,j)\in A(G)}\sum_{m=1}^{K}\sum_{P\in\mathcal{P}_{il},\mathcal{P}_{jm}}$$
$$\sum_{r=1}^{n_{mode}} TC_{iljmPr}\lceil\frac{D_{jP}y_{iljmPr}x_{ilP}x_{jmP}}{TLS_{iljmPr}}\rceil$$
$$+\sum_{i=1}^{N}\sum_{l=1}^{K}\sum_{P\in\mathcal{P}_{il}} IHC_{ilP}\lceil\frac{D_{iP}x_{ilP}}{IHLS_{ilP}}\rceil(ILT_{ilP}+PLT_{ilP}-OLT_{ilP})x_{ilP}$$
$$\text{subject to } \sum_{l=1}^{K} x_{ilP}=1,\forall 1\le i\le N, P\in\mathcal{P}_{il},$$
$$\sum_{r=1}^{n_{mode}} y_{iljmPr}=1,\forall i,l,j,m,P,$$
$$\text{such that } (i,j)\in A(G), P\in\mathcal{P}_{il},\mathcal{P}_{jm},$$
$$OLT_{ilP}x_{ilP}+TT_{iljmPr}y_{iljmPr}x_{ilP}x_{jmP}-ILT_{jmP}x_{jmP}\le 0,$$
$$\forall i,l,j,m,r,P, \text{ such that } (i,j)\in A(G), P\in\mathcal{P}_{il},\mathcal{P}_{jm},$$
$$0\le x_{ilP}\le 1, y_{iljmPr}=0 \text{ or } 1, ILT_{jmP}\ge 0.$$

P – **Set of all products**

P_{il} - **Set of P such that,** $\delta_{il}^{P}=1$ **, where,**

$\delta_{il}^{P}=1$ **if (i,l) can supply a component of P, and,**

$\delta_{il}^{P}=0$ **otherwise.**

Model Incorporating Risk

$$\text{MINLP4}: \min \sum_{i=1}^{N}\sum_{l=1}^{K} PC_{il}\lceil\frac{D_i x_{il}}{PLS_{il}}\rceil$$
$$+\sum_{i=1}^{N}\sum_{l=1}^{K}\sum_{j:(i,j)\in A(G)}\sum_{m=1}^{K}\sum_{r=1}^{n_{mode}} TC_{iljmr}\lceil\frac{D_j y_{iljmr}x_{il}x_{jm}}{TLS_{iljmr}}\rceil$$
$$+\sum_{i=1}^{N}\sum_{l=1}^{K} IHC_{il}\lceil\frac{D_i x_{il}}{IHLS_{il}}\rceil(ILT_{il}+PLT_{il}-OLT_{il})x_{il}$$
$$+\sum_{i=1}^{N} SR_i D_i z_i + +\sum_{i=1}^{N}\sum_{l=1}^{K}(R_{il}+PR_{il}+IPR_{il})D_i x_{il}$$
$$+\sum_{i=1}^{N}\sum_{l=1}^{K}\sum_{j=i+1}^{N}\sum_{m=1}^{K}\sum_{r=1}^{n_{mode}} TR_{iljmr}D_j x_{il}x_{jm}y_{iljmr}$$
$$\text{subject to } \sum_{l=1}^{K} x_{il}\le 1,\forall 1\le i\le N,$$
$$\sum_{r=1}^{n_{mode}} y_{iljmr}=1,\forall i,l,j,m, \text{ such that } (i,j)\in A(G),$$
$$z_i=1-\sum_{l=1}^{K} x_{il},\forall 1\le i\le N,$$
$$OLT_{il}x_{il}+TT_{iljmr}y_{iljmr}x_{il}x_{jm}-ILT_{jm}x_{jm}\le 0,\forall i,l,j,m,r,$$
$$\text{such that } (i,j)\in A(G),$$
$$0\le x_{il}\le 1, y_{iljmr}=0 \text{ or } 1, ILT_{jm}\ge 0.$$

PR – Risk due to production delay (per unit)
SR – Risk due to shortfall in inventory to satisfy the demand (per unit)
TR – Risk due to transport delay (per unit)
IPR – Risk due to intellectual property (per unit)
R – Relationship cost with the supplier (per unit)
z - Shortfall