CTL.SC3x- Supply Chain Dynamics

Key Concepts Document

This document contains the Key Concepts for the SC3x course. These are meant to complement, not replace, the lesson videos and slides. They are intended to be references for you to use going forward and assume that you have learned the concepts and completed the practice problems.

This draft was revised and updated by Dr. Alexis Bateman and Ahmed Bilal of MIT with support from our Community Teaching Assistants Mingrui Wei and Kris Kootale in the Winter of 2019 Version 3.

This is a draft of the material, so please post any suggestions, corrections, or recommendations to the Discussion Forum under the topic thread “Key Concept Documents Improvements.

Thanks,
The SCx Team, Summer 2019
Table of Contents

COMPLEX SYSTEMS ........................................................................................................... 5
  COMPLEXITY .................................................................................................................... 5
  BULLWHIP EFFECT ......................................................................................................... 8
  SYSTEM DYNAMICS ....................................................................................................... 11
  MODELING SYSTEM DYNAMICS .................................................................................. 15

SUPPLY CHAIN STRATEGY ............................................................................................... 22
  SUPPLY CHAIN STRATEGY ............................................................................................. 22
  RETHINKING YOUR SUPPLY CHAIN STRATEGY ......................................................... 28

PROCESS ANALYSIS & APPLICATIONS IN PRACTICE .................................................. 31
  PROCESS ANALYSIS IN PRACTICE .............................................................................. 31

GLOBAL SUPPLY CHAIN MANAGEMENT ......................................................................... 39
  GLOBAL SUPPLY CHAIN MANAGEMENT ..................................................................... 39
  INTERNATIONAL TRANSPORTATION ............................................................................ 44
  CURRENCY ISSUES AND FINANCING ........................................................................... 48
  SOURCING AND SHORING .............................................................................................. 54

EXOGENOUS FACTORS ..................................................................................................... 59
  ENTERPRISE RESILIENCE ............................................................................................. 59
  RESILIENCE FUNDAMENTALS ....................................................................................... 63
  EXOGENOUS FACTORS .................................................................................................. 66
  PALM OIL CASE STUDY .................................................................................................. 75

List of Figures

Figure 1: Traditional costs estimation underestimated additional complexity ................. 5
Figure 2: Complexity enters the SC through new products or through marketing and sales .... 6
Figure 13: Event-oriented approach to solve problems ..................................................... 11
Figure 14: Circular thinking and “side” effects ................................................................. 12
Figure 15: Causal Loop Diagram notation ....................................................................... 13
Figure 16: Example of a time lag and delay implemented using CLD ................................. 13
Figure 17: Stock and Flow diagram for a chicken-egg model ........................................... 14
Figure 18: CLD, BOT and S&F of a reinforcing loop ....................................................... 15
Figure 19: Behavior over time chart ................................................................................ 16
Figure 20: Preventing unintended consequences using BOT chart .................................. 16
Figure 21: CLD, BPT and S&F for a system with a shared resource ................................. 20
Figure 22: “A difficult, yet fundamental dichotomy”. Based on Shapiro and Heskett (1985) ... 23
Figure 23: Porter’s Five Forces ......................................................................................... 24
Figure 24: Growth share matrix. Source: adapted from Hedley (1977) ........................................... 25
Figure 25: SWOT Analysis .................................................................................................................. 26
Figure 26: Fisher’s 2*2 matrix. Source: Fisher, 1997 ......................................................................... 27
Figure 27: Lee’s matched strategies. Source: Lee, 2002 .................................................................. 27
Figure 28: The basic challenges ......................................................................................................... 28
Figure 3: Supply chain process variability ......................................................................................... 31
Figure 4: Main actors and processes in a supply chain ....................................................................... 32
Figure 5: Coordination across the functions in a SCM ....................................................................... 32
Figure 6: External facing processes .................................................................................................. 33
Figure 7: Order Fulfillment tasks ........................................................................................................ 34
Figure 8: Type of manufacturing processes ....................................................................................... 35
Figure 9: Product Development cycle ............................................................................................... 35
Figure 10: Returns Management tasks ............................................................................................... 36
Figure 11: Swim Lane Diagram .......................................................................................................... 37
Figure 12: Histogram ........................................................................................................................... 37
Figure 29: Duty Drawbacks ................................................................................................................. 40
Figure 30: Rules of Origin .................................................................................................................... 41
Figure 31: Four Main Groups of INCO Terms ...................................................................................... 44
Figure 32: Legs of an ocean shipment ................................................................................................. 45
Figure 33: Bull-Whip effect in the steamship industry ........................................................................ 46
Figure 34: Taxes on Foreign Earnings .................................................................................................. 50
Figure 35: Legal ways of avoiding double taxation and profit withholding ..................................... 51
Figure 36: Example of a Cash Flow Model .......................................................................................... 52
Figure 37: Payment Risk Diagram ...................................................................................................... 54
Figure 38: Causes and Effects of Disruptions .................................................................................... 60
Figure 39: Bow-Tie Risk Analysis Framework ...................................................................................... 61
Figure 40: Disruption Profile ............................................................................................................. 61
Figure 41: Two-dimensional classification: Disruption Probability vs. Consequences ....................... 62
Figure 42: Safety Pyramid .................................................................................................................... 64
Figure 43: DuPont Bradley Curve ....................................................................................................... 64
Figure 44: Impact of Regulation on the Supply Chain ....................................................................... 68
Figure 45: Pressure to Act Vs. Importance to Business ....................................................................... 73
Figure 46: Company Action Continuum .............................................................................................. 73
Figure 47: Uses of Palm Oil .................................................................................................................. 75
Figure 48: Palm Oil Production ............................................................................................................ 76
Figure 49: Palm Oil End to End Logistics ............................................................................................ 77
Figure 50: Problems with Palm Oil ...................................................................................................... 79

List of Tables

Table 1: Source of complexity ............................................................................................................. 5
Table 2: Main sources of variability for demand management .................................................. 34
Table 3: Stocks and Flows ......................................................................................................... 14
Table 4: Supply chain strategy evaluation criteria .................................................................... 28
Table 5: Free Trade Zones and Bonded Warehouses ............................................................... 42
Table 6: Trading Blocs ............................................................................................................... 43
Table 7: Air Freight Vs: Ocean Freight ....................................................................................... 45
Table 8: Types of Ships .............................................................................................................. 45
Table 9: Major railroad gauges in the world .............................................................................. 47
Table 10: Industry Response to Change ................................................................................... 56
Table 11: Where is Manufacturing Moving To ......................................................................... 56
Table 12: Example of Regulation ............................................................................................ 67
Complex Systems

Summary
Supply chain dynamics illustrates how reality can impact supply chains. We introduce the idea of complexity and we identify five main drivers of supply chain complexity. Supply chains are complex systems. However, a system is more than just the sum of its components, but rather also involves the product of their interactions and the need for their alignment.

Complexity
Supply chains are complex, are only getting more complex, complexity add costs to the supply chain! Therefore, we need to mitigate or minimize complexity. First we need to understand what complexity is!

Table 1: Source of complexity

<table>
<thead>
<tr>
<th>Product complexity</th>
<th>Customer complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small batch sizes</td>
<td>Customized products</td>
</tr>
<tr>
<td>Long set-up times</td>
<td>Short lead times</td>
</tr>
<tr>
<td>Unique components</td>
<td>Unpredictable orders</td>
</tr>
<tr>
<td>Special tests/inspections</td>
<td>Extensive technical support</td>
</tr>
<tr>
<td>Extensive material handling</td>
<td>Extensive post-sales support</td>
</tr>
<tr>
<td>Special vendors</td>
<td>Special tests or requirements</td>
</tr>
</tbody>
</table>

Figure 1: Traditional costs estimation underestimated additional complexity

Two types of complexity (Senge, 1990):
- Detail complexity: Distinct number of processes or parts within the system
- Dynamic complexity: Unpredictability of response of the system due to interactions

According to Herbet Simon (1962): “A system is complex if it is made up of a large number of parts that interact in a non-simple way”.

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Drivers of Complexity

Drivers of SC complexity (complexity increases according to these drivers):

- Numerousness - number of suppliers, products, customers...
- Variety/diversity of the different entities or components
- Interconnections/interactions between those entities
- Opacity of interactions
- Dynamic effects

Why do we care what the divers of complexity are? Drivers of complexity = the drivers of profitability.

Drivers of profitability:

- Increase revenue per unit
- Increase the number of customers
- Increase number of units sold
- Decrease cost per unit

Source of Complexity

Most complexity enters from the ends!

Start by mapping the complexity fingerprint: identifying where complexity lies by identifying the potential complexity drivers and count total number used.

Any initiative to reduce complexity in the SC needs to involve people from marketing and sales as well as from new product development under the R&D process.

Complexity-adjusted margin

\[
\text{Complexity ROI} = \frac{(\text{Incremental Margin} - \text{Variable Complexity Cost})}{(\text{Fixed Complexity Cost})}
\]
### Variable Complexity Cost
Low volume of a SKU drives costs
- Volume discounts for procurement
- Excess costs (obsolescence, storage, etc.)
- Shortage costs (expedite, lost sales, etc.)

### Fixed Complexity Cost
High SKU variety drives costs
- Resource costs (R&D, testing, etc.)
- External cash outlays (tooling, etc.)
- Indirect impacts (manufacturing switching, returns, etc.)

### Learning Objectives
- Learn what complexity is and how to recognize it
- Understand how to manage complexity in supply chains
- Identify how to assess complexity and mitigation options
- Help understand the dynamics within a system

### References
**For Supply Chain Systems**

**For Supply Chains as Complex Systems**
- [http://www.systemdynamics.org/](http://www.systemdynamics.org/)
Bullwhip Effect

The Bullwhip Effect was introduced. Essentially the Bullwhip Effect is when the upstream variability of demand is greater than the downstream variability. This can occur for many reasons to include: order batching, demand forecasting updates, rationing and shortage gaming, and price fluctuations. The concept was pioneered initially by Jay Forrester and was observed in practice in the supply chain by P&G in its disposable diaper line. The effect in supply chains was first described and quantified by Lee, Padmanabhan, and Whang in 1997.

The Bullwhip Effect is essentially a signal that a supply chain is not coordinated. The costs of this lack of coordination includes:

- Increased manufacturing costs
- Higher inventory levels & costs
- Longer replenishment lead times
- Higher transportation costs
- Lower product availability
- Deteriorates trading partner relationships
- Lowers supply chain profitability

The lesson discusses approaches to counteracting the Bullwhip Effect to include: Improve forecasting methodology, Design single-stage replenishment control, Shorten lead and review period times, Reduce batching of orders, Reduce the incentive of forward buying, and Better sharing of information.

The Bullwhip Effect

The Bullwhip Effect is the situation where the variability of demand in the supply chain increases as one moves upstream from the consumer to suppliers. It is primarily caused by four factors and is exacerbated by the observation that supply chains consist of multiple independent firms and that individual firms will tend to operate in order to maximize their own profits. These are the four factors that cause the bullwhip effect:

- Demand Forecasting – where forecasting relies on the demand each firm sees from its immediate downstream partner or customer and not the end downstream demand
- Rationing and Shortage Gaming – where suppliers ration supply and customers, knowing this, inflate orders or submit phantom orders however, orders evaporate when supply is made available. The net effect is false demand signals that ripple and are amplified upstream
- Order Batching – where customers bunch or batch orders for many different reasons to include:
• Ordering set up costs
• Optimal lot-sizing
• Periodic review policies

• Price Fluctuations – where the retailer incentivizes behavior from its consumers by changing prices that in turn causes batching of orders. These include:
  • Volume discounts
  • Minimum order quantities
  • Limited transportation mode options
  • Forward buying

Quantifying the Bullwhip Effect

We can measure the rough impact of the Bullwhip Effect under certain conditions:

• One retailer selling one item replenished by one wholesaler DC
  • Daily demand at store is \( \sim N(100, 10) \)
  • Daily review period with \((R,S)\) inventory policy (order up to)
  • \( S_t = \mu_t L + k\sigma_t \sqrt{L} \)
  • \( \mu_t \) = expected daily demand estimated at time \( t \)
  • \( \sigma_t \) = standard deviation of daily demand estimated at time \( t \)
  • \( L \) = lead-time in days
  • \( k \) = Safety factor

• Forecasting uses simple moving average of the last \( M \) time periods which implies that \( \mu \) and \( \sigma \) will change each period based on new forecast and impact the order up to level and safety stock.

Then, we can see that:

\[
\frac{Var[\text{RetailOrders}]}{Var[\text{CustomerDemand}]} \geq 1 + \frac{2L}{M} + \frac{2L^2}{M^2}
\]

Counteracting the Bullwhip Effect

There are several methods or approaches to counteracting the Bullwhip Effect. These include:

• Improve forecasting methodology
  • Eliminate multiple forecasts that only use immediate partner order data
  • Employ point-of-sale or end consumer data, if possible
  • Avoid “nervous” forecasting techniques

• Design single-stage replenishment control
  • Have upstream partner manage its downstream partner’s inventory
  • Referred to as Vendor Managed Inventory (VMI) or Continuous Replenishment Programs (CRP)
• Bypass the downstream stages – consumer direct policies

• Shorten lead and review period times
  o More frequent review and faster delivery reduces impact
  o Less time for uncertainty to build
  o Incent orders to be better distributed over time

• Reduce batching of orders
  o Reduce the fixed cost of order set up and delivery (lower friction)
  o Shift from minimum order quantity (MOQ) of individual SKUs (or families) to minimum volume quantity of a wider assortment of products
  o Reduce transportation costs by using: milk-runs, multi-zone trucks (ambient, refrigerated, and frozen), 3PL solutions . . .

• Reduce the incentive of forward buying
  o Be selective on the use of price promotions
  o Analyze the true costs of a promotion using ABC accounting
  o Shift sales incentives from “Sell-To” to “Sell-Through”
  o Use supply chain risk and other contracts to coordinate sales

• Better sharing of information
  o Allowing visibility into POS or end customer demand
  o Sharing of plans and intentions – sometimes called Collaborative Planning, Forecasting, and Replenishment (CPFR)
System Dynamics

In this lesson we review the basic components of system dynamics, what it is, how to apply it, and how to use models to understand it. We go over feedback loops, causal loop diagrams, time lags & delays, and stock & flow diagrams. All approaches to visualize system complexity. We then move into a discussion on modeling the systems. Throughout the course of the lesson, we build a “toolbox” for system dynamics which includes causal loop diagrams, behavior over time charts, stock & flow diagrams, and models.

“A system is not the sum of its parts, it is the product of their interactions.” Russell Ackoff

Event Oriented Thinking

Event-oriented thinking is problematic because:
- Assumes problem is an isolated event to be solved in isolation
- Linear thinking - does not consider feedback from others
- “pragmatic, action oriented, alluringly simple, and often myopic”
- Sometimes the solution is worse than the original problem!!!

Moving from linear to circular thinking

Move away from linear thinking to be able to incorporate our effects on others as well as the actions of others.
Figure 4: Circular thinking and “side” effects

Modeling Process
1. Articulate the Problem
2. Formulate the Dynamic Hypothesis
3. Formulate the Simulation Model
4. Test the Simulation Model
5. Design and Evaluate the Policy

Causal Links
- Causal link (arrows): Causal Links capture the relationship between two variables and must have either Positive (+) or Negative (-) polarity.
  - Positive Polarity (+ or S): variables move or change in the same direction
    o An increase in one variable causes an increase in the other variable
    o A decrease in one variable causes a decrease in the other variable
  - Negative link (-): variables move or change in the opposite direction
    o An increase in one variable causes a decrease in the other variable
    o A decrease in one variable causes an increase in the other variable

Feedback or Causal Loop Diagrams
A diagram consisting of variables connected by causal links representing relationships in a complex system.

Type
- Reinforcing loop: a collection of links that form a loop that provides positive feedback. Results in exponential growth (or decline) over time
- Balancing loop: a collection of links that form a loop that provides negative feedback. Generally results in some sort of equilibrium or state of balance over time
Time Lags & Delays
The longer the delay the more “aggressive” the response and the longer to reach steady state. Delays between actions and consequences are everywhere... such as the bullwhip effect!

An example of a time lag in the shower:

“Information transferred in the form of orders tends to be distorted and can misguide upstream members in their inventory and production decisions... the variance of orders may be larger than that of sales, and the distortion tends to increase as one moves upstream”
Lee, Padmanabhan and Whang (1997)
Commonly Recognized Patterns in Supply Chains:
- Oscillation – fluctuation in orders increases as we move upstream
- Amplification – the size of the fluctuations increases as we move upstream
- Phase Lag – the impact is delayed longer as we move upstream

Stock and Flow Diagrams

<table>
<thead>
<tr>
<th>Stocks</th>
<th>Flows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define the “state” of the system</td>
<td>Define the rate of change of system states</td>
</tr>
<tr>
<td>Examples:</td>
<td>Examples:</td>
</tr>
<tr>
<td>• Balance sheet</td>
<td>• Cash flow statement</td>
</tr>
<tr>
<td>• Wealth</td>
<td>• Income – Expenses</td>
</tr>
<tr>
<td>• Water in a bath tub</td>
<td>• Flows in through faucet and out drain</td>
</tr>
<tr>
<td>• Inventory in a DC</td>
<td>• Throughput (replenishment – shipments)</td>
</tr>
<tr>
<td>• Integrals</td>
<td>• Derivatives</td>
</tr>
</tbody>
</table>

Stocks:
- Define the “state” of the system
- Stocks have memory
- Stocks change the time path of flows
- Stocks decouple flows
- Stocks create delays
- Examples:
  - Balance Sheet
  - Wealth
  - Water in a bath tub
  - Inventory in a DC
  - Integrals

Flows:
- Define the rate of change system states
- Examples:
  - Cash Flow Statement
  - Income – Expenses
  - Flows in through faucet and out drain
  - Throughput (replenishment - shipments)
  - Derivatives
Modelling System Dynamics

So far in this lesson we have reviewed Causal Loop Diagrams and Stock & Flow Diagrams, we will now add two more approaches to your system dynamics tool box including Behavior Over Time Charts and Models.

![Diagram of CLD, BOT and S&F of a reinforcing loop](image)

**Figure 8:** CLD, BOT and S&F of a reinforcing loop
Behavior over time charts

- BOT charts arise from the relationships described in the CLD
- BOTs track a primary attribute of the system (# customers, profit, sales, # eggs, etc.)
- A BOT chart is NOT a point forecast, instead the critical aspect is its shape

Figure 9: Behavior over time chart

Examining the Behavior over time can prevent unintended consequences for the future. For instances, focusing myopically can lead to a poor outcome. BOT charts inform this progression over time to assess this outcome. See example below regarding high raw materials costs, the BOT chart was able to visualize the unintended consequence of a shortsighted fix.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Myopic Fix</th>
<th>Unintended Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Raw Material Costs</td>
<td>Source from low-price vendors</td>
<td>Increased scrap and returns; lower customer satisfaction</td>
</tr>
</tbody>
</table>

Figure 10: Preventing unintended consequences using BOT chart

Converting Stock & Flow Diagrams into a Model

In the example discussed in the lecture, of egg laying and hatching, we want to simulate the behavior of the system:
Simulation Model Example

Modelling the reinforcing loop

Stock and Flow diagram

The number of eggs laid per time period \( (N_E) \) is a function with two inputs:
- Number of chickens \( (N_C) \)
- Rate of eggs laid per chicken \( (r_L) \)

\[
N_E = f(N_C, r_L) = r_L \cdot N_C
\]

\[
N_E = 5 \cdot N_C
\]

The number of chickens hatched in time period \( i \) \( (N_{C,h}) \) is a function with two inputs:
- Number of eggs laid in time \( i-3 \) \( (N_{E,i-3}) \)
- Percent of eggs allowed to hatch \( (r_H) \)

\[
N_{C,h,i} = f(N_{E,i-3}, r_H) = r_H \cdot N_{E,i-3}
\]

\[
N_{C,h,i} = 0.2 \cdot N_{E,i-3}
\]

Key Points
- The reinforcing loop results in the ever-increasing growth in both number of chickens and eggs.
- Lowering the parameter for hatching rate causes some fluctuation at the start – but the exponential growth continues – albeit at a slightly slower pace.
- Changing the hatching delay from 3 weeks to 1 week reduces the early fluctuation, and leads to steeper growth.
Modelling the reinforcing & the balancing loop

**Stock and Flow diagram**

- There is oscillation between chickens and eggs over time
- The amplitude of peaks and valleys decrease over time
- The overall pattern can be virtuous, vicious, or stable – depending on interplay of parameters!
- The delay exacerbates this oscillation

Model & BOT

Behavior with a Management Goal

**Stock and Flow diagram**

- Having a goal or target enables a system to be better controlled
- The magnitude of the response and “tightness” of the control bounds dictate the volatility of the behavior
- Making decisions on myopic conditions can lead to volatility
- Tracking what is potentially in the pipeline can lead to a more stable outcome
- Parallels to supply chain and inventory management – track the inventory position, not just what is on hand!

Model & BOT
Modelling a Shared Resource

System Dynamics can model systems with a shared resource. These models can be used to determine the best allocation strategy for the shared resource. Such Systems are common in supply chain systems. An example will be to allocate a shared workforce (also known as Flex Team) among Fulfillment center and a Transport operation for a retailer.

While modelling a shared resource, we need to take in to consideration the following three aspects:

- **Performance of a function** i.e. How does performance improve as the management assign the Flex Team to the Fulfillment Center or Transportation?
  - The performance degrades over time if no additional workforce is allocated. Adding a workforce proportionally increases the performance until we reach a saturation point. Beyond this point, increase in workforce doesn’t lead to additional increase in performance.

- **Management response** i.e. How does management respond to poor performance in the Fulfillment Center or Transportation operations?
  - A management response must be modeled by taking into consideration the following three parameters:
    - Timing i.e. if the KPI drops to a threshold, when should the management pay attention?
    - Magnitude i.e. how much should the management respond?
    - Symmetry i.e. should the management respond the same way if the performances are eroding, trending down, or if the performance is trending up?

- **Sharing Rule** i.e. What is the sharing rule (proportional or dominance)?
  - In a proportional rule, the departments get allocation proportionally to what they have requested while in dominance, a certain department get most of what they have requested for and the remaining is allocated to the other department(s).

The below picture shows the casual loop diagram, behavior over time and the stock and flow diagram of a system with shared resource:
The below table shows two management response options and the corresponding outcome:

<table>
<thead>
<tr>
<th>Management Response</th>
<th>Outcome of the model</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Minimal allocation when KPI is “OK”</td>
<td>• Severe oscillation between KPI target and dropping below threshold</td>
</tr>
<tr>
<td>• Swift and drastic action when KPI falls below threshold</td>
<td>• Alternating resource between two competing needs: Transportation &amp; Fulfillment Center</td>
</tr>
<tr>
<td>• Effort increases significantly in proportion to the KPI level</td>
<td>• Management response is sudden and dramatic – goes from ignoring to full attention</td>
</tr>
</tbody>
</table>

---

**Figure 11:** CLD, BPT and S&F for a system with a shared resource

---

**Table:**

<table>
<thead>
<tr>
<th>Percentage of Flex Team to Share</th>
<th>Percentage Difference Actual is from Target KPI Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>20%</td>
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<td>90%</td>
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<tr>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

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**Figure:** Causal Loop Diagram (CLD) and Behavior Over Time (BOT) Chart.
• Always keep above a “sustaining” allocation even at high KPI levels
• Gradual escalation immediately when KPI starts degrading
• Peak effort is capped to prevent “robbing” from other functions

• Firefighting rarely fixes the underlying problem.
• Comparing measured versus dramatic management responses
  o Immediate shifting from “darkness to spot light” introduces volatility
  o It is better to allocate a proportion of shared resource for flexibility – not all of it.
  o Avoid cycles of over and under investing/supporting.
  o Measure consistently and act earlier – do not wait for crisis

Learning Objectives
• Introduction to the concepts and tools of system dynamics
• Review Feedback Loops and their role system dynamics
• Recognize Time Lags and Delays
• Learn Tools to Capture and Model Systems, Causal Loop Diagrams, and Stock and Flow Diagrams
• Review the tools of system dynamics including behavior over time charts and modeling
• Learn how to model system dynamics stocks and flows including management practices

References


Don Woodlock’s videos on System Dynamics
https://www.youtube.com/playlist?list=PL7490F4FA4B45DA26

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Supply Chain Strategy

Summary
Strategy is key to an effective supply chain. To understand this, we review the most common business strategy frameworks and methodologies. We provide some examples that help to understand how supply chains need to align to the selected company’s strategy in order to enable it. There is not a single best supply chain for every firm. Typically, each company should develop and utilize a portfolio of different supply chains.

We also introduce a novel way of thinking about supply chain strategy. It demonstrates a way of tackling the problem of supply chain strategizing. Our primary resource for this lesson is the material developed by the MIT CTL Supply Chain Strategy Lab led by Dr. Roberto Perez Franco. We discuss the nature of the problem that supply chain strategizing presents to supply chain practitioners and present ten supply chain strategy evaluation criteria.

Key Concepts
Strategy is an “art”, not exactly a science, this means focusing on the big picture and overall results of an effort. Here are some definitions:

According to the Oxford English Dictionary: “The art of a commander-in-chief; the art of projecting and directing the larger military movements and operations of a campaign.” Perspectives and challenges of the general and soldier are very different.

According to Merriam-Webster: “The science and art of military command exercised to meet the enemy in combat under advantageous conditions.”

Supply chain strategy
The importance of strategy for supply chain management has been recognized for a long time. Shapiro and Heskett (1985) highlighted that “logistics’ most important role is strategic”. They recommended that logistics managers apply a variety of perspectives while running their logistics systems:

- **Internal perspective**: understand structure, economics and requirements of the logistics systems as well as constraints and components
- **Inter functional perspective**: interact constantly with other functional managers in areas such as marketing, production, and finance
- **Channel perspective**: think in terms of maximizing the total channel benefit, considering that the firm’s decisions affect and is affected by channel partners
- **Strategic perspective**: well-designed logistics management can influence company’s strategy and has the potential to “advance a company’s strategic goals”
A dichotomy: The two faces of logistics (supply chain management)
Successful supply chain management requires attention to detail, to day-to-day control and coordination, and to the tactical and analytic. However, managers should also be able to see “the big picture,” and be cognizant of the broad, qualitative, long-term aspects of supply chain management. This awareness will ensure that the firm’s supply chain function, combined with the other functional areas, can further the overall objectives of the organization.

![Diagram: Tactical vs Strategic, Short-term vs Long-term, Quantitative vs Qualitative, Detailed vs Broad](image)

Figure 12: “A difficult, yet fundamental dichotomy”. Based on Shapiro and Heskett (1985)

Shapiro and Heskett (1985) point out that this “ever-present tension between the strategic and the tactical, the broad and the detailed”, “all conspire to make the job of a supply chain manager a challenging one.”

Two strategic roles for the supply chain

**As input to formulate new overall strategy**
Supply chain must be an input when formulating a new overall strategy. Organizations usually have – and should have – an *overall strategy* that gives them direction and helps them succeed. This overall strategy is called by many names, depending on the type of organization we are referring to. In the case of organizations that compete against others, this is often called their *competitive strategy*. In the case of business units, it is often called their *business strategy*. But in all cases, the overall strategy seeks to provide the organization with a path or direction to success.

**As enabler of an existing overall strategy**
Implementing an overall strategy means translating objectives into decisions, goals into action. An overall strategy that provides a set of high-level strategic objectives has to be elaborated into more specific objectives, policies and choices across a wide range of areas of activity. This may include many diverse functions that are relevant to the supply chain, such as purchasing, logistics,
operations and sales. The means that the strategy executed has to be in line with the principles and values the organization embraces, across a series of areas of interest such as quality, sustainability, service level, safety, etc. There is a gap between the overall strategy of an organization and the execution of this strategy. Supply chain strategy helps to bridge this gap.

Strategic tools

Porter’s Five Forces
Porter argues that a company’s ability to increase profit is affected not only by rivalry of immediate competitors but also by four other forces, which determine the intensity of competition and the attractiveness of an industry. These five forces are:

1. **Internal rivalry** among existing competitors, which is influenced by different factors such as number of existing competitors, rate of market growth, balance between supply and demand, among others.
2. **Threat of new entrants**, which refers to how difficult it is to become a competitor in a given market and is influenced by access to specific technology, brand credibility and recognition, laws and regulations, etc.
3. **Ease of substitution**, which depends on alternative products or services available that customers could choose to buy instead.
4. **Relative power of suppliers**, which is influenced by the number of suppliers available, availability of substitutes for the material or component you are procuring, number of customers the supplier has, cost of switching to another supplier, among others.
5. **Relative power of customers**, which is determined by the quantity bought by each customer, availability of similar products from competitors, cost of switching from one seller to another, amount of information that is available to customers, customers’ profit margin, etc.

![Figure 13: Porter’s Five Forces](image-url)
Growth-Share Matrix

The Growth-Share Matrix is a tool that was developed by the Boston Consulting Group in the 70’s, used to manage a portfolio of businesses within a firm. It is important to understand the categorizations for each business line because the supply chain required for each category will be very different. According to the market share and the business potential growth rate, we can classify the lines of businesses in a 2x2 matrix. The four types of businesses are:

- **Stars**: are lines of business with high growth rate and high market share, which generate a lot of cash and require investments to maintain the market share.
- **Cash Cows**: are lines of business with high market share but low growth rate. Like the stars, cash cows generate a lot of cash but, because of the low growth rate, investments do not make sense.
- **Dogs**: are lines of business with low market share and low growth rate, which do not generate any profit; the strategy for these is to divest.
- **Question marks**: are lines of business with high growth rate and low market share, there are two potential strategies for these lines of businesses: invest to increase market share or divest and reallocate your resources.

![Growth share matrix](image)

**Figure 14: Growth share matrix. Source: adapted from Hedley (1977)**

SWOT Analysis

The SWOT analysis, developed by Kenneth Andrews, is used to categorize internal and external factors that influence strategic decisions. SWOT is an easy way to have a structured brainstorming session with a team to better understand the lay of the land. SWOT stands for Strengths, Weaknesses, Opportunities and Threats.
Strategic Fit
Porter introduces the concept of “fit”, which means that activities are consistent with each other and reinforce each other to create a competitive advantage and superior profitability.

Porter identifies three types of “fit”, which “are not mutually exclusive”:
- First order fit ensures that “competitive advantage of activities cumulate and do not erode”
- Second Order fit “occurs when activities are reinforcing”
- Third order fit is “optimization effort”

What is Strategy?
According to Porter’s famous paper:
- Strategy is creating fit among a company’s activities
- Successful strategy is a result of doing many things well, and integrating them
- If there’s no fit among activities, there’s no distinctive strategy and the strategy will be unsustainable

Supply Chain Strategy
According to Narasimhan et al. (2008): “supply chain strategy can be viewed as the pattern of decisions related to sourcing products, capacity planning, conversion of raw materials, demand management, communication across the supply chain, and delivery of products and services.”

According to Ciglioni et al. (2004): “what companies actually did, rather than what they claimed their strategic intent to be, is the best clue to reveal their very supply chain management strategies.”
Match and Mismatch in Supply Chain Strategies
Marshall Fisher introduced the concept of match and mismatch of supply chain strategies in 1997. Figure 3-5 includes his 2x2 matrix.

![Fisher's 2x2 matrix. Source: Fisher, 1997](image)

Lee’s Matched Strategies
Lee (2002) uses the uncertainty framework as a way to classify risks. Figure 3-6 presents this 2x2 matrix.

![Lee's matched strategies. Source: Lee, 2002](image)
Rethinking your Supply Chain Strategy

The Basic Challenges
Supply chain strategy presents a set of interrelated challenges:

- **Challenge 1**: Assess your current supply chain strategy
- **Challenge 2**: Anticipate future supply chain needs
- **Challenge 3**: Craft an improved supply chain strategy

Ten supply chain strategy evaluation criteria
The first challenge is to assess the current supply chain strategy, which means understanding what you have in place today. To understand the strategy, you must map the current supply chain strategy and evaluate it. To evaluate whether the current supply chain strategy is good enough there are 10 evaluation criteria.

First criterion is **coverage**. A good supply chain strategy must be comprehensive and cover every area that matters for a company’s supply chain. It must have **clarity** – policies and choices in a supply chain strategy must be unambiguous and understood by all of the decision makers. It must be **feasible**, realistic and able to be achieved. **Internal consistency** is key to supply chain strategy with different objectives, policies and choices and can be thought in three different levels: compatibility, coherence, and synergy.

Each component of a good supply chain strategy must **support**, enable, advance or help realize some element of the overall organization’s strategy. Supply chain strategy must also have: **sufficiency**, external consistency, advantageousness, parsimony, and riskiness.

| Table 3: Supply chain strategy evaluation criteria |
|-----------------|-----------------|
| 1                | Coverage        |
| 2                | Clarity         |
| 3                | Feasibility     |
| 4                | Internal Consistency |
| 5                | Support         |
| 6                | Sufficiency     |
| 7                | External Consistency |
| 8                | Advantageousness |
Evaluation criteria can be summarized as: “a good supply chain strategy should be comprehensive, clear, feasible, consistent both internally and externally, sufficiently supportive, competitively advantageous, not wasteful, and not riskier than is acceptable to the organization.”

Scenario Planning
The second challenge is anticipating future supply chain needs, which in a short-term timeline are identified using forecasting techniques. However, for a longer timeline we use the scenario planning technique. Scenario planning is a method that shifts from predicting events to preparing for multiple potential futures. It is defined as: “a structured brainstorming methodology that immerses decision makers of an organization in different potential future scenarios in order to better understand potential risks, blind spots, opportunities, and future needs.”

Creating scenarios
A scenario is essentially a story about a future based on a set of driving forces. They have high impact and high uncertainty for your selected time frame. Some criteria for creating a good set of scenarios are:

- Avoid the preferred and/or probable future
- Capture the right decision
- Plausible, within realistic limits
- Include real alternatives
- Consistent
- Different
- Memorable names
- Challenge the status quo

In addition to creating scenarios, we need to translate events into effects and apply the scenarios.

Five categories of effects for supply chains:

- Impact on sourcing patterns
- Impact on flow destination
- Impact on routing
- Impact on flow volume
- Impact on value density

Applying Scenarios
1. Immerse a large group of people in each scenario
2. Bring everyone together and evaluate, compare and contrast the solutions/strategies proposed across the different scenarios
3. Eliminate the no gainer strategies
4. Monitor with sensors in the ground whether to apply strategies that are only applicable to some scenarios

Progressive formulation
The third challenge is to craft an improved supply chain strategy. These are the steps to perform a progressive formulation:

- Identify a starting point: a revised overall strategy
- Identify areas of decision or activity and interest, add or drop areas accordingly
- Identify sequence of events that you want to follow
- Use evaluation criteria on each area of decision
- Repeat this process in each level of abstraction

Learning Objectives

- Learn basic concepts of business and supply chain strategy
- Identify the most common business strategy frameworks
- Understand that there is not a single best supply chain for every firm
- Outline a process to develop and improve a supply chain strategy
- Learn how to tackle the problem of supply chain “strategizing”
- Identify the main criteria for evaluating a supply chain strategy

References

- Additional references can be found here: strategy.mit.edu
Process Analysis in Practice

Process analysis is an important perspective in supply chain management. According to Wallace Hopp (2011), “a supply chain is a goal-oriented network of processes and stock points used to deliver goods and services to customers.”

Impact of variability
Variability within a process occurs due to either arrival and/or process variability.

Sources of input or arrival variability include:

- Scheduling
- Transportation delays
- Quality issues
- Upstream processing
- Random demand

Sources of process variability include:

- Variety of items
- Operator speed
- Failures
- Set ups
- Quality problems.

Supply chain process variability
One of the key problems in Supply Chains is dealing with variability. There are two main sources of variability: interarrival variability and process variability.

Reducing variability
There are several approaches for reducing variability:

- Identify & measure sources of variability and defects
- Develop plans and courses of action
- Segment customers, SKUs, suppliers, etc.

Figure 19: Supply chain process variability
In addition, the approaches for buffering against variability are:

- **Inventory** – traditional approach, implies high inventory levels OR flexible inventory – module parts, common platforms, generic stock
- **Capacity** – maintain excess capacity at facilities to handle peaks OR flexible capacity – cross trainer personnel, multi-use equipment/facilities
- **Time** – plan time for system to recover OR flexible time dynamically allocate waiting time across customer segments

### Core Supply Chain Processes

**Main actors and processes in a supply chain:**

![Diagram](image)

Figure 20: Main actors and processes in a supply chain

Processes follow the work flow so coordination across functions is the key to SCM.

![Diagram](image)

Figure 21: Coordination across the functions in a SCM

According to Lambert (2014) there are seven core supply chain processes. We can categorize them in internal and external processes.

**Internal facing processes:**

- Demand management
- Order fulfillment
- Manufacturing flow management
- New product development
• Returns management

External facing processes:
• Customer management
• Supplier relationship management

These are critical links in the supply chain, they mirror process – to a large degree. A rough process to assess:
1. Review/align firm strategy
2. Identify segmentation criteria
3. Establish product and service agreement (PSA) guidelines for different segments
4. Develop metrics – primarily profitability
5. Create guidelines for sharing improvement benefits

To work on CRM and SRM – you can also segment based on different criteria. For customers it could be profitability, growth, stability, volume, competitive positioning, buying behavior, sophistication, and location. For suppliers, they can be segmented on profitability, growth, volume purchased, criticality, innovation, quality, sophistication, and potential to co-create value.

Internal Facing Processes
Internal Facing Processes including: demand management, order fulfillment, manufacturing flow management, new product development, returns management.
Demand Management – potential variability drivers

Table 4: Main sources of variability for demand management

<table>
<thead>
<tr>
<th>Source</th>
<th>Potential problems</th>
<th>Possible solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promotions</td>
<td>Creates lumpy demand; Cannibalizes future demand; Misdirects scarce resources</td>
<td>Plan and coordinate timing, duration, and level with operations and customers in advance</td>
</tr>
<tr>
<td>Sales metrics</td>
<td>Creates hockey stick effect at end of periods; Creates surges and lumpy demand</td>
<td>Design sales metrics to lessen end of quarter effect</td>
</tr>
<tr>
<td>Minimum order quantities</td>
<td>Creates lumpy demand; Increases potential for obsolescence and spoilage</td>
<td>Incorporate all costs when determining MOQ; Work to minimize the MOQ in order to speed up inventory velocity</td>
</tr>
</tbody>
</table>

Order Fulfillment

Strategic Tasks
1. Review/align firm strategy – coordinate with CRM teams
2. Define requirements – specific lead team and customer service requirements
3. Evaluate network – how/where customers will be service
4. Define Plan – establish rules for allocating scarce product, informational flow
5. Develop metrics to monitor – cash-to-cash cycle time, order fill rates, perfect order

Operational Tasks

Manufacturing flow management

Strategic Tasks
1. Review/align firm strategy
2. Determine level of flexibility
3. Determine Push/Pull boundaries
4. Identify manufacturing constraints & capabilities
5. Develop metrics to monitor
Returns Management

Strategic Tasks
1. Review/align firm strategy
2. Define avoidance, gatekeeping, and disposition
3. Create network for return flows
4. Define credit/refund rules
5. Develop metrics to monitor

Operational Tasks

![Process Map Diagram](image)

Figure 26: Returns Management tasks

Process map

A process map is a model that is a symbolic representation of the workflow used to better understand, communicate, level-set, codify, and converge on how a process works. There are different types: flowcharts, relationship maps, cross-functional (swimlane) maps, value stream maps, etc.

Main steps to create a process map:

- Determine the scope and level of detail
- Based on scope, identify and list the people or functions involved
- Using sticky pads, brainstorm the steps involved
- Work through the process chronologically, placing the sticky pads in the appropriate swim lanes
- Discuss and debate the draft process map and adjust accordingly
- Do functions touch the same items multiple times?
- Are there repeated and redundant handoffs?
- Are steps missing or extraneous?
- Transfer the diagram to paper; add a date and version
Example Swim Lane Diagram

Process improvement tools

**Tools for checking variability**
- Histograms: help understand outliers
- Time series charts: help understand where to focus

Example Histogram

**Tools for identifying causes of variability**
• 5 Whys
  o tool for encouraging brainstorming
  o forces team to look beyond superficial solutions
• Cause and effect diagrams (fishbone / Ishiwaka):
  o Tool that provides structure for understanding root causes
  o Ensures that a balance list of ideas have been considered

Learning Objectives
• Understand the Supply Chain as a process
• Learn how to measure the performance of a process
• Identify sources of process variability
• Quantify how process variability impacts the performance of a queue
• Understand supply chain processes and variability
• Identify strategies to reduce variability
• Describe the seven core processes in a supply chain
• Learn tools and techniques to help with process analysis

References
• Lambert, D. et al. (2014) Supply Chain Management: Processes, Partnerships, and Performance, SCMI.

For In Practice
Global Supply Chain Management

Summary
This review covers global supply chain management concepts and explain the challenges and opportunities of trading between countries. Since most supply chains are global, it is important to consider the many factors that will influence your supply chain. It is also important to note that while guidance is provided here on how to work in global supply chains, some of the rules and data changes all the time.

Global Supply Chain Management

From 1950 to now, global population has increased by 2.8x and World trade has increased 20x.

World Trade Organization (WTO)
The World Trade Organization (WTO) was founded in 1995 to promote fair trade. Its principals include trade without discrimination, freer trade, predictable, more competitive and more beneficial for less developed countries.

Problems with the WTO include Trade barriers have shifted and LDC abuse of rules.

Duty determination
Duty is the amount of tax paid on an imported good. The amount of duty that an importer has to pay is determined by three factors:

- The type of goods (their classification)
  - Harmonized Tariff Schedule (HTS) is a 10-digit code used to describe all goods in trade for duty, quota, etc. The first 6 digits are standardized internationally; the last 4 digits are country specific.
  - Which code to use based on codes, duty rates differ, everyone tries to twist the definitions to their own advantage
- The value of the goods (their valuation)
- The country from which the goods originated (the rules of origin)

Duty Drawbacks
There are three types of duty drawbacks:

- Same condition drawback: when you import an item and then re-export this item in the same condition
- Different condition drawback: or sometimes also called manufacturing drawback, when you use an imported item in the assembly of another product
• Domestic goods returned in different condition: when an item that was previously exported comes back as part of an assembly of another product
• Below shows how Duty Drawbacks work:

![Diagram showing Duty Drawbacks]

Figure 29: Duty Drawbacks

Sales Taxes on Imports: VAT, GST, HST

• Besides charging Duty on imports, many countries charge a Sales Tax also:
• VAT – value added tax - used in Europe, tax based on a % of the (dutiable value + duty)
• GST – goods and services tax – used in Canada, Australia, N Zealand and many others … defined the same as VAT but may apply to cost of inland transport also
• HST – harmonized sales tax – used in Canada to represent a combined federal GST plus a local provincial sales tax

Valuation
Valuation is important because most of the duties are collected as a percentage of the value of goods, this is called ad valorem. For Customs’ purposes, valuation is generally the amount billed by the exporter and shown on the invoice. However, there are situations where the amount shown in the invoice may not represent an “arms-length transaction.” This occurs when the exporter and importer are “related parties” such as a parent company and its subsidiary. There are four alternative methods used by Customs authorities worldwide to determine the value of goods:
• Comparative method: use the value of similar goods
• Deductive method: work backwards from price
• Computed or reconstructive method: build up from manufacturing cost
• Method of last resort: make an educated guess

**Dutiable Value: FOB vs CIF**

• Countries calculate “Dutiable Value” based on either the FOB value or the CIF value.

• FOB value – “Free on Board”
  
  o Price paid for the goods plus the cost of assists, extra packing, commissions, royalties, transportation, loading, unloading, handling, and insurance to deliver the goods from the Seller onto the ship at the Port of Export

• CIF value – “Cost, Insurance, & Freight”
  
  o Equals FOB plus marine insurance and international (ocean) freight

**Rules of Origin**

Rules of origin are important because duties may differ by origin countries. There are two methods used to figure out the rules of origin:

• Substantial transformation: last country where the product underwent a substantial transformation
  
  o Lots of opportunities for multinationals to rearrange where they make things and route shipments to take advantage of differing duty rates.

• Change in Harmonized System Code: last country where the harmonized system code of the product changed
  
  o This method is the one currently followed by the United States for textile products.

---

![Figure 30: Rules of Origin](image)

*Can I just ship the items through Country B to get a lower duty rate?*
Generalized System of Preferences
Developed countries usually provide opportunities to developing countries to grow their economies by designating them as Generalized System of Preference (GSP). Countries designated as GSP benefit from reduced duty rates and quotas for their goods.

- **US: Generalized System of Preferences**
  - Promotes economic development by eliminating duties on up to 5,000 types of products when imported from one of 122 designated beneficiary countries and territories.

- **Europe: Generalized Scheme of Preferences:**
  - Standard Level -- about 30 countries, reduced duties
  - GSP+ Level -- about 14 countries, no duties
  - EBA Level -- about 49 countries, no duties or quotas (Everything but Arms)

- **Most Favored Nation Trading Status**
  - Designation for normal trading partner

Free Trade Zone and Bonded Warehouses

<table>
<thead>
<tr>
<th>Free Trade Zone</th>
<th>Bonded Warehouses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main purpose: duty-free access to low cost labor</td>
<td>Main purpose is to delay the paying of duties</td>
</tr>
<tr>
<td>No duty paid if re-exported</td>
<td>No duty paid if re-exported</td>
</tr>
<tr>
<td>Duty delayed if imported</td>
<td>Duty delayed if imported</td>
</tr>
<tr>
<td>Work can be performed on the goods</td>
<td>Little / no work can be performed on the goods</td>
</tr>
<tr>
<td>Great for processing goods in low cost labor countries</td>
<td>Great for delaying duty on imported $$$ goods</td>
</tr>
<tr>
<td>Great for showing off products to international buyers</td>
<td></td>
</tr>
</tbody>
</table>
Trading Blocs

Table 6: Trading Blocs

<table>
<thead>
<tr>
<th>Name</th>
<th>Countries</th>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>European Union (umbrella)</td>
<td>28 European countries</td>
<td>Trade Bloc</td>
<td>Umbrella term</td>
</tr>
<tr>
<td>Caribbean Community</td>
<td>15 Caribbean countries</td>
<td>Preferential</td>
<td>Reduced tariffs between members</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trade Area</td>
<td></td>
</tr>
<tr>
<td>African Union</td>
<td>54 African countries</td>
<td>Free Trade Area</td>
<td>Zero tariffs between members</td>
</tr>
<tr>
<td>MERCOSUR</td>
<td>Arg, Brz, Par, Uru, Ven</td>
<td>Customs Union</td>
<td>Zero tariffs between members AND the same external tariffs</td>
</tr>
<tr>
<td>ASEAN</td>
<td>10 SE Asian Nations</td>
<td>Monetary</td>
<td>Same currency</td>
</tr>
<tr>
<td>NAFTA</td>
<td>US, Can, Mex</td>
<td>(Currency) Union</td>
<td></td>
</tr>
</tbody>
</table>

Dumping

Dumping is a form of predatory pricing where producers charge a high price in the home market but a very low price in another market to gain market share. In international trade there are two types of penalties:

- **Anti-dumping Duty**: import duty to bring the price up to the price charged at the home market
- **Countervailing Duty**: or anti-subsidy duty, import duty to products that have subsidies at home

Landed Cost Analysis

Landed cost usually means all the costs leading up to the point where you are ready to take the goods out of the port of import.

The calculations must be done in THIS ORDER:

1. Calculate the FOB value
2. Calculate the CIF value (= FOB + ocean freight + marine ins.)
3. What is dutiable value for the importing country (FOB or CIF)?
4. Calculate the Duty (= duty rate x dutiable value)
5. Calculate the VAT taxable value (= CIF + duty)
6. Calculate the VAT tax (= VAT rate x taxable value)
7. Calculate the Landed Cost (= CIF + duty + VAT)
International Transportation

International transportation differs significantly from domestic transportation. The main ways are reviewed including INCO terms, transportation options, and ports.

INCO terms

INCO stands for International Chamber of Commerce. These terms define which responsibilities belong to the buyer and which responsibilities belong to the seller during an international shipment. They also define who pays for freight cost, insurance, duties, cost of goods, and other various fees. There are four main groups of INCO terms: E, F, C, and D which are groups based on responsibility transfers between parties.

- **E Term (1)**
  - Ex-Works means the buyer assumes total responsibility for the shipment. The buyer is responsible for freight costs, insurance, export and import clearance, and all customs charges.

- **F Terms (3)**
  - FOB (Free on Board) seller delivers the goods to the outbound port.
  - FCA (Free Carrier) - seller delivers the product to the buyer’s carrier.
  - FAS (Free Alongside Ship) - seller to delivers the product alongside a given vessel at a port.

- **C Terms (4)**
  - CFR (Cost and Freight) – seller pays the cost of the product and freight cost to destination port.
  - CIF (Cost, Insurance, and Freight) - seller pays the insurance and product cost and freight cost to the destination port.
  - CPT (Carriage Paid To) is similar to CIF, except that the buyer pays for insurance. The seller, however, is responsible for export clearance.
  - CIP (Carriage and Insurance Paid To), multimodal moves and is the same as CPT, except the seller must also purchase cargo insurance in the buyer’s name.

- **D Terms (5)**
  - DAF (Delivered at Frontier), Seller gets product to the border, cleared for export. Buyer takes over and clears inbound customs at destination country.
  - DES (Delivered Ex Ship). Seller gets product to the destination port but still on the ship. Buyer takes over – to get it off the ship and imported.
  - DDU (Delivered Duty Unpaid). This is similar to DES, except the seller assumes responsibility for getting the goods off the ship.
  - DDP (Delivered Duty Paid) the maximum obligation by seller, responsible to the buyer’s door.

![Figure 31: Four Main Groups of INCO Terms](image-url)
Air Freight vs. Ocean Freight

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Air Freight</th>
<th>Ocean Freight</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-time reliability</td>
<td>Very reliable, 1-2 days delivery window</td>
<td>Not reliable, 1-2 weeks delivery window</td>
</tr>
<tr>
<td>Freight Cost (ignoring inventory)</td>
<td>Expensive</td>
<td>Cheaper</td>
</tr>
<tr>
<td></td>
<td>5 to 10+ times Ocean</td>
<td></td>
</tr>
<tr>
<td>Basis of Freight cost</td>
<td>Weight is most important</td>
<td>Volume is most important factor</td>
</tr>
<tr>
<td>Transit time</td>
<td>1-3 days to (almost) anywhere</td>
<td>5 to 40 days</td>
</tr>
<tr>
<td>Pollution</td>
<td>Very high</td>
<td>Much lower</td>
</tr>
</tbody>
</table>

Type of ships
The most common types of ships are presented below.

<table>
<thead>
<tr>
<th>Type of ship</th>
<th>Type of Cargo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roll-On/Roll-Off or Ro-Ro ship</td>
<td>Wheeled cargo</td>
</tr>
<tr>
<td>Break-Bulk Ship</td>
<td>General cargo</td>
</tr>
<tr>
<td>Oil tanker</td>
<td>Oil in bulk</td>
</tr>
<tr>
<td>Chemical Carrier</td>
<td>Chemicals in bulk</td>
</tr>
<tr>
<td>Dry-Bulk Carrier</td>
<td>Unpackaged bulk cargo</td>
</tr>
<tr>
<td>LNG ship or Gas Carrier</td>
<td>Liquefied natural gas (LNG)</td>
</tr>
<tr>
<td>Container Ship</td>
<td>Non-bulk cargo</td>
</tr>
</tbody>
</table>

Ocean Shipment Overview
• Dray: local haul to the port
• Demurrage: penalty for extra days that containers stay at a dock
• Cabotage: when a foreign-flagged vessel picks up and drops off in the same country
• TEU: twenty-foot equivalent unit
• Weekly service: string of ships following each other

The Steamship Industry
The steamship industry is a volatile industry in which few carriers handle most of the freight. Carriers collaborate and cooperate among each other, there are known as alliances. This industry is characterized by having very different freight rates depending on the direction of the trip. Because of volume discount pricing, this industry attracts consolidators and Non-Vessel Operating Common Carrier (NVOCC). Historically the steamship industry has faced the Bull-Whip effect, which is the time lag in carrier response to the demand curve.

Top Ocean Carriers
• There are 50-75 ocean carriers of significance.
• Top few carriers handle the vast majority of shipments.
• They form “Conferences” to collude on rates and manage capacity to set rates. (outlawed in Europe)
• They form “Alliances” to cooperate on capacity by lane – same string will have ships from different carriers.

Volume Discount Pricing – the more you buy, the cheaper per unit.
• This pricing scheme is ripe for Consolidators
• In transportation:
  • Truckload Broker (CH Robinson, Coyote Logistics)
  • Air Freight Forwarder (Damco)
  • NVOCC (non-vessel operating common carrier) (Expeditors Intl, UTi, APEX, Damco)

![Figure 33: Bull-Whip effect in the steamship industry](image-url)
International Surface Transport

International Surface transports are railroads and trucks that cross international borders.

- Biggest challenges
  - Truck transportation: safety standards, protecting local jobs
  - Railroad transportation: different safety requirements, work rules and interoperability (different widths between tracks)

### Table 9: Major railroad gauges in the world

<table>
<thead>
<tr>
<th>Gauge</th>
<th>Name</th>
<th>Installation (km)</th>
<th>Installation (miles)</th>
<th>Percent of track in world</th>
<th>Where used:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000 mm (3 ft 3 3/8 in)</td>
<td>Metre gauge</td>
<td>95,000</td>
<td>59,000</td>
<td>7%</td>
<td>SE Asia, India, Argentina, Brazil, Bolivia, northern Chile, Switzerland, East Africa</td>
</tr>
<tr>
<td>1,067 mm (3 ft 6 in)</td>
<td>Three foot six inch gauge</td>
<td>112,000</td>
<td>70,000</td>
<td>9%</td>
<td>Southern and Central Africa, Indonesia, Japan, Taiwan, Philippines, New Zealand, Queensland Australia, Western Australia</td>
</tr>
<tr>
<td>1,435 mm (4 ft 8 1/2 in)</td>
<td>Standard gauge</td>
<td>720,000</td>
<td>450,000</td>
<td>55%</td>
<td>Europe, Argentina, United States, Canada, China, Korea (South), Korea (North), Australia, India, Indonesia, Middle East, North Africa, Mexico, Cuba, Panama, Thailand, Venezuela, Peru, Uruguay, Philippines, Japan, Taiwan and Spain.</td>
</tr>
<tr>
<td>1,520 mm (4 ft 11 27/32 in)</td>
<td>Russian gauge</td>
<td>220,000</td>
<td>140,000</td>
<td>17%</td>
<td>Russia, Finland, Estonia, Georgia, Latvia, Lithuania, Mongolia, Ukraine</td>
</tr>
<tr>
<td>1,524 mm (5 ft)</td>
<td>Finnish gauge</td>
<td>5,865</td>
<td>3,644</td>
<td>small</td>
<td>Finland</td>
</tr>
<tr>
<td>1,600 mm (5 ft 3 in)</td>
<td>Irish gauge</td>
<td>9,800</td>
<td>6,100</td>
<td>small</td>
<td>Ireland, Australia, Brazil</td>
</tr>
<tr>
<td>1,668 mm (5 ft 21/32 in)</td>
<td>Iberian gauge</td>
<td>15,394</td>
<td>9,565</td>
<td>small</td>
<td>Portugal, Spain</td>
</tr>
<tr>
<td>1,676 mm (5 ft 6 in)</td>
<td>Indian gauge</td>
<td>134,008</td>
<td>83,269</td>
<td>11%</td>
<td>India, Pakistan, Argentina, Chile, Sri Lanka, Bangladesh, United States</td>
</tr>
</tbody>
</table>

### Ports and Terminals

A port is a general term referring to a big community of players, which include:

- Port Authority
- Terminal Operators
- Warehouse Operators
- Consolidators / De-consolidators
- Customs Officials
- Railroads
- Dray Operators
- Freight Forwarders
- Customs Brokers
A terminal is the location within a port where ships load & unload, it has:

- Quay, ship to shore cranes, RTG cranes
- Container storage yard
- Administration buildings

Currency Issues and Financing

In global supply chains it is essential to understand currency issues and financing. To understand this, we review several important concepts including: exchange rate risk, transfers pricing, and profit repatriation and its effects on corporate income taxes. We also briefly review description of trade finance and international trade payment methods.

Exchange Rate Risks

There are two factors that will trigger exchange rate risk when together:

- Two different currencies (i.e., buy in one currency but get paid in another)
- Time delay between beginning and end of transaction

Currency Futures Contract: A contract to exchange one currency for another at some future point in time at a pre-specified exchange rate. Normally there is a fee to do this.

The most common ways to protect against exchange rate risk are:

- Use only one currency
- Use a bank to hedge the transaction - pay a fee to the bank to guarantee the price you will get paid
- Hedge yourself:
  - Currency Futures Contract: a contract to exchange one currency for another at some future point in time at a pre-specified exchange rate (this usually requires a fee)
  - Foreign currency hedging: is a risk reducing strategy where two offsetting, opposite positions, are taken in two different parallel markets. The positions are such, that their end results offset each other.

Internal ways to hedge foreign currencies within your own company:

- Leading Expenditure: to pay in advance if currency is expected to rise
- Lagging Expenditure: to pay late if currency is expected to fall
- Netting Receipts and Payments: to hedge the net exposure

External ways to hedge currencies:

- Forward Contracts: a contract where a buyer and seller agree on an exchange rate in advance
- Currency Swaps: two parties with two different currencies take an equivalent loan in their home currency and trade the cash
- Foreign Currency Options: pay a fee to have the optional right to buy or sell a specific amount of a specific currency at a specific price at a specific future time
Spot Contracts: contracts that are completed in 1-3 days to avoid high fluctuations

Corporate Income Taxes
Companies can be charged taxes by any government for corporate profit but also inventory value, value of property plant and equipment.

1. Taxes in each country are charged based on how much profit was made in each country.
2. Tax rates vary significantly from country to country.
3. Profitability can vary significantly from product to product.
4. Margins can vary significantly from region to region (e.g. same product priced differently in different markets).
5. Transfer pricing is used to establish intracompany selling prices (and thus establishes the profit margin in each country).

International Income Taxes
Taxes in each country are charged based on how much profit was made in that country. The tax rate varies significantly from country to country. Profitability varies significantly by type of product and profit margins can vary significantly from region to region.

Tax Haven
A Tax Haven is a country with a low corporate income tax rate such as Ireland, Switzerland, Singapore, or Puerto Rico.

Permanent Establishment
A Permanent Establishment (PE) is a fixed place of business that generates income or value added tax liability in a particular jurisdiction. The tax systems in some civil law countries impose income and value added taxes only where an enterprise maintains a PE in the country. These are the things that may get a business labeled as having a PE in a country:

- A branch
- A warehouse
- A factory
- A mine or oil or gas well
- A management office
- Owning inventory in a country
- Buying or selling in the country
- Being the importer of record, being the exporter of record
- Owning property in the country
- Having employees in the country
Taxes on Foreign Earnings

Types of Tax Relief

**Foreign Tax Credit (FTC):** when countries allow companies to deduct the amount of tax paid in another country.

**Participation Exemption (PEX):** a partial to full exemption of taxes for companies that are subsidiaries of companies with a certain level of ownership in a specific country.

**Double taxation agreement (DTA):** treaties between a pair of countries to provide partial or full tax exemption.

Transfer Price

A transfer price is a “market price” for intracompany transfer of goods. It is needed because duties are charged based on the value of the goods being imported. This means that the invoice amount between related parties is not always a good indication of the value of the good. Transfer price is also a way to shift profit from one country to another, given that income tax rates might be very different.

- **What are the implications of a HIGH transfer price?**
  - More profit is realized in the exporting country, less profit is realized in the importing country.
  - More import duty is paid if the goods move into the importing country.

- **What are the implications of a LOW transfer price?**

---

**Figure 34: Taxes on Foreign Earnings**

<table>
<thead>
<tr>
<th>Parent Company</th>
<th>Subsidiary</th>
<th>Subsidiary</th>
<th>Subsidiary</th>
<th>Subsidiary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent Company</td>
<td>Branch or</td>
<td>Subsidiary</td>
<td>Subsidiary</td>
<td>Subsidiary</td>
</tr>
<tr>
<td></td>
<td>Local Office</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>N/A</td>
<td>Does not matter</td>
<td>none</td>
<td>Yes: Zero tax in A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>with $0 Repatriation</td>
<td></td>
<td>on profits already taxed in B</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25% x 1000 = $250</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Assume $750 ($1000 - $250)</td>
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<td></td>
<td>35% x $750 = $262.50</td>
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<td></td>
<td></td>
<td>$0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>DTA allows ZERO tax in country A since already taxed in B</td>
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<td></td>
<td>25% x 1000 = $250</td>
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<td>Assume $750 ($1000 - $250)</td>
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<td>35% x $750 = $262.50</td>
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<td></td>
<td></td>
<td>$0</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>DTA reduces tax paid in A to only 10% (difference in Tax rates)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Country A</th>
<th>Country B</th>
<th>Country A</th>
<th>Country B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent Company</td>
<td>Parent Company</td>
<td>Parent Company</td>
<td>Parent Company</td>
</tr>
<tr>
<td></td>
<td>Subsidiary</td>
<td>Subsidiary</td>
<td>Subsidiary</td>
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</tbody>
</table>
Less profit is realized in the exporting country, more profit is realized in the importing country.

Less import duty is paid if the goods move into the importing country.

- What does the exporting country want you to do with regard to Transfer Price?
  - Set it very high -- so they get more TAXES from you.

- What does the importing country want you to do with regard to Transfer Price?
  - Mixed effect -- if set high might get more duty, but less income tax. If set low get less duty but more income tax.

Profit Repatriation

Profit repatriation is bringing profits earned in a foreign country back to the home country. Usually paid as dividends to the parent company.

Barriers to Repatriation:
- Government limits
- Reporting requirements
- Withholding taxes on dividends, royalties, interest payments
- Double Taxation

How do companies Legally Repatriate Income while avoiding double taxation and withholding taxes?

Key: don’t convert profits in country B into dividends and then pay the dividends to parent in country A.

Key: have lower profits in country B and have higher expenses paid to parent company in country A.

![Figure 35: Legal ways of avoiding double taxation and profit withholding](image)

Mechanics of Profit Repatriation:
- Transfer Pricing (avoid the need to repatriate): Have transfer prices “rigged” so a lot of profit occurs in the home country. Limitations: governments review for “an arms-length transaction.”
- Royalty Payments: charge a fee to foreign-subsidiary for the use of the parent company’s name and brand
- Leading and Lagging Payments: use currency fluctuations to favor the home country
- High Interest Loan to Subsidiary: loan money to the foreign-subsidiary with high interest
• Parallel Inter-Company Loans: partner with another company to interchange loans with foreign subsidiaries of the other company in the parent company’s home country
• Re-Invoicing Centers (RIC): use a Tax Haven to route buy-sell transactions
• Counter or Barter Trade: exchange goods instead of money between parent and foreign-subsidiary

Managing Working Capital

Figure 36: Example of a Cash Flow Model

Cash-to-Cash Cycle Time

$$\text{CTC} = \text{IDS} + \text{DSO} - \text{DPO}$$

Where,
CTC is Cash to Cycle Time
IDS is Inventory Days of Supply
DSO is Days of Sales Outstanding (Accounts Receivable)
DPO is Days of Payables Outstanding (Accounts Payable)

Ways to Free Up Working Capital
These are ways to free up working capital. Although their effect is to decrease working capital, a thorough analysis of the side effects of each one of these should be performed.
Most common ways used:
• Lower transit time
• Return excess to suppliers
• Lower inventory targets, increase deliveries and runs
• Improve manufacturing cycle time
• Use smaller lots
- Sell off excess and obsolete
- Use shorter payment terms with customers
- Have vigorous collection of past due payments
- Ask for longer payment terms to suppliers (not usually recommended)
- Delay payments to suppliers (not usually recommended)

Innovative Ways
- Bill on receipt
- Use vendor-owned adjusted time inventory
- Implement Lean Manufacturing techniques
- Build to order
- Offer early payment discount
- Offer a pay by credit card option
- Ask about payments prior to due date
- Electronic Funds Transfer (EFT)

Trade Financing Actions
- **Early Payment Program:**
  - Offered by OEM: OEM pays Supplier early but charges the Supplier at a discounted rate
  - Using a Funder: Funder pays supplier immediately, and charges a percentage to supplier, the OEM also gets a discount for using the Funder
- **A/R Financing** - Selling Receivables: Supplier sells its receivables to a Funder who pays the Supplier immediately but gets a discount, this method is very similar to the Early Payment Program Using a Funder but the OEM is not involved in this scheme
- **Revolving Line of Credit:**
  - Supplier goes alone: Supplier borrows cash from a Funder, which charges an interest rate (based on the supplier’s financial health) and takes supplier’s invoices as collateral for the loan
  - OEM helps supplier: OEM publishes a list of “approved invoices” to show that it is committed to pay. Therefore, when the supplier borrows cash from the Funder the interest rate is lower as the interest rate is based on the OEM’s financial health
- **Early Payment Program to Extend DPO:** Funder is used to pay to the Supplier immediately and to extend the payment terms to the OEM, the Funder charges to both Supplier and OEM

Methods of Payment in International Trade
- **Cash-in-Advance:** means that the buyer pays before receiving the goods; this method is used in high-risk trade relationships or export markets.
• **Letters of Credit**: is a document issued by the buyer’s bank committing to pay to the seller even if the buyer fails to pay to the bank; this method is used in new or less-established trade relationships.

• **Documentary Collections**: occurs when the Seller’s bank collects all the export documents (BOL, Commercial Invoice, etc.) of the goods shipped by the buyer, the Seller’s bank sends these documents to the Buyer’s bank demanding payment. The Buyer’s bank will hold these documents until the payment is made, this method is used in established trade relationships.

• **Open Account**: is when goods are shipped before payment along with all the export documents. This arises in secure trading relationships or markets or in competitive markets to win customers.

---

**PAYMENT RISK DIAGRAM**

![Payment Risk Diagram](image)

*Sourcing and Shoring*

In a global world, the topics of sourcing and shoring are hotly debated. To break apart these topics, we identify the motivations and the challenges to move manufacturing abroad. Beyond the initial decision to move abroad, there are additional key elements on social responsibility that companies lose grasp of when work moves farther away such as slavery or conflict minerals. Finally, we provide examples of different global supply chain strategies.

**Approaches for Manufacturing Internationally**

• **Contract Manufacturing**: a company hires another company to manufacture goods, usually in a foreign country

• **Licensing**: a company allows another firm to use its intellectual property to make products in exchange for a royalty
• Franchising: a company gives another firm a “bundle” of intellectual property items and allow the firm to reproduce its entire business model in exchange for royalties
• Joint Venture: two or more companies join to set up a new company to enter a new marketplace
• Subsidiary: a wholly owned foreign company that is independent from the parent company and gives total control to the foreign company

Motivations and challenges of offshoring
Here are some of the reasons that explains why manufacturing moved to Asia & China:
• Very low labor cost, huge labor pool
• Very few restrictions on pollution, working conditions, quality, and exports
• New factories, new equipment
• New infrastructure
• Herd mentality
• Supply based moved - self-fulfilling trend.
• Corporate profit motive & competitive pressure outweighed loyalty to community
• Consumer savings outweighed loyalty to community

Some of the challenges related to the previous decision are:
• Very long lead times
• Long supply lines --- long distance ocean transportation
• Time zone challenges
• Communication challenges --- language differences
• Need for higher inventory levels
• Intellectual property theft, counterfeiting of products
• Extra cargo security
• Emergency air shipments are now a very long way

Changes in the last 20 years: China is more prosperous; labor costs have skyrocketed; labor shortage in coastal cities; Chinese Currency appreciation; restrictions on quality, working conditions, environment and safety; huge coastal factories have gotten bad reputation; green movement favors local sourcing; contamination scares; political backlash; U.S. Energy prices have fallen.
Industry Response to Changes

Table 10: Industry Response to Change

<table>
<thead>
<tr>
<th>Industry</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automotive Parts</td>
<td>Growth in Mexico</td>
</tr>
<tr>
<td>Aerospace Parts</td>
<td>Growth in Mexico</td>
</tr>
<tr>
<td>Appliances</td>
<td>Growth in USA, Mexico</td>
</tr>
<tr>
<td>Apparel</td>
<td>China still dominant but Growth in Bangladesh, Vietnam, other SE Asia</td>
</tr>
<tr>
<td>Footwear</td>
<td>Growth in Vietnam</td>
</tr>
<tr>
<td>Consumer Electronics</td>
<td>Staying in China</td>
</tr>
</tbody>
</table>

Where is Manufacturing Moving to:

Table 11: Where is Manufacturing Moving To

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Example</th>
<th>Sourcing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pursue absolute Lowest Cost</td>
<td>Apparel, Most Footwear</td>
<td>Most still in China but Vietnam, Bangladesh are up &amp; coming</td>
</tr>
<tr>
<td>Low Cost but also closer to demand</td>
<td>Aerospace parts, Auto parts Some footwear</td>
<td>Moving more to Mexico, Moving to Dom Rep</td>
</tr>
<tr>
<td>Fast, responsive supply chain for Low Volume, High Margin</td>
<td>High end consumer goods</td>
<td>Slowly returning to USA</td>
</tr>
<tr>
<td>Bound by huge installed supplier base</td>
<td>Consumer electronics</td>
<td>Stay in China</td>
</tr>
</tbody>
</table>
Global Supply Chain Design Strategies

**Vertical integration**
The following metrics are helpful to analyzing the effect of vertical integration:

\[
\text{Inventory Turn} = \frac{\text{Annual Sales}}{\text{Average Inventory}}
\]

\[
\text{Combined Inventory Turn} = \frac{1}{\sum_{i=1}^{n} \text{Inventory Turn}_i}
\]

where \( n \) is the number of plants vertically integrated

**Outsourcing**
- **Typical Situation**
  - Companies import with Transfer Price from subsidiary to parent or to another subsidiary
  - They have a PERMANENT ESTABLISHMENT (PE) in each country
  - They pay taxes in each country

- **Tax avoiding strategy:**
  - Design a network that complies with export restrictions, minimizes taxes, and provides the flexibility to ship from and to anywhere
  - Avoid PE in all but one country (headquarters location)
  - Use subcontractors for manufacturing and exporting, use distributors for importing and distributing
  - OEM buys from manufacturers and sells to distributors only in international air space or international waters

How to avoid permanent establishment
- Do not Manufacture in a country: *Use Contract Manufacturers (CM) instead*
- Do not be the Exporter of Record: *CM to be the exporter of record*
- Do not be the Importer of Record: *Customer or Distributor is the importer of record.*
- Do not own inventory in a country: *Inventory is owned by CM, Distributors, Suppliers, Customers.*
- Do not sell goods inside a country: *All sales of goods occur in int’l space*

**Learning Objectives**
- Understand most common practices used in global supply chain management
- Introduce international trade concepts and understand challenges and opportunities
- Understand the basics of international transportation
- Identify the main challenges faced in Air Freight, Ocean Freight and Surface transport
- Understand currency issues and how to prepare against exchange rate risks
• Overview concepts related to corporate income taxes, transfer pricing and profit repatriation
• Understand trade financing and how companies can help each other
• Identify four methods of international trade payment and letters of credit
• Understand different ways for manufacturing internationally
• Identify social issues, slavery and conflict minerals

References

For All

For International Transportation

For Currency Issues and Financing
• US. Gov. Trade Finance Guide 2007 pp3-28

For Sourcing and Shoring
• Trafficking in Persons Report, US Dept of State, July 2015
Exogenous Factors

Key Concepts

Enterprise Resilience
Companies are reliant on their supply chains, as a result of this, they are vulnerable to disruptions which pose a risk to their business. While all businesses are at risk, there are some more resilient than others, meaning that they recover quickly. To understand these two concepts, we focus on how to estimate risks, how to deal with them in terms of prioritizing and how to prepare companies for disruptions. Finally, we analyze how to respond and mitigate the problems once a disruption occurs.

There are two different ways to look at disruptions, i) thinking about causes and ii) thinking about effects or modes of failures. Cause thinking helps estimate likelihoods, while effects thinking helps estimate impacts and consequences.

Causes of Disruptions
These are different types of risks or causes of disruptions:
- **Random Phenomena**: weather phenomena or natural disasters
- **Accidents**: any undesirable event, such as explosions
- **Governments & Politics**: trade barriers, trade embargo, military coups, political instability, changes in regulations
- **Non-Compliance**: non-compliance of standards such as air pollution, water contamination, safety, etc.
- **Competition**: technological innovation, process innovation
- **Economy**: macroeconomic shocks that lead to economic contractions such as financial economic recessions and depressions
- **Social disconnect**: companies not connecting with customers’ will and desire
- **Intentional disruptions**: when there is a smart attacker on the other side, who will attack in the worst time and worst place, including terrorist attacks, strikes, cyber attacks

Modes of failure
These are ways how supply chains can fail and/or effects of disruptions:
- Inability to acquire supplies
- Inability to ship/loss of shipment
- Inability to communicate
- Inability to convert
- Loss of personnel
- Unavailable credit
- Brand/Trust diminution

Figure 38: Causes and Effects of Disruptions
Bow-Tie Risk Analysis Framework

One of the classical frameworks for thinking about risk and disruption is the Bow-Tie Risk Analysis Framework:

![Figure 39: Bow-Tie Risk Analysis Framework]

**Disruption Profile**

![Figure 40: Disruption Profile]
Classification of Risks

The traditional classification used to prioritize risk, includes two dimensions: probability of disruption and consequences. Usually, supply chain managers focus on the severe consequences-high probability quadrant (upper right). However, the most dangerous events are those in the severe consequences-low probability quadrant because companies are typically not prepared and do not know how to prepare for these events.

![Figure 41: Two-dimensional classification: Disruption Probability vs. Consequences](image)

In addition to disruption probability and consequences, a three-dimensional classification includes detectability. Dependability is defined as how long it takes from the time we know that an event is going to happen until it happens.

- **Probability**: investigate the causes and estimate their likelihoods
- **Consequences**: identify impact, prepare options, drills, mitigate options and ways to “bounce back”
- **Detection**: develop detection ability and define decision rules

Power Law: Likelihood and Impact

Likelihood and impact of many disruptions obey the power law, which can be used to estimate the relationship between the frequency and damage of events.

\[ f(x) = x^{-k} \]

Detectability and Preparation

There is a third dimension to characterize disruptions: detectability. The warning signs to identify suppliers are presented. the three types of elements to prepare for disruption are discussed: redundancy, flexibility and preparation.
Warning Lag
The warning lag is the time between alarm and event. It can occur:
- **After the attack**: in this case the time of detection is negative, you discover that something happened only after the event occurred
- **Immediate**: the time between the alarm and the event is zero, you realize that the event is happening when its occurring
- **Short term**: there is some time between the alarm and the event but not much to prepare
- **Medium term**: there is time between the alarm and the event, allowing the company to prepare
- **Long term**: the time between the alarm and the event is long so there is opportunity, enough time to prepare and take actions

Warning Signs of Supplier Failure
These might be signals that will allow you to sense that something is happening with the supplier:
- **Financial**: failure to prepare timely financial reports, multiple adjustments to annual reports, frequent negotiations of banking covenants, deteriorating working capital ratios, lengthening accounts payable
- **Operational**: high employee turnover in key positions, failed projects/failed acquisitions, operating loss, lack of capital investment, late/missed deliveries, quality issues, billing and invoicing errors, carrier selection errors

Resilience Fundamentals
Companies should weigh the benefits of uncertain future cost against certain current costs. Current costs are derived from the three ways to prepare for disruption:
- **Redundancy**: is creating/having some extra capacity, inventory, suppliers
- **Flexibility**: means interchangeability, is being able to change processes fast, cross-training people to be able to perform more than one task, using postponement and standardization
- **Readiness/preparation**: is having real options or the tools to respond
Safety management

![Safety Pyramid](image)

**Figure 42: Safety Pyramid**

Du Pont Bradley Curve

![DuPont Bradley Curve](image)

**Figure 43: DuPont Bradley Curve**
Ways to deal with limited supply

- Allocation: use some criteria to allocate what is available
- Auctions: give the product to the customer who wants it most
- Dilution
- Substitution
- Demand shaping

Learning Objectives

- Understand the concept of warning lag
- Learn resilience fundamentals
- Understand how to prepare for disruptions
- Learn how to think to prioritize and to prepare for risks
- Distinguish between different causes of disruptions and effects

References


Exogenous Factors
Exogenous Factors are external factors being forced on the supply chain that business has little control over. They may be expected or unexpected but can often shape the way that supply chains operate and may force different responses. In this lesson we will walk through exogenous factors, their sources, examples, and how companies respond.

STEEP FRAMEWORK
One way to organize the various factors impacting the supply chain is the STEEP Framework which consists of social, technological, economic, environmental, and political impacts.

- Social factors include demographics, religion, lifestyles and values
  - ex: aging population, crowdsourcing
- Technological factors include innovations, communication, R&D, and patents
  - Ex: machine learning, apps
- Economics factors include interest rates, global trade, taxes/fees/fines and inflation
  - Ex: trade between countries, financials
- Environmental factors include availability of resources, air & quality, food safety, pollution
  - Ex: drought, emissions, water pollution, product disclosure, labor conditions
- Political factors include regulatory stance, Government stability, tax policies, and trade unions
  - ex: disclosure, absolute requirements

Regulations
Regulations: a rule or directive made and maintained by an authority, typically governments. Economists view of regulations are that they are basically economic or social. Economic regulations set who can sell and what to charge such as market entry/exit, price controls. While social regulations prevent market failures by correcting for negative externalities like pollution, safety as all we information disclosure to consumers.

Types of regulation by mechanism:
Regulations can be applied in certain ways – as you can see in the following examples.
The objective of regulations is to impact behavior whether that be discouraging a behavior by banning or encouraging a behavior by requiring it. There are many challenges with regulations including:

- They affect almost every economic activity to some degree,
- They are constantly changing – deregulation or increase in regulation,
- They are often inconsistent (and sometime opposing) across regions and countries, and
- Firms are responsible for knowing and complying with all existing regulations and laws.

**Impacts on the Supply Chain**

Impacts on the supply chain can be refined to government, society, natural resources, and customers. These factors are actively influencing how supply chains are designed and operate. Firm and supply chain behavior can be influenced by both “hard” (Government & Natural Resources) and “soft” (Society & Customers) factors.

For instance, how can an event or exogenous factors impact freight flows. It can have an impact on sourcing patterns, flow destination, routing, flow volume, and value density.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute Mandates or Command &amp; Control</td>
<td>Strict rules or “Bright Lines” about what is allowed, what is not and how to act.</td>
<td>Endangered Species Act, Electronic Logging Devices (ELD), Seatbelt Laws, Emission Standards, RoHS</td>
</tr>
<tr>
<td>Liability Regulations</td>
<td>Companies or other parties can be held responsible for actions locally or internationally, currently or in the past.</td>
<td>Foreign Direct Liability, CERCLA Act (Superfund), Product Liability Act</td>
</tr>
<tr>
<td>Performance Based or Incentive Regulations</td>
<td>Governments set a standard to achieve but firms have flexibility on how to achieve them</td>
<td>Clean Air and Clean Water Acts, Extended Producer Responsibility (EPR), Take-back Laws</td>
</tr>
<tr>
<td>Market Based Regulations</td>
<td>Regulations that encourage behavior through market signals (incentives and penalties) and allow for trading and credits</td>
<td>Greenhouse Gas Emissions, Ethanol, Cap &amp; Trade</td>
</tr>
<tr>
<td>Disclosure &amp; Transparency</td>
<td>Regulations that do not dictate behavior, but require specified disclosure about product content/performance and/or business processes/practices.</td>
<td>Modern Slavery Act, REACH, Conflict Minerals Act</td>
</tr>
</tbody>
</table>
There are many types of regulations that are impacting the supply chain, some we will cover include factors related to products and processes.

- **Products**
  - Direct content (testable)
  - Lifecycle or pedigree (credence)
- **Processes**
  - End of life activities
  - Transportation, logistics, packaging
  - Sourcing practices

**Regulations on Product Content**

As far as consumers go, there is an increasing amount of attention and concern based on whether a product is ingested (food and pharmaceuticals), worn or in immediate proximity (clothes, cell phones), or in the general environment (metals in electronic goods, carbon).

Various Regulations across the globe focused on hazardous content:

- **Europe**: regulations focused on chemicals and raw materials in electronics and recycling
  - RoHS (Restriction of Hazardous Substances Directive)
  - WEEE (Waste Electrical and Electronic Equipment Directive)
  - REACH (Registration, Evaluation, Authorization and Restriction of Chemicals)
- **China**: Order No. 39 Final Measures for the Administration of the Control and Electronic Information Products (sometimes called the “China RoHS”)
- **South Korea**: Act for Resource Recycling of Electrical and Electronic Equipment and Vehicles
Monitoring Credence Attributes

Credence attributes are those that are not testable by a downstream company or the consumer. There are different attributes that make up a product. Some are testable and some are not. Types that are testable by a downstream consumer might include the color or texture or the experience of a product like the sweetness or consistency.

Credence attributes are NOT testable. Those are attributes that are practices in the supply chain but are not testable such as carbon footprint, child labor, or food safety adherence.

How to handle a problem like credence:

- We need to measure, monitor, track, and trace
- For environmental evaluation, requires Life Cycle Analysis (LCA)
  - Product-centric, cradle-to-grave analysis
  - Boundaries (breadth, depth, precision)
- Most Common Method to handle credence: Labels
  - Standard Setting: Need agreed upon targets, terminology & definitions
  - Testing – objective measure
    - For testable attributes – describe method for assessment
    - For credence attributes - need to Track and Trace to preserve the “identity” of the product (thus need for LCA!)
  - Certification Process
    - Self-certification versus 3rd party certification
    - Certification of the external certifiers!
  - Enforcement of Standards
    - Legal versus social versus market . . .

Disclosure Regulations

One of the most obvious regulatory impact on supply chains are disclosure regulations. These are that require companies to disclose certain information about practices and processes in the supply chain.

Examples include the California Transparency in Supply Chain Act and UK’s Modern Slavery Act.

For instance, companies of a certain size must disclose whether they have forced labor in their supply chain. Forces labor is all work or service which is exacted from any person under the threat of a penalty and for which the person has not offered himself or herself voluntarily (ILO).

Most Common Forms in Supply Chains

- Bonded labor - working to pay off a never-ending debt
- Forced labor - forced to work, cannot escape
- Migrant workers - no alternatives to survive
- Domestic workers - cannot leave the house
Common Industries:
- Agriculture
- Manufacturing
- Textile & Garments
- Mining
- Fishing
- Warehousing

Children in employment – all children engaged in any economic activity for ≥1 hour/week, for pay or not, part time or full time, inside or outside the family setting.

Children in child labor – subset of above – workers below the minimum age engaged for many hours/weeks not doing permitted “light work.”

Hazardous work – subset of above – children engaged in work that is harmful to their safety, health and moral development. Includes night work, long hours, exposure to physical, psychological or sexual abuse; work underground, under water, at dangerous heights, in confined spaces, heavy loads, dangerous machinery, dangerous substances.

Comparing the Disclosure regulations

California Transparency in Supply Chains Act - a company must disclose to what extent, if any:
- Engages in verification of product supply chains to evaluate and address risks of human trafficking and slavery. The disclosure shall specify if the verification was not conducted by a third party.
- Conducts audits of suppliers to evaluate supplier compliance with company standards for trafficking and slavery in supply chains. The disclosure shall specify if the verification was not an independent, unannounced audit.
- Requires direct suppliers to certify that materials incorporated into the product comply with the laws regarding slavery and human trafficking of the country or countries in which they are doing business.
- Maintains internal accountability standards and procedures for employees or contractors failing to meet company standards regarding slavery and trafficking.
- Provides company employees and management, who have direct responsibility for supply chain management, training on human trafficking and slavery, particularly with respect to mitigating risks within the supply chains of products.

Modern Slavery Act - An organization’s slavery and human trafficking statement may include information about:
- the organization’s structure, its business and its supply chains;
- its policies in relation to slavery and human trafficking;
- its due diligence processes in relation to slavery and human trafficking in its business and supply chains;
- the parts of its business and supply chains where there is a risk of slavery and human trafficking taking place, and the steps it has taken to assess and manage that risk;
• its effectiveness in ensuring that slavery and human trafficking is not taking place in
  its business or supply chains, measured against such performance indicators as it
  considers appropriate;
• the training about slavery and human trafficking available to its staff.

**Takeaways for supply chain managers:**
• Requires mapping of supply chains
• Added vendor/supplier compliance vetting — inclusion of a “Supplier Code of Conduct”
• Risk assessment includes not only legal compliance, but for reputation and market risks
• Contracting and use of 3rd party auditing firms/organizations
• But labor is just one attribute of many that are becoming scrutinized
• Should firms treat them all equally or differ our response based on other factors?

**Unintended Consequences – A cautionary Tale**
As regulations are well meaning and are designed to improve conditions by controlling,
practices and processes, they can sometimes have unintended consequences. For instance, the
Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010: “An Act to promote the
financial stability of the United States by improving accountability and transparency in the
financial system, to end “too big to fail”, to protect the American taxpayer by ending bailouts, to
protect consumers from abusive financial services practices, and for other purposes.”

In Section 1502 – it required the disclosure of the use of conflict minerals. The country of origin
is essentially a **credence** attribute for these minerals.

**Supply Chain response for Dodd-Frank**
• Where are the challenges?
  o Manufactured items can contain hundreds to thousands of parts/components
    and suppliers/vendors
  o Mineral content is usually not contained in BOM or ERP
  o Sourcing of materials is global and suppliers from other countries are not
    required to assist
  o Any 3TG found to be from the covered area requires much higher scrutiny and
detailed reporting
• What could possibly go wrong?
  o Cost of compliance for manufacturer can be very high
    ▪ Estimated >10 million paperwork hours annually spent by firms
    ▪ Over $10 billion in additional costs annually (2016)
    ▪ In 2014, Intel sent 90 employees to investigate smelters globally
  o This has led to an initial *de facto* embargo of minerals from the DRC resulting in
    loss of revenue to legitimate mines in the area
  o Continuing (or increased) sales of conflict minerals to firms in countries not
    operating under these regulations

Product Oriented Regulations/Pressures

- **Safety** – ensure safe operations across supply chain
  - Examples: Hours of Service (HOS) Rules, Truck Size and Weight Restrictions, Driver Licensing, Electronic Logbooks (ELD)
  - Can influence design and operation of networks
  - Typically treated as absolute mandates or constraints

- **Waste Reduction** – promotes more efficient use of resources
  - Examples: Truck fuel efficiency, GHG emissions by trucks, Smart package sizing, Efficient mode selection (TL to IM conversion), Zero-waste facilities
  - Happy coincidence that reduction of waste (miles, cardboard, fuel) improves efficiency and usually reduces total costs
  - Typically treated as cost reductions in making better trade-off decisions

- **End-of-Life** – encourage companies to design products for reuse, recyclability, and materials reduction
  - Takes many different forms involving governments, manufacturers, and others
  - Introduces (imposes) entirely new processes to supply chains

For **End of Life Processes** there are two main approaches: **Product Stewardship** and **Extended Producer Responsibility** (EPR). Product-centric strategy is where everyone involved in the lifespan of the product is responsible for all environmental, health, and other impacts. EPR is Manufacturer centric strategy designed to promote the integration of environmental costs associated with goods throughout their life cycles into the market price of the products.

In relation to this there are **take-back laws** to prevent waste. Their primary goal is to prevent waste encourage companies to design products that are easier to reuse or recycle, contain safer materials, reduce their environmental impact, and minimize waste management costs. As well as Promote innovation in recycling technology & collection systems
Firm Response and Approach
A company needs to segment its response to these issues for strategy. They must segment potential responses and action based on pressure and importance. Responses are on a continuum from “Do nothing” to “Focus all Activities”. A way of identifying what is important to the company and to the stakeholders is a materiality assessment, there are other similar frameworks for doing this.

Figure 45: Pressure to Act Vs. Importance to Business

Figure 46: Company Action Continuum
Warning!
This lesson barely scrapes the surface of an ever-changing and increasingly important topic!
It is not intended to make you an expert, just provide you with a framework to think about handling exogenous forces in your supply chain.

Learning Objectives

• Recognize there are many exogenous factors being placed on the supply chain including social, market, government, and natural.
• Identify types of regulations supply chains are held responsible and their impact on the supply chain.
• Become familiar with different product attributes like direct and credence.
• Review supply chain processes like safety, waste reduction, and end-of-life.
• Understand that firms can respond in different ways and are segmented by factor, market, etc.
Palm Oil Case Study

Palm Oil is a widely used oil in a large range of products. It is common in most CPG products because of its properties as well as packaged food products because of its shelf life and attributes as a non-trans fat. The reasons we spend so much time focusing on palm oil is because it brings together many of the exogenous factors we reviewed in Lesson 1 and culminates in different responses from different companies based on their stakeholders’ demands and business interests.

Palm oil is with you all day long:

![Figure 47: Uses of Palm Oil](image)

The Rise of Palm Oil

- 1848 – oil palm, a native of West Africa was brought by Dutch Traders to SE Asia
- Found useful in soap and lubricant for steam engines, grew well in SE Asia
- Grew rapidly in 1960s in SE Asia, esp. in Malaysia where government sought to reduce the country’s dependence on rubber and tin.
- Demand grew and plantations took over in Malaysia and Indonesia, today 85% of palm oil from these two countries
Together Malaysia and Indonesia make up over 85% of the market!

At the same time Palm oil has grown rapidly in demand, so has areas of forest cleared. It’s clear that there are many reasons for forest cleared, but this shows some correlation between the two processes.

And in 2010 – Kit Kat, Nestle was attacked for their use of palm oil by Greenpeace. This propelled this issue into the public eye.
The Problem with Palm Oil

The rapid demand of palm oil has resulted in both positives and negatives. The positive impact of palm oil is that it provides economic growth to countries like Malaysia and Indonesia, it brings livelihoods to some that did not have viable livelihood previous to palm oil, it is more productive per tree than its nearest competitor, in fact 10x more productive meaning it takes up less space to produce the same amount of oil, and it is also not a trans fat.

Social and environmental Impacts

However, the rapid demand beginning especially in the 2000s has caused rapid deforestation that results in carbon emissions as a result of rainforest clearing, haze from burning of rainforest, loss of biodiversity as a result of rainforest clearing and more. There are also extensive social implications such as:

- Child and family labor and insufficient protection
- Frequent use of forced, bonded labor
- Use of fixed short term contracts
- Land grabs
- Complex and opaque supply chain
Types of Plantations
Palm oil is largely grown on 3 types of palm oil plantations including estates, associated or scheme smallholders and smallholders. Both estates and associated or scheme smallholders are generally more organized and easier to work with. Estates are often owned by larger corporations while associated or scheme smallholders are structurally bound by contract or credit agreement to a particular mill. Smallholders are generally self financed, managed, equipped, and not bound to any one mill.

Organization for Sustainability
There are many different types or organizations working towards more sustainable palm oil. They have different objectives, strategies, and approaches and often have conflict over what sustainable palm oil means. Some are advocating for the cause, some are catalysts for change, and some support business in their journey to achieve more sustainable palm oil.

- NGOs
  - The Forest Trust
  - World Resources Institute
  - Wild Asia
  - Rainforest Action Network

- Industry associations
  - Roundtable on Sustainable Palm Oil (RSPO)
  - Palm Oil Innovation Group (POIG)

- And many more...

To begin to encourage sustainable palm oil, there are three main ways to trace material to source to verify practices on the ground. See below:
Corporate Responses

Build on the framework from Lesson 1 Exogenous Factors, this framework adds some more specifics on practices in the “embrace” category. One can insure by putting in extra measures to make sure they are not committing ill practices in their supply chain. They might re-design or change something in their supply chain to improve practices in the supply chain. And in the greatest amount of effort they might transform a part or all their supply chain to ensure sustainable practices.
Different corporate responses are reviewed between Nestle, Unilever, P&G’s and and Dr. Bronner’s different approaches. Based on their company orientation, pressure from NGO’s, capacity to change, and long-term objectives, each company had a different approach. Nestle spent a lot of their efforts on getting a high level of traceability to sources, this is particularly because of Greenpeace’s attacks and their naivety on where their material was coming from. P&G spent a lot of time researching their options and essentially focused their efforts on supporting smallholders because of their portion of spend on smallholders. Unilever, with their orientation towards industry wide change, worked heavily on different organizations and collaborations that sought to elevate the practices in the palm oil supply chain. For the small Dr. Bronner’s, their whole company orientation was on sustainable supply chains, so they chose to spend considerable time transforming their supply chain by vertically integrating with a subsidiary.

Different Scenarios for Palm Oil

- Many different scenarios as we can imagine (Scenario Planning)
  - All palm oil becomes sustainable, sustainable palm oil becomes cost competitive
  - Companies move away from palm oil as a key oil source
  - Continue on path with incremental changes

- This problem is not isolated, similar challenges with other materials:
  - Social pressure
  - Finite amounts
  - Regulation
  - Market Demand

Learning Objectives

- Recognize the different exogenous factors apparent in the palm oil supply chain
- Become familiar with the different forces being placed on the supply chain and the new expectations by society and consumers
- Become familiar with commodity supply chain challenges
- Recognize companies will respond in different ways based on their orientation, capacity, and long-term goals
- Identify different scenarios and how they might help company strategy