



Quantitative Decision Making : Metrics and Performance Indication

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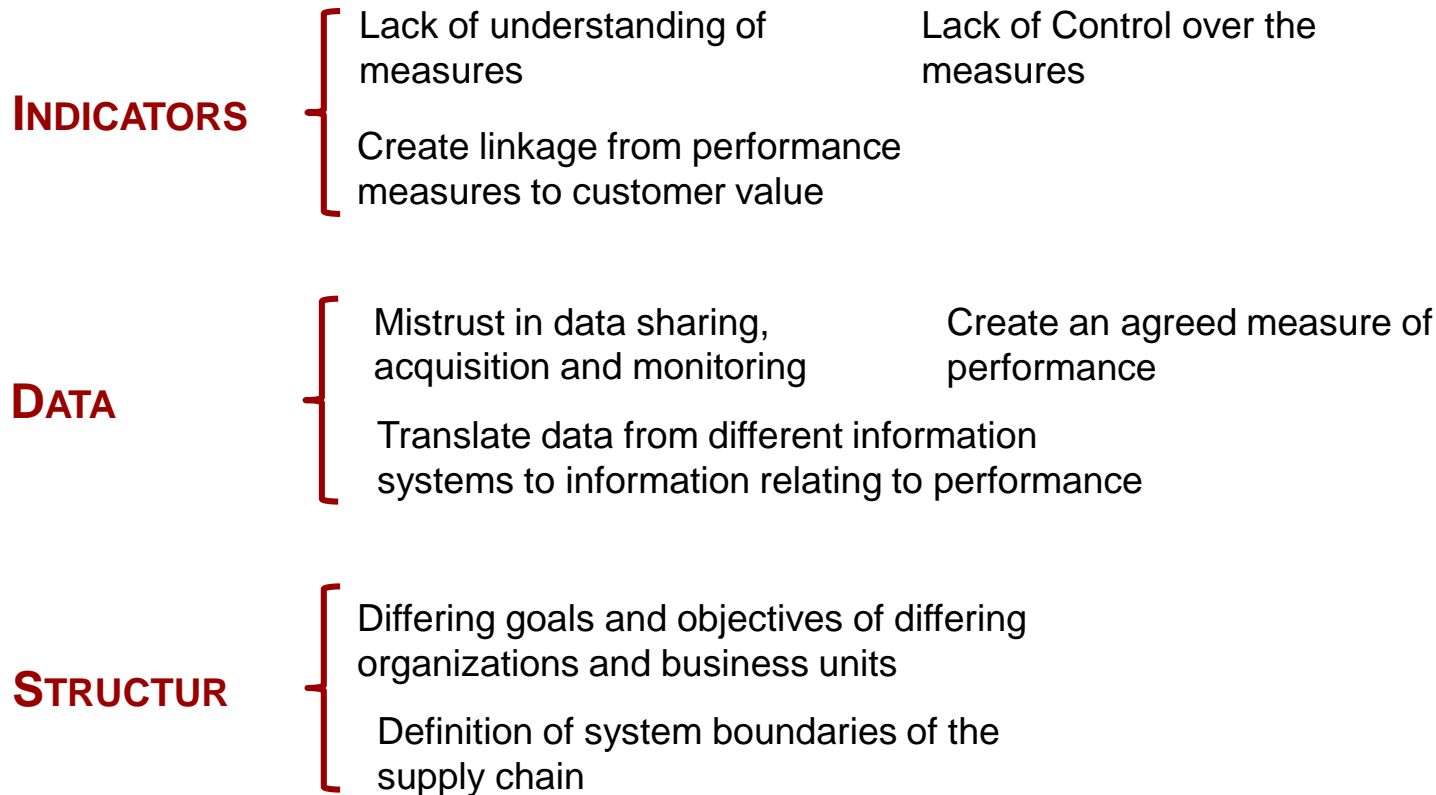
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Agenda

1. Metrics
2. Performance Dimensions
3. Different Performance Indication Systems
4. Common Performance Indicators

Motivation for Supply Chain metrics – Why bother?

- Performance metrics, tools and models are supposed to counter several issues



Performance measurement systems

” *The core purpose of a performance measurement system is for quantifying the efficiency and/or effectiveness of action.*

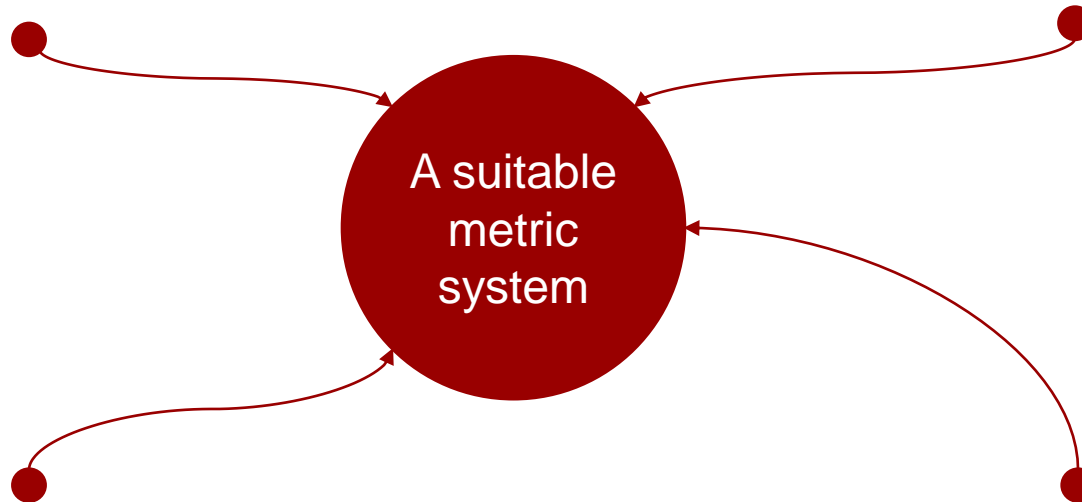
- performance measurement systems consist of a number of individual performance measures.
- There are various ways in which performance measures can be categorized
- Performance measures need to be positioned in a strategic context, as they influence what people do.
- Measurement may be the “process of quantification”, but its affect is to stimulate action, what is realized through consistency of action that strategies are realized.

Creating Supply Chain metrics

The metric employed in a supply chain is dependent on several factors, including:

Product characteristics (functional vs. innovative)

Supply Chain Strategy (e.g. risk hedging, efficient, responsive and agile)



Supply Chain Structure (e.g. liner, network, amorphous)

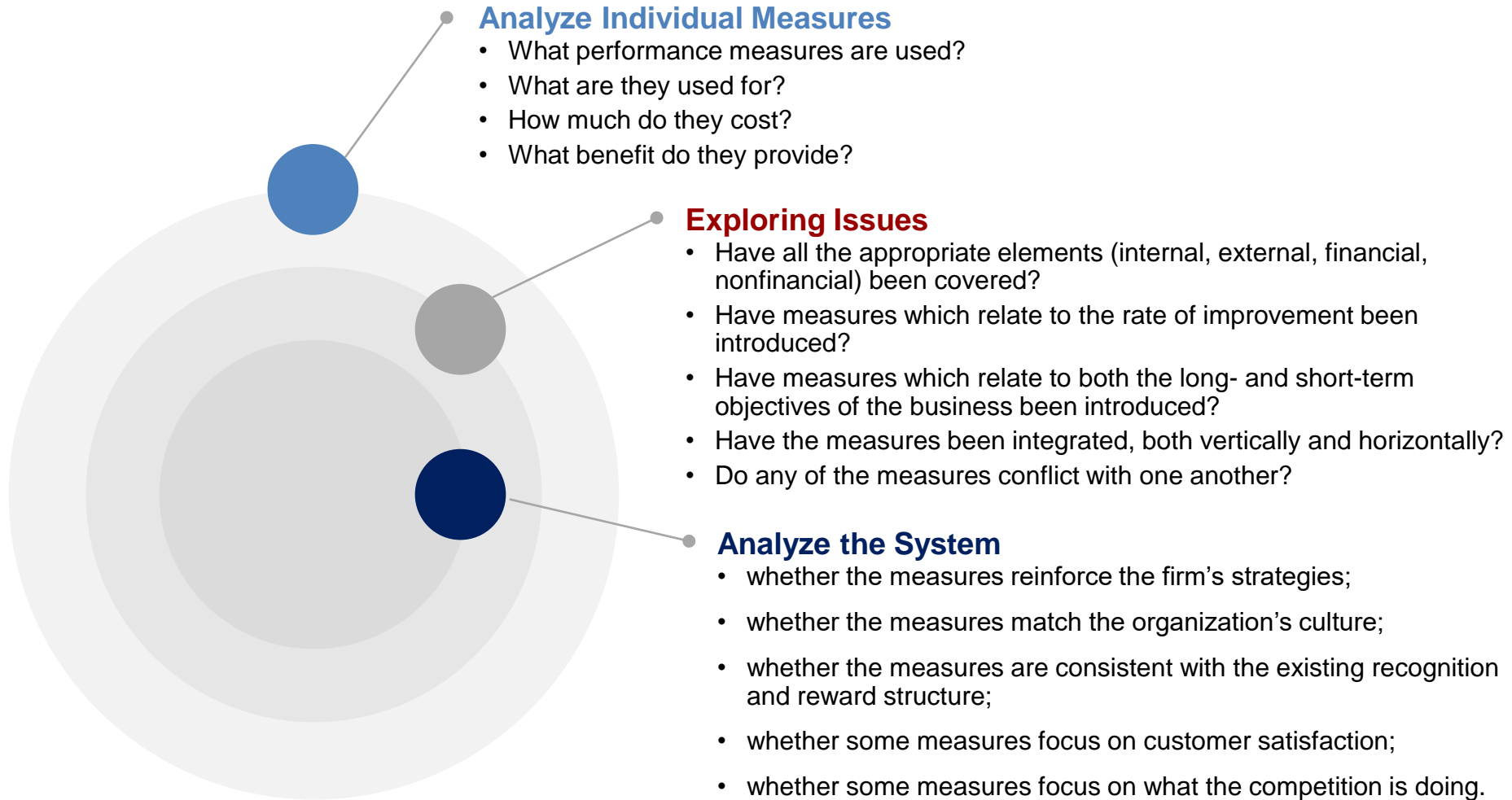
Desired competencies of the Supply Chain (agility-adaptability-alignment)

Issues of Supply Chain metrics

The problems of ratios that are not systematized (or poorly systematized) have been pointed out above.

- Which problems occur in supply chains with key figures?
 - lack of connection with strategy
 - insufficient focus on customers and competitors
 - focus on cost to the detriment of non-cost indicators
 - loss of supply chain context, thus encouraging local optimization
 - lack of a balanced approach
 - lack of system thinking

Analyzing a performance measurement system

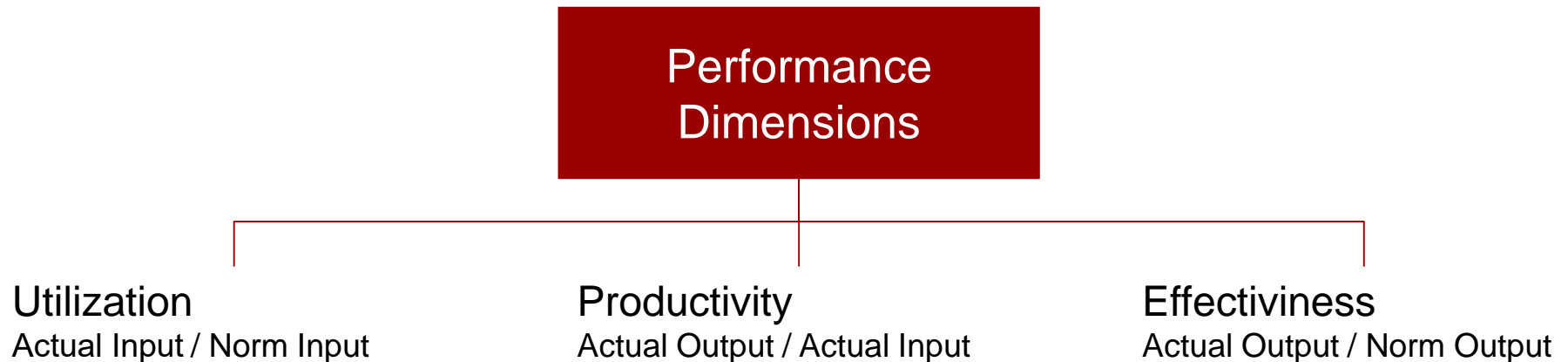


Summary: Metrics

- A supply chain measurement system should cover the effectiveness and efficiency of the supply chain actions
- The right performance system is dependent on several factors of the supply chain, including product characteristics, supply chain strategy, supply chain structure and desired competencies
- To analyze the performance measurement system, the individual measurement as well as covered issues and the alignment with strategy has to be evaluated

Performance Dimensions

- Business activities are typically modeled as transformational processes converting inputs into outputs through some applied work
- The objective is to maximize the output (quantity, quality, or both) while minimizing the input consumed (labor, equipment, raw material, time)
- The Performance of a process regarding input and output is measured in Utilization, Productivity and Effectiveness



*Norm: predetermined or competitive standard specified by some manager

Utilization

” *Utilization is a measure of input usage and is usually presented as a ratio or percentage of the actual amount of an input used to some norm value.*

Productivity

Effectiveness

- inputs can be characterized as being financial, physical assets, or inventory.
- Resulting from that, Utilization can either be
 - spending measures
 - Nonfinancial resource measures
 - or inventory measures
- Examples:
 - labor hours used / budgeted number of hours
 - area of warehouse occupied / total area
 - hours of machine use / machine capacity

Utilization Metrics – Spending measures

Application Areas

Spending Measures: capture how much is spent on/cost of portions or the entire logistics process

- *historic* indicates trend but is not useful for comparison of firms/companies,
- *base* e.g. total cost or total sales is comparable but less valid, since it might be out of reach process manager, and
- *budget* shows adherence to plans but not managerial excellence

Nonfinancial Resource Measures: capture durable, long lived assets such as loading equipment, truck fleets, and distribution facilities.

- **usage ratio** compares the amount of the asset actually consumed to the amount available (the measures are usually asset specific and thus barely comparable across different assets)
- **amortize costs** (either by the amount consumed or by the amount available) and includes this dollar value in spending metrics.
 1. *consumed* captures the efficiency of the process accurately but ignores additional costs resulting from bad managerial decisions
 2. *available* accounts for all durable inputs accessible for use by the process managers

Inventory Measures:

- **Static measures** capture the level of the inventory (expressed in physical, financial or other terms) at a specific point in time
- **flow metrics** capture the speed of the inventory as it flows through the system over a period of time (*inventory turnover ratio* (ITR), *days of supply* (DOS))

” *Productivity is a measure of transformational efficiency and is typically reported as the ratio of actual outputs produced to actual inputs consumed*

- Types of productivity measures
 - partial measures
 - total factor productivity
 - financial productivity measures
- Examples:
 - ton-miles delivered / costs incurred
 - orders processed / number of hours of labor
 - Number of pallets unloaded / hour of dock time

Productivity Metrics – Factor Productivity Measures

Application Areas

Partial Factor Productivity Measures: Capture how much productivity change can be accounted for by a single factor or a subset of factors while holding all others constant.

- **Single factor productivity (SFP) ratios:** the *output* used is typically the cost driver of the function being measured, while the *input* is based primarily on the most controllable resource within a particular function (costs, labor hours, machine hours).

Total Factor Productivity Measurement: measure of total output produced per unit of input where the multiple inputs and outputs are combined through the means of aggregated indices or estimated using specified cost or production functions.

- Difficult to compute and interpret, comparison depends of methodology used and do not imply actions to take for improvement

Financial Productivity Measurement: uses monetary values for both the inputs and the outputs.

- **Return on investment (ROI)** is the most common measure.
 - It is usually defined as output revenues minus input costs divided by the current and fixed assets. Thus, it requires the translation of the physical logistics output into a financial value, usually through some sort of transfer pricing.
 - It might be misleading as some components are subject to arbitrary allocation of overhead and can differ significantly from company to company

Effectiveness

Utilization

Productivity

” *Effectiveness is a measure of the quality of process output and is typically reported as a ratio of actual output to a norm output.*

- Types of effectiveness measures
 - setting standards (are the right services at the right levels of performance being offered?)
 - adhering to standards (are the agreed upon standards being met?)
- Measuring the adherence to a standard without determining the correctness of it obscures the true effectiveness of the process
- Examples:
 - Number of items filled / number of items requested
 - Number of shipments on-time / number of shipments sent
 - Number of transactions w/o error / number of transactions

Effectiveness Metrics – Setting Standards

Application Areas

Setting Standards: The organization needs to define "quality output", presenting customer expectation or desire, in practical terms and then compare the actual output to these offered service standards.

- A perfect delivery, defined as a transaction between the buyer and the customer which meets or exceeds all of the agreed upon service standards, differs from customer to customer.
 - *Internally focused standards* for output are used to as control to limit the spending on unnecessary speed.
 - *Externally focused standards* are concerned with satisfying the customers' service requirements.

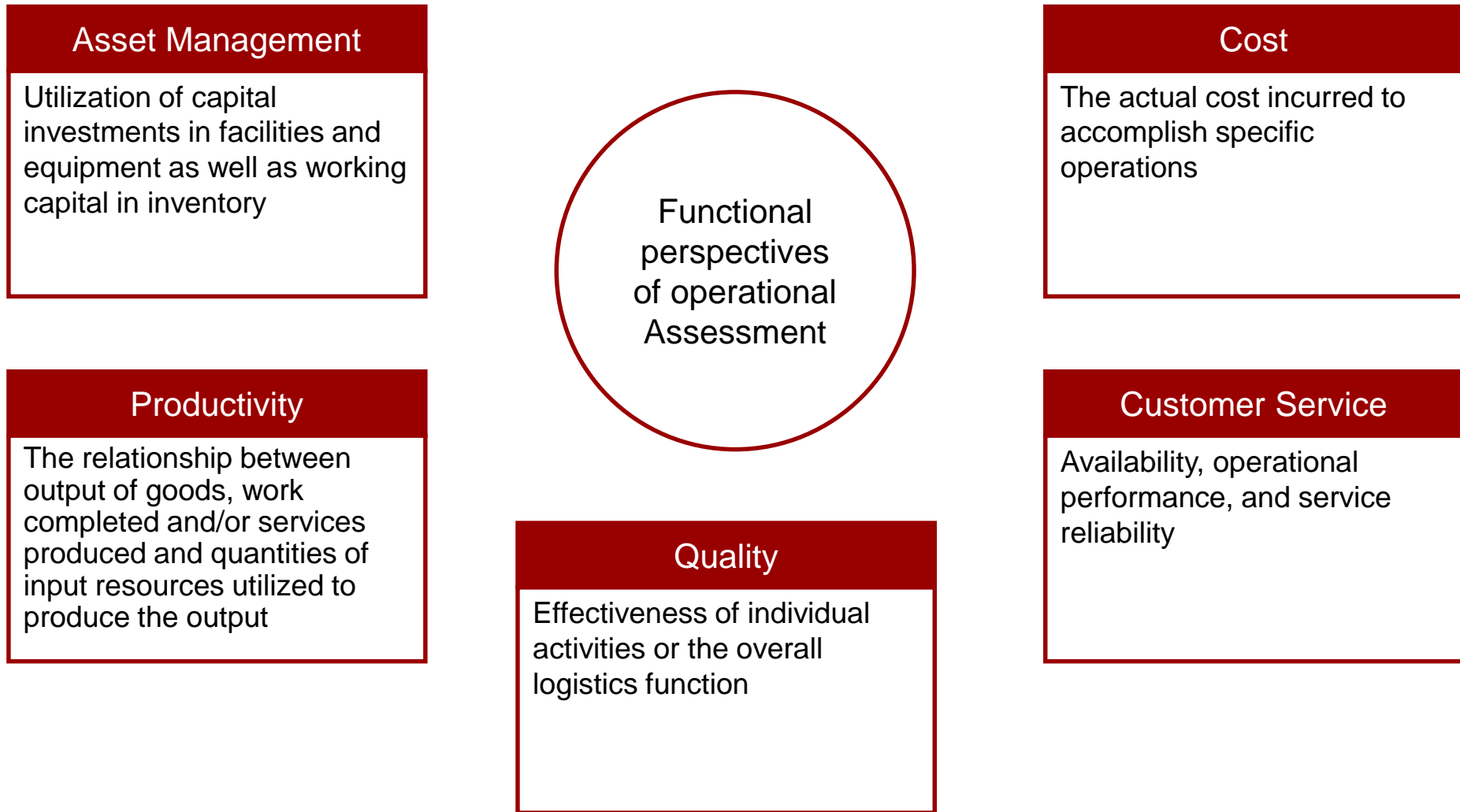
Adhering to Standards: Once service standards are determined / "quality" is defined, metrics to track the adherence to these standards can be developed.

- *Scope:* All effectiveness metrics designate a measurement location and a time span
- *Level of Detail:*
 - Aggregation at customer orders level is useful for tracking order deliveries
 - Aggregation at SKU level is useful for recognizing order characteristics
 - Recognition of conditions (missing, not delivered, substituted, damaged) provides a more diagnostic hint of failures as compared to a delivered vs. not delivered distinction
- *Weighting factors:* While summarizing effectiveness of orders, the orders can be weighted (e.g. number of items filled divided by number of items requested, value of the product, the process time, or the priority of the customer)

Summary: Performance Dimensions

- Considering logistics from a process perspective transforming input to output, there are three dimensions of performance: utilization, productivity and effectiveness
- No single performance measurement can capture the total performance of the firm, is useful for single process owners to derive actions and creates comparability to other facilities or firms

Different Performance Systems - Operational Assessment



Different Performance Systems - Key Supply Chain Performance Indicators

Attribute	Description
Quality	conformance to requirement or fitness for use
Flexibility	The supply chains agility in responding to random changes in the marketplace in order to gain or maintain competitive advantage
Cost	Supply chain costs include all costs associated with operating the supply chain, including the cost of goods and total supply chain management cost
Supplier Reliability	identify suppliers with exceptional performance or developmental needs, improve supplier communication, reduce risk and manage the partnership based on the Analysis
Innovation	ensures that existing technologies, as well as technologies under development
Responsiveness	how quickly a supply chain delivers products to the customer
Order delivery lead time	encompasses the fulfilment of the average percentage of orders among supply chain members that arrive on time, complete and damage-free, satisfying customer requirements.
Final Product delivery lead time	refers to the performance of the supply chain in delivering the correct product to the correct place at the correct time in the correct condition and packaging in the correct quantity with the correct documentation to the correct customer
Product Variety	measures the number of product families processed in a facility
Asset Management	effectiveness of an organisation in managing assets to support demand satisfaction

Different Performance Systems - Framework for Performance Measurement

Quantitative Measures

Cost

Total cost is a sum of all its complex attributes (Distribution, Manufacturing, Inventory, Warehouse, intangible)

Resource Utilization

Percentage of excess or lack of a particular resource within a period (labour, machine, capacity, energy)

Qualitative Measures

Quality

The standard of a product which is related to the customer satisfaction level

Trust

Trust is the reliability and consistency between different levels of the supply chain

Flexibility

The adaptability of the company to respond to diversity or change.

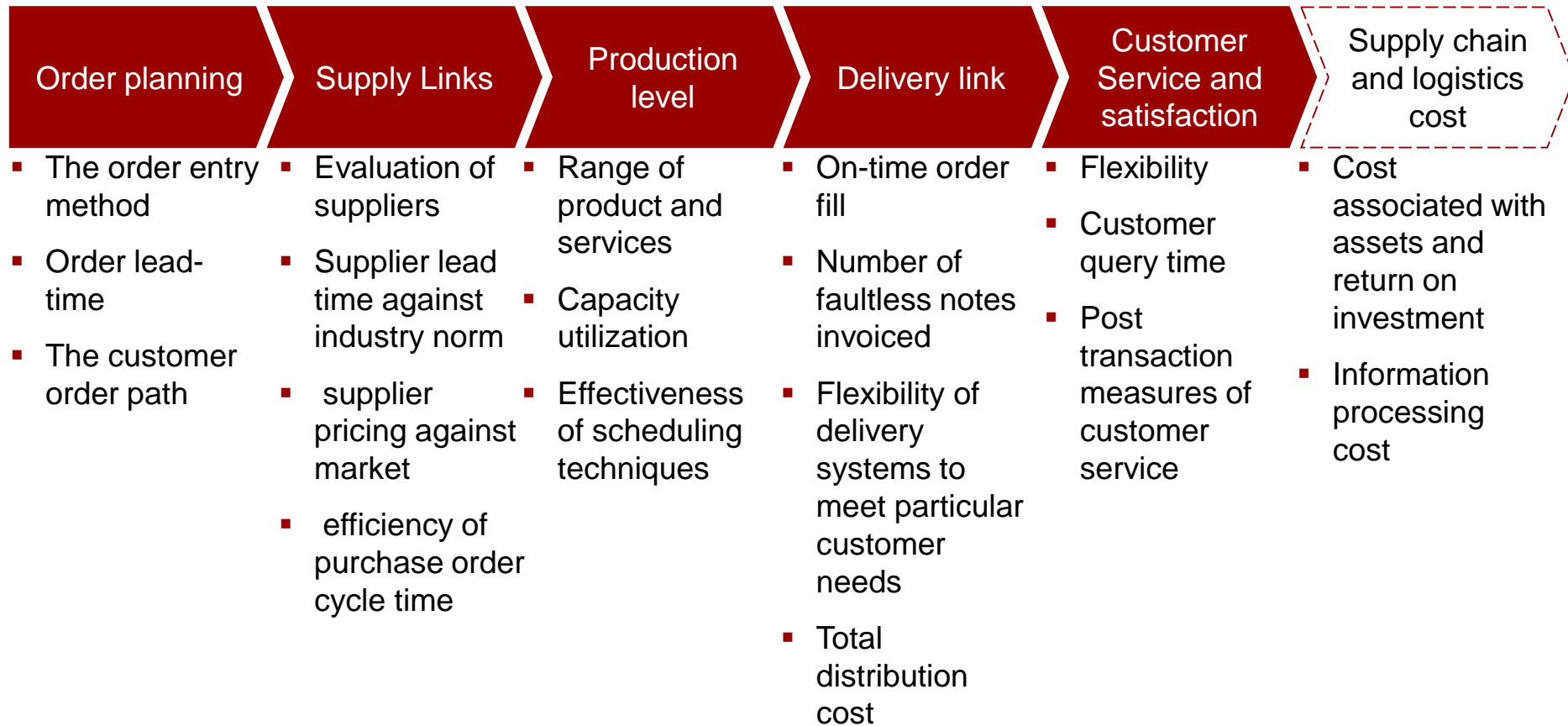
Innovativeness

Launches of new products or use of new technologies

Visibility

The time and accuracy of information transfer

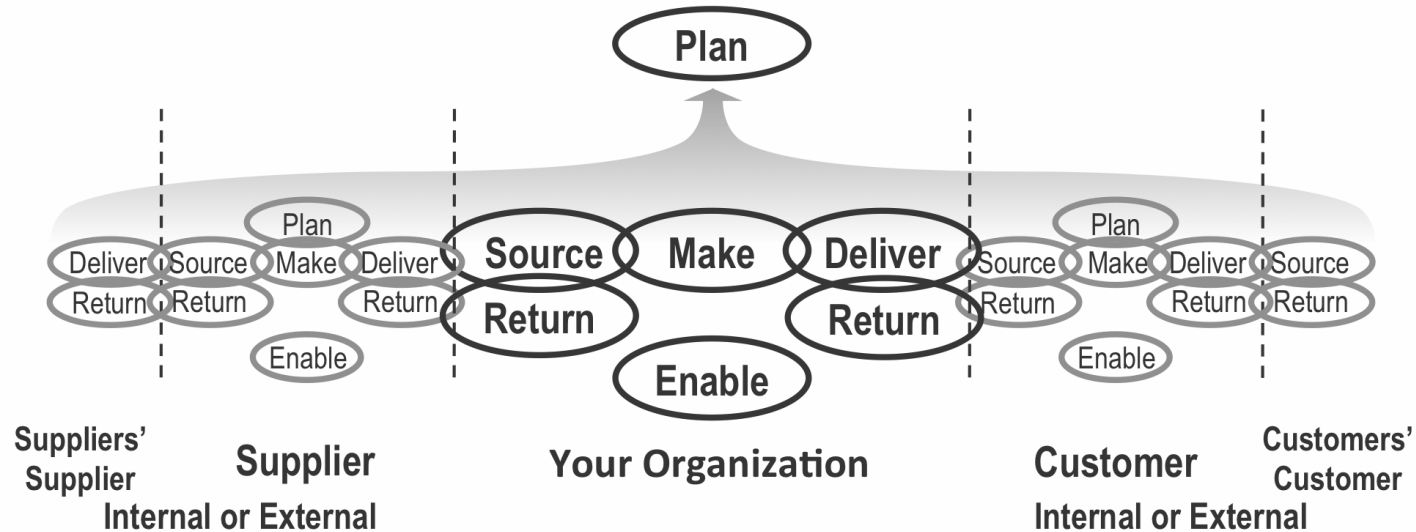
Different Performance Systems - Performance measures on supply chain activities/processes



Different Performance Systems - SCOR Model I/II Metrics

Attribute/ Metric	Reliability	Responsiveness	Agility	Cost	Assets
Description	ability to perform tasks as required	the speed at which tasks are performed	ability to respond to external influences	cost of operating the process	ability to efficiently utilize assets
Level-1 Metric (strategic)	Perfect Order Fulfillment	Order Fulfillment Cycle Time	<ul style="list-style-type: none"> Upside Flexibility Downside Adaptability 	Total Cost to Serve	<ul style="list-style-type: none"> Cash-to-Cash Cycle Time Return on Fixed Assets
Level-2 Metric (identify causes of performance gaps in level-1)	<ul style="list-style-type: none"> % of Orders Delivered In Full Delivery Performance to Customer Commit Date ... 	<ul style="list-style-type: none"> Source cycle time Make cycle time Delivery retail cycle time ... 	<ul style="list-style-type: none"> Upside Source Flexibility Upside Deliver Flexibility Upside Make Adaptability ... 	<ul style="list-style-type: none"> Planning cost Sourcing cost Order management cost ... 	<ul style="list-style-type: none"> Days Sales Outstanding Days Payable Outstanding Supply Chain Fixed Assets ...
Level-3 Metric (diagnostics for level-2)	<ul style="list-style-type: none"> Delivery Item Accuracy Orders Delivered Defect Free ... 	<ul style="list-style-type: none"> Transfer product cycle time Fill shopping cart cycle time ... 	<ul style="list-style-type: none"> % of labor used in logistics, not used in direct activity Additional delivery volume ... 	<ul style="list-style-type: none"> Order management labor cost Fulfillment automation cost ... 	<ul style="list-style-type: none"> Deliver Fixed Asset Value Make Fixed Asset Value ...

Different Performance Systems - SCOR Model II/II Processes



- The SCOR Model assigns the metrics to different attributes and levels of a metric systems as well as to SCOR processes and best practices

Summary: Performance Indication Systems

- Performance systems have some generally accepted and reoccurring categories ... and divert in additional categories, covering aspects like ...
- There is no single performance system eligible for every company or organization. The System has to be individualized with a companies / supply chains strategy.
- Different organizations and companies will select different indicators for the same performance category. Therefore, it is important to familiarize with the performance system before taking actions.

Coming up next:

While the performance indication systems differ, several **common performance indicators** reoccur in most of them and are often used in business settings.

Fill rate

- The fill rate measures a firm's performance relative to product Availability.
- For the order fill rate, the most common, an order missing one item is considered incomplete

$$\text{Order fill rate} = \frac{\text{\# of orders delivered complete}}{\text{\# of customer orders}}$$

- There is a variety of fill rates

$$\text{Value fill rate} = \frac{\text{Total euro value delivered to customers}}{\text{Total euro value of customer orders}}$$

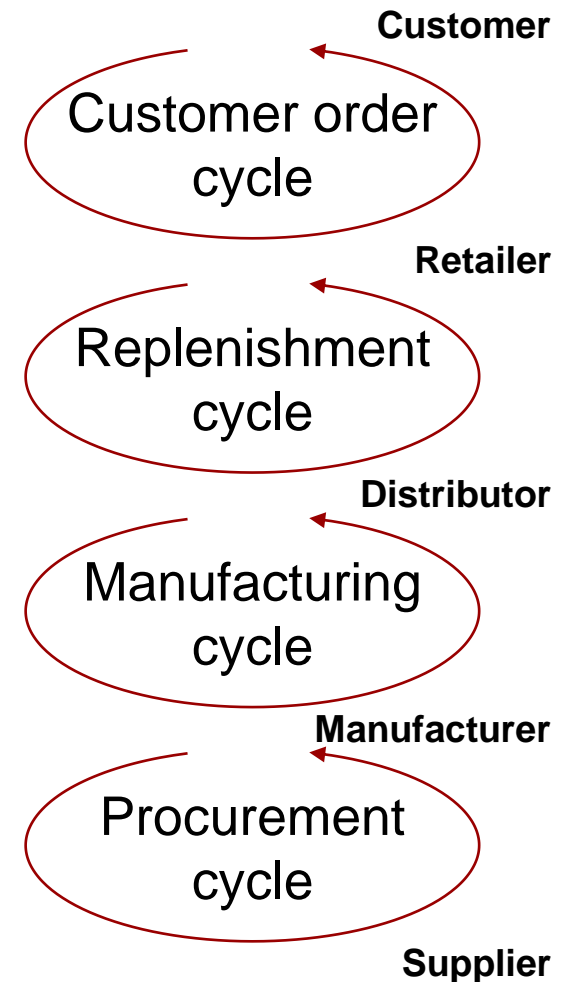
$$\text{Line fill rate} = \frac{\text{\# of purchase order lines delivered complete to customers}}{\text{\# of purchase order lines ordered by customers}}$$

$$\text{Item fill rate} = \frac{\text{\# of items delivered to customers}}{\text{\# of items ordered by customers}}$$

* #: Number

Cycle Time – The cycle view of the supply chain

- all supply chain processes can be broken down into four process cycles (Not every supply chain will have all four cycles clearly separated.)
 - Customer order cycle
 - Replenishment cycle
 - Manufacturing cycle
 - Procurement cycle
- Within each cycle...
 - The buyer wants to ensure product availability and economies of scale
 - The supplier attempts to forecast customer orders and reduce cost of receiving the order
- In the customer order cycle, demand is external to the supply chain and thus uncertain. In all other cycles, order placement is uncertain but can be projected based on policies followed by the particular supply chain stage
- From Supplier to customer, the Scale of the order size usually declines



Cycle Time

- The (customer) order cycle time measures by the number of time units elapsed between order receipt and delivery to customer

Order cycle time = time of order delivery – time of order receipt

- Regarding the different cycles, there is a great variety of cycle times. The cycle in focus should be identified before comparing cycle times
- Cycle time may not be interpreted as covering the full cycle for some companies:

cycle time = time of order readying to ship – time of order receipt

cycle time = time of finishing order picking – time of order receipt

- The measurement is also known as customer response time, often hard to distinguish from lead time

On-time delivery

- On-time delivery can be represented by the percentage of orders delivered on or before the due date.

$$\text{On-time delivery} = \frac{\text{\# of orders delivered on or before due date}}{\text{\# of customer orders}}$$

- Regarding the cycle time interpretations, “on-time” can be understood in different ways (e.g. shipped on-time, picked on-time)

Inventory turnover and days of supply

- The inventory turnover rate measures how many times the inventory has been replaced during a time period.
- There are different ways firms measure inventory turnover

$$\text{inventory turnover} = \frac{\text{Cost of goods sold during a time period}}{\text{Avg. inventory valued at cost during the time period}}$$

$$\text{inventory turnover} = \frac{\text{Sales revenue during a time period}}{\text{Avg. invent. valued at selling price during time period}}$$

$$\text{inventory turnover} = \frac{\text{Units sold during time period}}{\text{Avg. unit inventory during time period}}$$

- The invert, days of supply, tracks the amount of inventory that is available to meet forecasted sales volume

$$\text{Days of supply} = \frac{1}{\text{inventory turnover rate}}$$

Accuracy

- Accuracy of work performances in activities as order entry, warehouse picking, document preparation, or invoicing are measures of quality
- It reflects the ratio of how often an activity is done correctly to how often the activity is done

$$\text{order entry accuracy} = \frac{\text{\# of orders entered correctly}}{\text{\# of orders entered}}$$

$$\text{picking accuracy} = \frac{\text{\# of items picked correctly and correct amount}}{\text{\# of items picked}}$$

Alternative Supplier/Service Provider Benchmarking

- Is the practice of requesting prices from a number of suppliers for a particular product or service and comparing the prices to the existing supplier in order to determine whether the current price paid is representative of the market/industry

- As Material landed cost:

Material landed costs = purchased material cost

+ material transport cost

+material customs duties, Taxes and tariffs cost

+material risk and compliance

- ...or as Cost of Goods sold:

Cost of Goods sold = direct labor costs

+ direct material cost

*+overhead cost**

*e.g. cost of software, hardware, maintenance, consumables, lease, rent, remanufacturing, refurbishment, indirect cost associated with supporting processes, risk management, quality management, process improvement, compliance remdaiton, office supplies, ...

- If an existing supplier contract is for many different materials/ or service requirements, usually only a sample of those materials/service requirements are used to test the market price.
 - Price may not reflect service level
- In a formal contract with a supplier, a clause that allowing to benchmark against the market should be included. It gives the opportunity to discuss pricing concerns with the existing supplier
- Caution on spot market rates: it does not always return comparable results

Summary: Common Performance Indicators

- Some Common Performance Indicators you should know are
 - Fill rate
 - On-time delivery ratio
 - Cycle time
 - Inventory turnover rate
 - Accuracy
 - Price comparison

References

- Caplice, C.; Sheffi, Y. (1994): A Review and Evaluation of Logistics Metrics. The International Journal of Logistics Management.