# MGT 528 – OPERATIONS: ECONOMICS & STRATEGY

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*4. Performance Metrics and Pricing*

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École Polytechnique Fédérale de Lausanne
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## AGENDA

**Supply-Chain Performance**

Performance Drivers

Performance Measures

Optimizing Profit: Price Discrimination

Key Concepts to Remember

# INVESTORS CARE ABOUT RETURN ON ASSETS (ROA)
## … Ignorant about the Details of a Company's Supply Chain

**ROA = (Net Income) / (Average Total Assets)**

**Assets = Capital (Equity) + Liabilities** **… from Balance Sheet**

**Net Income = « Revenues – Cost »** **… from Income Statement**

> **Key Question: How can a company link investment performance (ROA) to *operational* decisions and *operational* performance indicators?**



# THREE BASIC FINANCIAL STATEMENTS

**Balance Sheet – A snapshot *at a point in time* of the financials of a company.**

**Income Statement – The revenues and expenses of a company *over a period of time*.**

**Statement of Cash Flows – The changes in the cash account of a company *over a period of time*.**

# THE BALANCE SHEET

| Assets | Liabilities/Equity |
|---|---|
| Converted to cash or used up within a year → **Current Assets**<br>• Cash<br>• Accounts receivable<br>• Marketable Securities<br>• Inventories | Obligations due within a year → **Current Liabilities**<br>• Accounts payable<br>• Estimated Tax Liability |
| **Noncurrent (fixed) Assets**<br>• Plant, Property and Equipment | **Noncurrent Liabilities**<br>• Long-Term Debt |
| | **Equity**<br>• Paid-in Capital<br>• Retained Earnings |

**Assets = Liabilities + Equity**



# INCOME STATEMENT

**Revenues**
- Cost of Goods Sold (Material, Labor, Overhead)

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= Gross Margin

- Selling, General, and Administrative (SG&A)
- Depreciation

---

= Operating Profit

- Interest

---

= Net Income Before Taxes (NIBT)

- Taxes

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= Net Income After Taxes

## STATEMENT OF CASH FLOWS

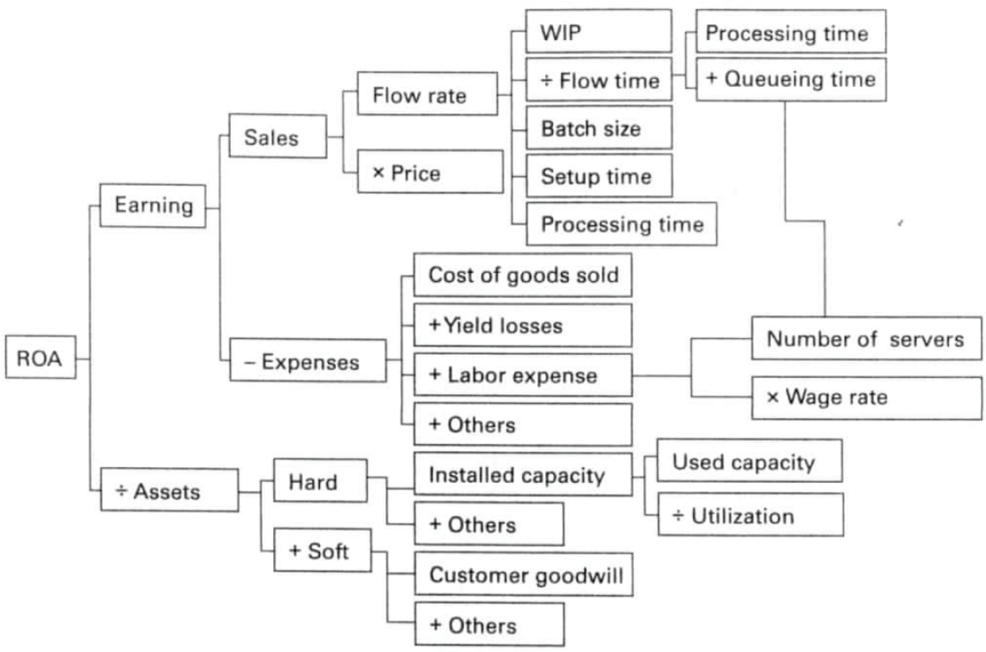
**Accounting is done on an accrual basis rather than a cash basis.**

**Yet cash flow is what determines whether a company ultimately goes bankrupt or not.**

**The statement of cash flows measures the inflows and outflows of cash over a period of time.**

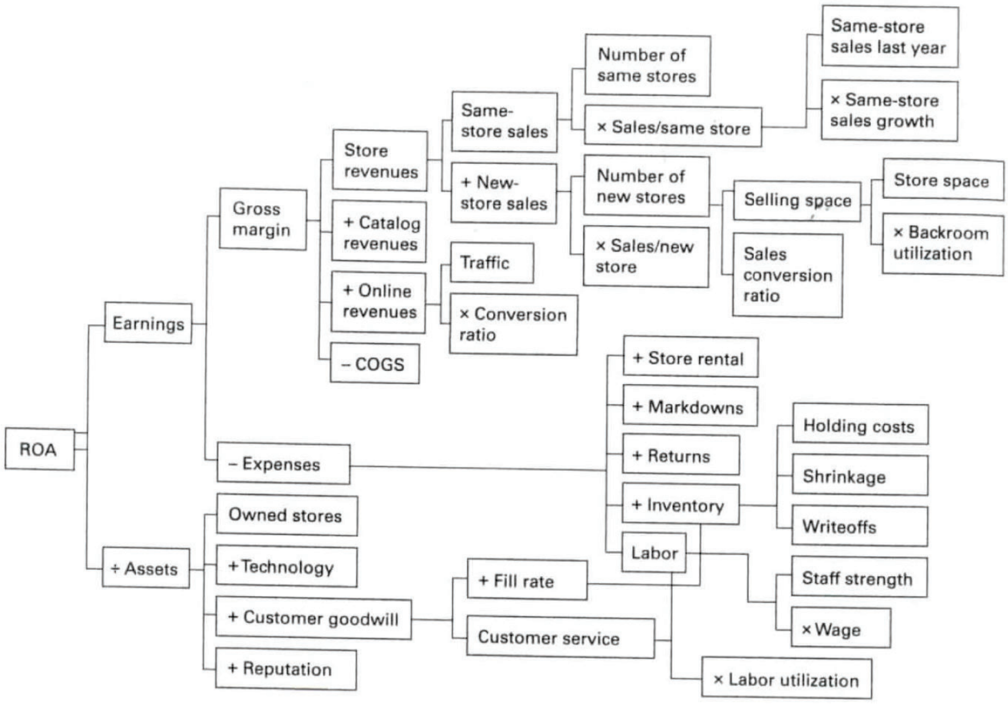


## AN ROA TREE BREAKS DOWN PERFORMANCE




Source: Lai, R. (2013) *Operations Forensics*, MIT Press, Cambridge, MA.

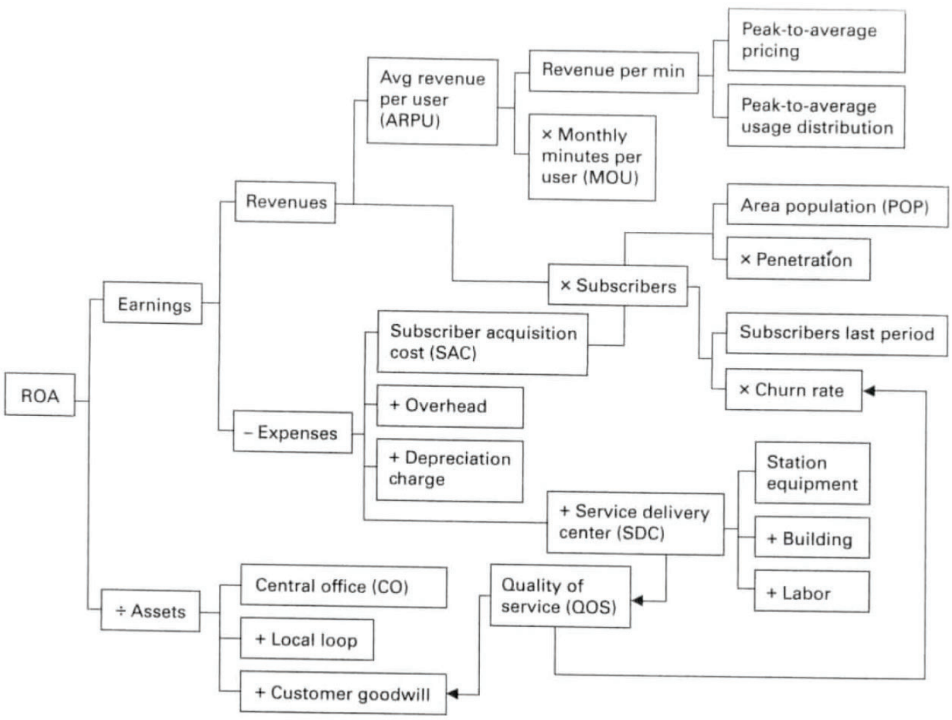
# ROA TREE NEEDS TO BE CUSTOMIZED
## Example: Retailing




Source: Lai, R. (2013) *Operations Forensics*, MIT Press, Cambridge, MA.

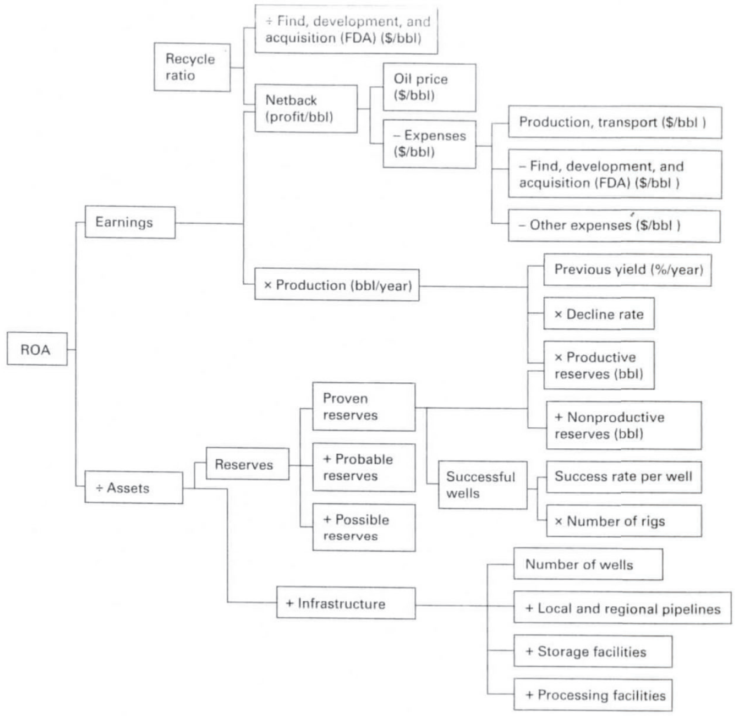


# ROA TREE NEEDS TO BE CUSTOMIZED
## Example: Telecommunications




Source: Lai, R. (2013) *Operations Forensics*, MIT Press, Cambridge, MA.

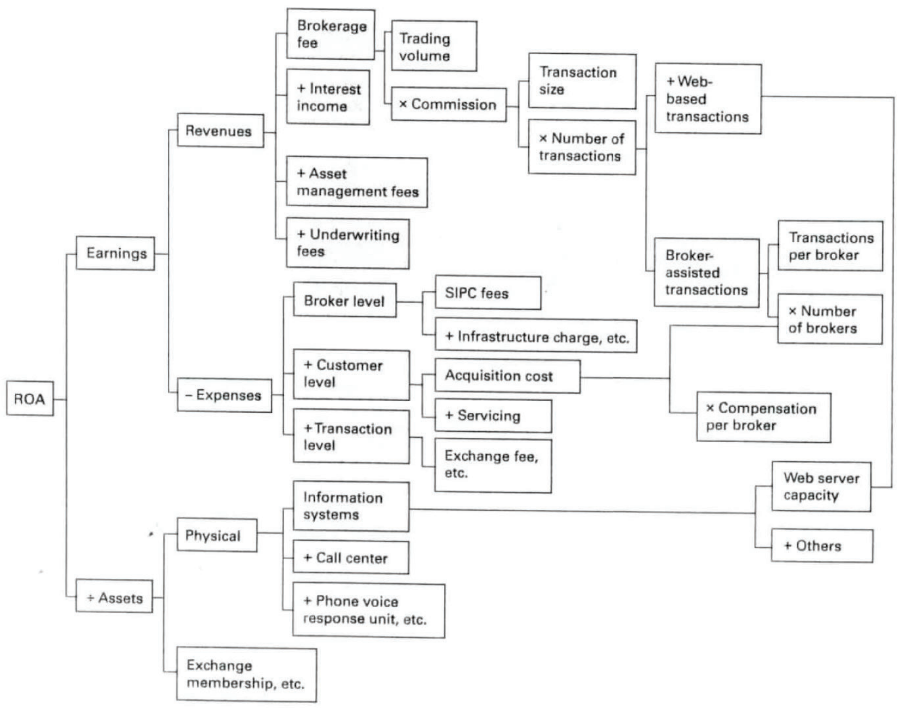
# ROA TREE NEEDS TO BE CUSTOMIZED
## Example: Oil Company




Source: Lai, R. (2013) *Operations Forensics*, MIT Press, Cambridge, MA.

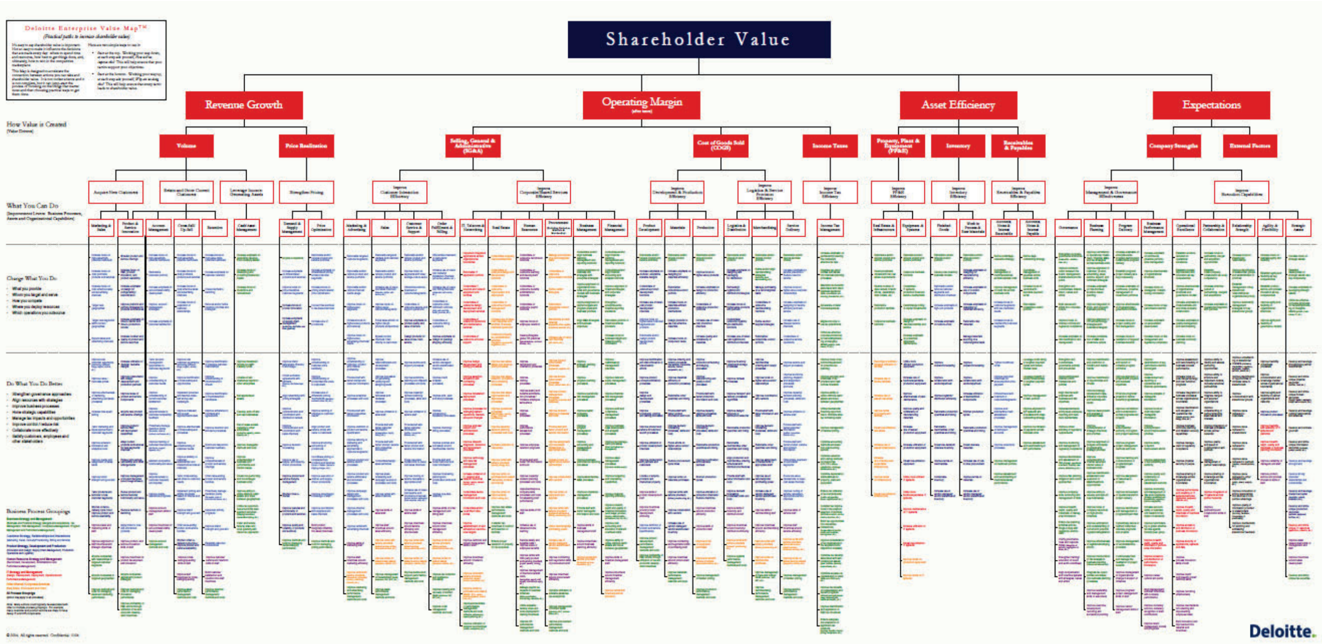


# ROA TREE NEEDS TO BE CUSTOMIZED
## Example: Securities Brokerage




Source: Lai, R. (2013) *Operations Forensics*, MIT Press, Cambridge, MA.

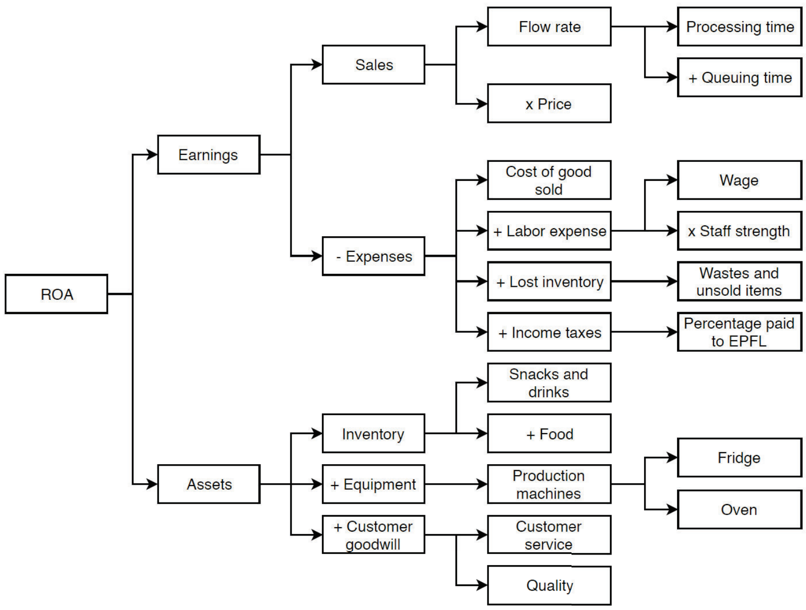
# «ENTERPRISE VALUE MAP»
## Opportunity to Engage with Consulting Client




Source: Deloitte.



# EPFL CAFETERIA – ROA ANALYSIS
## Example: INM Sandwiches




Source: Schmutz, N., Terrier, P.-E., Feppon, N., (2019) "INM Sandwiches: Supply Chain Performance and Price Optimisation," MGT-528 Course Project, EPFL, Lausanne, Switzerland.

# AGENDA

Supply-Chain Performance

**Performance Drivers**

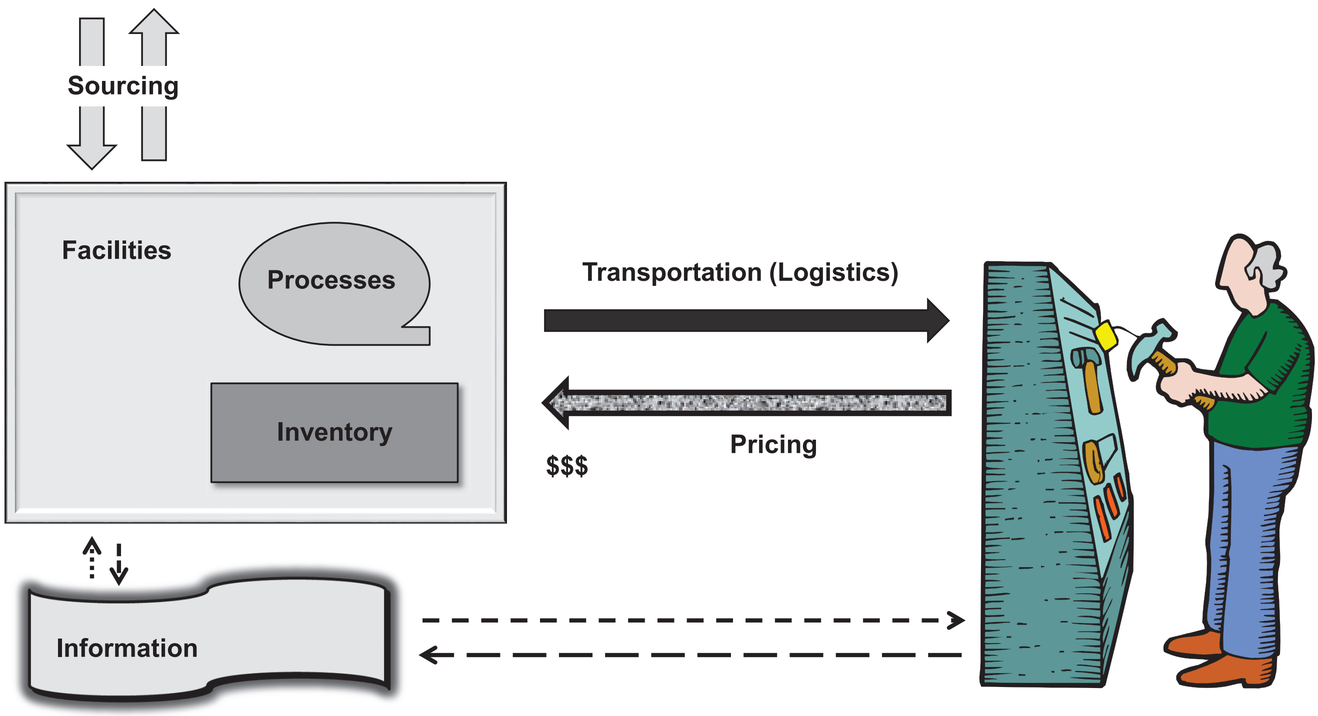
Performance Measures

Optimizing Profit: Price Discrimination

Key Concepts to Remember



# DRIVERS FOR SUPPLY-CHAIN PERFORMANCE



# DRIVERS FOR SUPPLY-CHAIN PERFORMANCE (Cont'd)

1. **Facilities**
   - Sites for production, storage, distribution, retailing, and other operations
2. **Processes**
   - Protocols and procedures for internal and external interactions
3. **Inventory**
   - Raw materials, work in progress (WIP), finished goods
4. **Transportation**
   - Physical delivery of finished goods to the customer (using different channels)
5. **Pricing**
   - Design of tariff structure to maximize firm profit, given the prevailing regulation, and available information about customer preferences and the competitive environment
6. **Sourcing**
   - Contracts (possibly relational) with other firms about outsourcing of functions or supply-chain partnerships
7. **Information**
   - Decision-relevant information (e.g., about demand, internal operations, partners, and competitive environment)



# PERFORMANCE DRIVERS (Cont'd)
## 1. Facilities

Key **decisions**

- Location
  - Centralization (cost effectiveness) vs. decentralization (responsiveness)
  - Other factors (e.g., proximity to customers)
- Capacity (e.g., cost effectiveness vs. flexibility)
- Manufacturing mode (e.g., BTS vs. BTO, focus on product vs. process)
- Warehousing mode (e.g., SKU storage, job lot storage, cross-docking)

> As discussed in an earlier lecture, the number of facilities can be used to index the tradeoff between the dimensions of the firm's strategic positioning

## PERFORMANCE DRIVERS (Cont'd)
### 2. Processes

Key decisions

- Service level
- Process design
- Information requirements
- IT infrastructure
- Personnel intensity



## PERFORMANCE DRIVERS (Cont'd)
### 3. Inventory

Because supply and demand are typically not matched (b/c of uncertainty and positive lead times), inventory is needed to avoid frequent stockouts

Impact on

- material flow time: time elapsed between when material enters the supply chain to when it exits the supply chain
- throughput
  - rate at which sales to end consumers occur
  - I = RT (Little's Law)
  - I = inventory; R = throughput; T = flow time

If responsiveness is a priority, a firm may be able to locate inventory closer to customers (→ more facilities)

If cost effectiveness is important, inventory can be centralized to internalize risk-pooling benefits

# PERFORMANCE DRIVERS (Cont'd)
## 3. Inventory

**Key decisions**

- <u>Cycle inventory</u>
  - Average amount of inventory used to satisfy demand between shipments
  - Depends on lot size
- <u>Safety inventory</u>
  - Inventory held in case demand exceeds expectations
  - Costs of excess inventory vs. cost of lost sales
- <u>Seasonal inventory</u>
  - Response to predictable intra-annual demand fluctuations
  - Cost of additional inventory vs. cost of flexible production



# PERFORMANCE DRIVERS (Cont'd)
## 4. Transportation

**Key decisions**

- <u>Mode</u>: how to move the product between stages in the supply chain
- <u>Spectrum</u>: how to (selectively?) adapt to cost-effectiveness or responsiveness (e.g., faster transportation → greater responsiveness, higher cost)
- <u>Alignment</u> with inventory and facility decisions
- <u>Route and network design</u>
  - Route: path along which a product is shipped
  - Network: collection of locations and routes
- <u>In-house vs. outsourcing</u>

# PERFORMANCE DRIVERS (Cont'd)
## 5. Pricing

Pricing determines the transfers in a supply chain in return for goods and services; it can be used to match demand and supply

Key decisions

- Pricing and economies of scale (e.g., quantity discounts: nonlinear pricing)
- Everyday low pricing versus high-low pricing
- Fixed price versus menu pricing
- Overall trade-off: Increase the firm profits
- Price discrimination (information requirements, instruments)



# PERFORMANCE DRIVERS (Cont'd)
## 6. Sourcing

Key decisions

- In-house vs. outsourcing
- Supplier selection, evaluation, and retention (SRM!)
  - Route: path along which a product is shipped
  - Network: collection of locations and routes
- Procurement/negotiation process
- Design of business processes so as to enable efficient purchase/transfer of goods and services across supply chain
- Pricing strategies to improve efficiency and responsiveness – firm can use price discrimination to manage different throughputs and service levels (e.g., price discrimination by response time)

## PERFORMANCE DRIVERS (Cont'd)
## 7. Information

**Information establishes a connection between the stages in the supply chain – allows coordination between stages; it is crucial to daily operation of each stage in a supply chain (e.g., production scheduling, inventory levels); it allows supply chain to become more efficient and more responsive at the same time (reduces tradeoff)**

**Key decisions**

- **What information is most valuable? How much is it worth spending on it?**
- **Push (MRP) versus pull (demand information transmitted quickly throughout the supply chain)**
- **Coordination and information sharing**
- **Forecasting technology and aggregate planning**
- **Enabling technologies**
  - **EDI**
  - **RFID**
  - **Internet**
  - **ERP systems**
  - **Supply chain management software (decision support tools)**



## KEY CONSIDERATIONS FOR SUPPLY-CHAIN DESIGN

**Some exogenous trends**

- **Increasing variety of products**
- **Decreasing product life cycle**
- **Increasingly demanding customers**
- **Fragmentation of supply-chain ownership**
- **Globalization**
- **Organizational inertia**

# AGENDA

**Supply-Chain Performance**

**Performance Drivers**

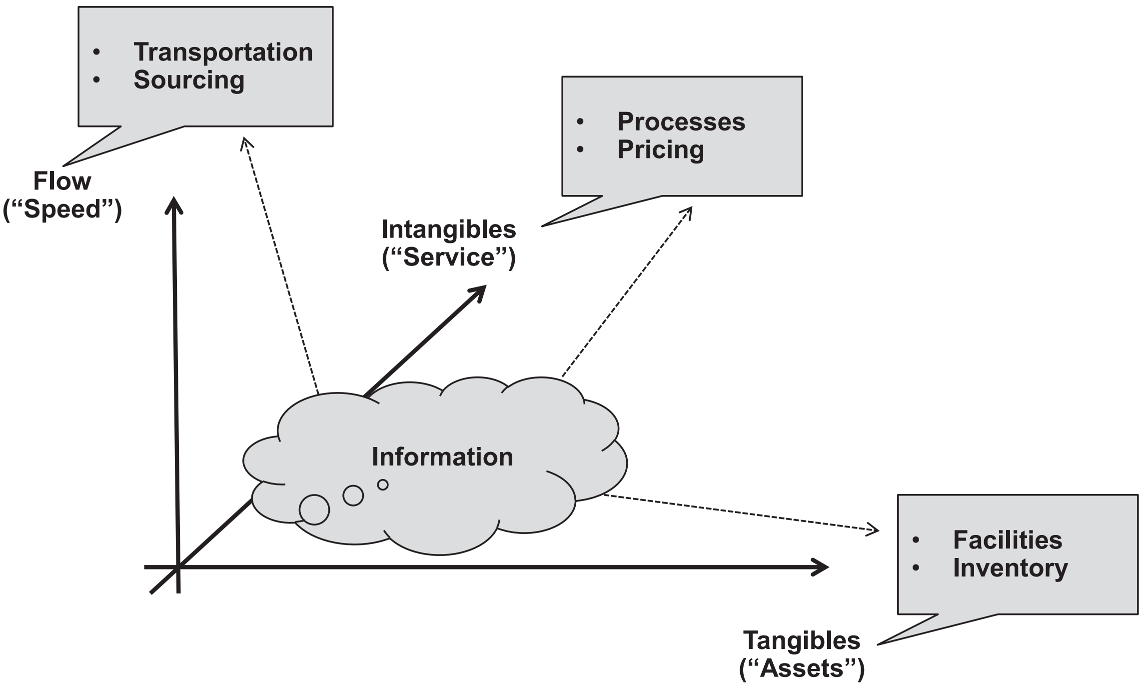
**Performance Measures**

**Optimizing Profit: Price Discrimination**

**Key Concepts to Remember**



# PERFORMANCE MEASURES IN THREE CATEGORIES
## Hausman (2003)



# PERFORMANCE MEASURES I: ASSETS

**Main operational asset: inventory**

A. <u>Standard metrics</u>
- Value
- Inventory turns = (cost of goods sold) / (inventory value)

B. <u>Nonstandard metrics</u>
- Disagreggation with respect to raw materials, WIP, finished goods (note the possible incentive conflicts along the supply chain)

C. <u>Information</u>
- Vendor-managed inventory transfers responsibility for capital investment downstream (typically closer to where the decision-relevant demand information is obtained)

D. <u>Supply-Chain Perspective</u>
- Consider aggregate inventory for entire supply chain



# PERFORMANCE MEASURES II: SERVICE

**Main performance goal: customer satisfaction**

A. <u>Standard metrics</u>
- Build-to-stock (BTS): fill rate, delivery process on time, lost sales,
- Build-to-order (BTO): quoted response time, delivery process on time, late order age distribution

B. <u>Nonstandard metrics</u>
- Age distribution for backorders/late orders

C. <u>Information</u>
- Process information transmitted to customer (including status updates)
- Disaggregate responsiveness data for different processes/stages

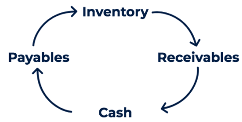
D. <u>Supply-Chain Perspective</u>
- Consider service impact of all supply-chain stages (not just last)

# PERFORMANCE MEASURES III: SPEED

**Basic premise: higher speed is better**

**A. Standard metrics**

- **Capacity utilization**




**B. Nonstandard metrics**

- **Cycle flow (time at a stage/node)**
- **Cash-conversion cycle [in days] = (inventory value)/(COGS/365) + (accounts receivable)/(Credit Sales/365) – (accounts payable)/(COGS/365)**
- **Upside flexibility = volume margin (in % of units of last demand cycle) that supply chain is able to add on to next demand cycle if necessary**

**C. Information**

- **Information sharing across supply-chain stages allows for anticipation**

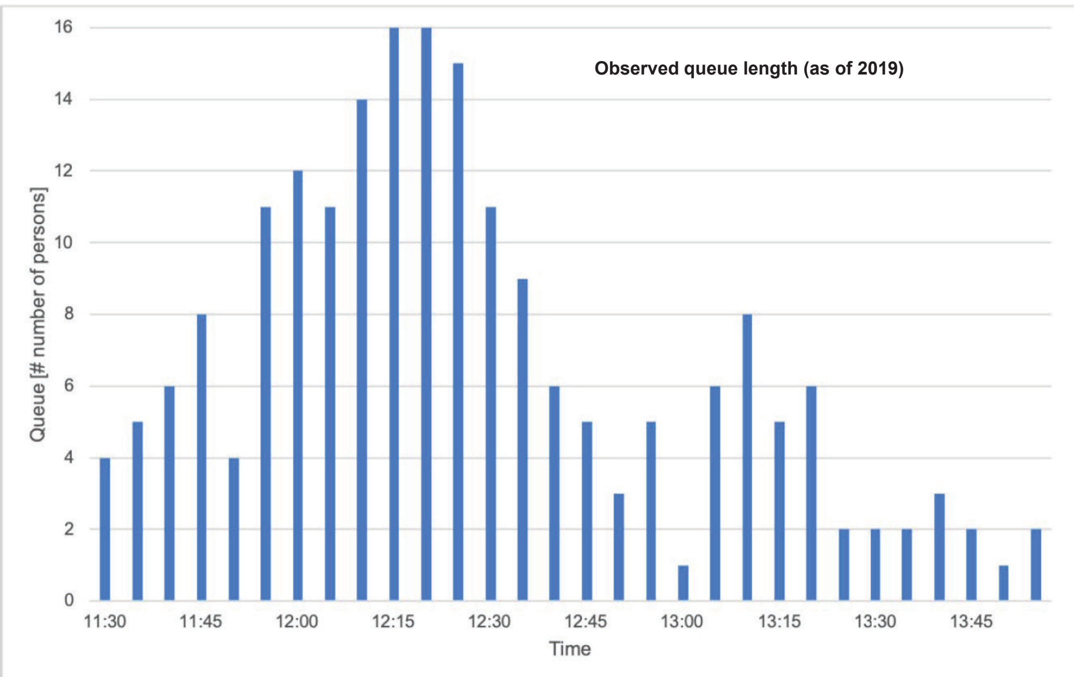
**D. Supply-Chain Perspective**

- **Supply-chain cycle time is what matters to guarantee sustained speed**

COGS: Cost of Goods Sold



# EPFL CAFETERIA – ADD PROCESSOR AT PEAK TIMES
## Example: INM Sandwiches – Service Speed Increase

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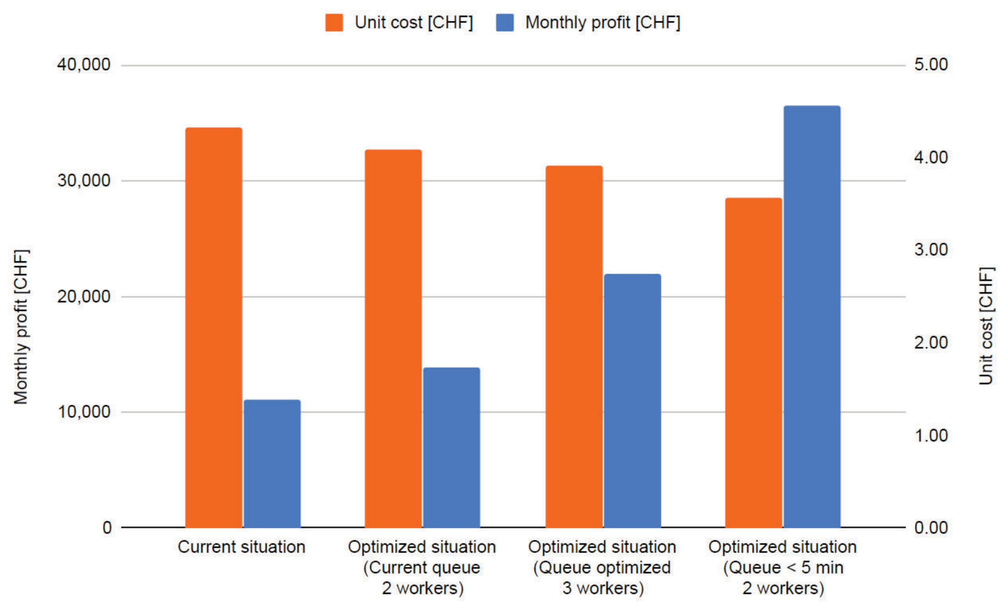


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## WHAT IS PRICE DISCRIMINATION?

**Definition. Price discrimination exists if *different units of the same good are sold at different prices to one or more consumers*.**

**One commonly distinguishes three different degrees of price discrimination.**

- **First-Degree Price Discrimination: the seller charges a *price for each unit corresponding to the maximum willingness to pay* over all available consumers of that unit. This is also referred to as perfect price discrimination as it maximizes the seller's revenues.**
- **Second-Degree Price Discrimination: the seller charges *different amounts for different numbers of units* bought by the *same* consumer. This is also referred to as nonlinear pricing.**
- **Third-Degree Price Discrimination: the seller charges *different prices to different consumer groups* based on observable differences between the groups.**

# FIRST-DEGREE PRICE DISCRIMINATION

**If the maximum willingness to pay for each unit is available, then the seller can order these values so that the willingness to pay for additional units is nonincreasing. This yields a nonincreasing inverse demand curve p(q) as a function of the seller's output q.**

**The seller can choose the optimal output by maximizing**

$$\Pi(q) = \int_0^q p(\hat{q})d\hat{q} - C(q)$$

**with respect to q. The first-order necessary optimality condition is**

$$p(q) = MC(q)$$

**In other words, the *seller should increase output until the maximum willingness to pay for the next unit exactly equals her marginal cost of producing that unit*.**

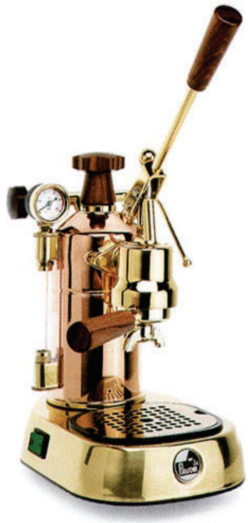
**Note that with perfect price discrimination, the monopolist's deadweight loss vanishes, and so does the consumers' surplus.**



# SECOND-DEGREE PRICE DISCRIMINATION

- **Second-degree price discrimination (or "nonlinear pricing," or "screening") is a mechanism-design problem. It is more difficult than first-degree or third-degree price discrimination, but it is also more realistic.**
- **It operates under the assumption that the seller knows that consumers have heterogeneous preferences but is unable to directly distinguish the different consumers. Information about a given consumer's preferences (his utility function) is assumed to be only privately available to that consumer.**
- **In order to incentivize a consumer to reveal his utility function (or his "type") the seller needs to offer several options for the consumer to choose from. Through his choice the consumer "reveals" his preference, and the seller may thereby be able to charge different consumers (or groups of consumers) different prices.**
- **The solution to the problem will naturally depend on the seller's model of the consumers' heterogeneity.**

# AN EXAMPLE



**Question. At what qualities and what prices should a company offer a “vertically differentiated” product, such as an espresso maker?**



# A SWISS VERSION
## (Try to Guess the Price)


**Question. What type of differentiation is that?**

# THERE ARE MANY OTHER EXAMPLES
## SD Cards





# THERE ARE MANY OTHER EXAMPLES
## SD Cards (Cont'd)




# CONSIDER A SIMPLE SCREENING MODEL

**Model Features**

- Two Types ("high" $\theta_H$ and "low" $\theta_L$, with $\theta_H > \theta_L > 0$ )
- Utility increasing in instrument and in type, quasi-linear in wealth
- Outside option valued at zero

- Risk-neutral seller, maximizes expected profit
- Prior beliefs of principal (corresponding to the probability $\mu$ of a consumer being a high type) given
- Instrument (i.e., product quality) costly to provide, C(q) $\geq$ 0

**What is missing? – SORTING CONDITION …**

$$\hat{q} \geq q \quad \Rightarrow \quad u(\hat{q}, \theta_H) - u(q, \theta_H) \geq u(\hat{q}, \theta_L) - u(q, \theta_L)$$

**u exhibits "increasing differences" (or is "supermodular")**

**The sorting condition enables the seller to separate high types from low types.**



# SELLER'S PROBLEM

**The seller chooses the qualities and prices of the products such as to maximize her expected profits, i.e., she solves the constrained optimization problem**

$$\max_{p_L, p_H, q_L, q_H \geq 0} \left\{ (1-\mu)\left(p_L - C(q_L)\right) + \mu\left(p_H - C(q_H)\right) \right\}$$

**subject to**

$$u(q_L, \theta_L) - p_L \geq 0 \quad \text{(IR-L)}$$
$$u(q_H, \theta_H) - p_H \geq 0 \quad \text{(IR-H)}$$

**Individual Rationality**

$$u(q_L, \theta_L) - p_L \geq u(q_H, \theta_L) - p_H \quad \text{(IC-L)}$$
$$u(q_H, \theta_H) - p_H \geq u(q_L, \theta_H) - p_L \quad \text{(IC-H)}$$

**Incentive Compatibility**

# THE SELLER'S PROBLEM CAN BE SIMPLIFIED

**Two constraints are binding.**

**1. (IR-L) is binding at optimum**

**Proof. Assume not. Then** $u(q_L,\theta_L) - p_L > 0$ **, so that**

$$u(q_H,\theta_H) - p_H \geq u(q_L,\theta_H) - p_L \geq u(q_L,\theta_L) - p_L > 0$$

(IC-H) $\quad \partial u / \partial \theta > 0$

**But this means that** $p_L$ **cannot be optimal, a contradiction. QED**

**2. (IC-H) is binding at optimum**

**Proof. Assume not. Then**

(*) $$u(q_H,\theta_H) - p_H > u(q_L,\theta_H) - p_L \geq u(q_L,\theta_L) - p_L = 0$$

(IC-H) $\quad \partial u / \partial \theta > 0$

**But this means that the seller could increase** $p_H$ **, a contradiction. QED**



# THE SELLER'S PROBLEM CAN BE SIMPLIFIED (Cont'd)

**Two constraints are redundant.**

**3. (IC-L) can be neglected**

**Proof. Since (IC-H) is binding, it is** $u(q_H,\theta_H) - p_H = u(q_L,\theta_H) - p_L$

**Hence,** $$p_H - p_L = u(q_H,\theta_H) - u(q_L,\theta_H) \geq u(q_H,\theta_L) - u(q_L,\theta_L)$$

(SC)

**Therefore** $u(q_L,\theta_L) - p_L \geq u(q_H,\theta_L) - p_H$ **QED**

**4. (IR-H) can be neglected**

**The proof follows directly from (*) in the proof of claim 2.**

# THE SIMPLIFIED PROBLEM

**The seller's nonlinear pricing problem is equivalent to**

$$\max_{p_L, p_H, q_L, q_H \geq 0} \left\{ (1-\mu)\left(p_L - C(q_L)\right) + \mu\left(p_H - C(q_H)\right) \right\}$$

**subject to**

$$u(q_L, \theta_L) - p_L = 0 \qquad \textbf{(IR-L)}$$

$$u(q_H, \theta_H) - p_H = u(q_L, \theta_H) - p_L \qquad \textbf{(IC-H)}$$

**The constraints (IR-L) and (IC-H) can be directly substituted into the objective function.**



# THE SIMPLIFIED PROBLEM

**The seller's nonlinear pricing problem is equivalent to**

$$\max_{q_L, q_H \geq 0} \left\{ (1-\mu)\left(u(q_L, \theta_L) - C(q_L)\right) + \mu\left(\left(u(q_H, \theta_H) - u(q_L, \theta_H) + u(q_L, \theta_L)\right) - C(q_H)\right) \right\}$$

**Hence, the seller's optimal quality levels obtain as follows (for $\mu > 0$):**

$$q_L^* \in \arg\max_{q_L \geq 0} \left\{ \left(u(q_L, \theta_L) - C(q_L)\right) - \frac{\mu}{1-\mu}\left(u(q_L, \theta_H) - u(q_L, \theta_L)\right) \right\} \qquad \textbf{(Distorted Quality Level)}$$

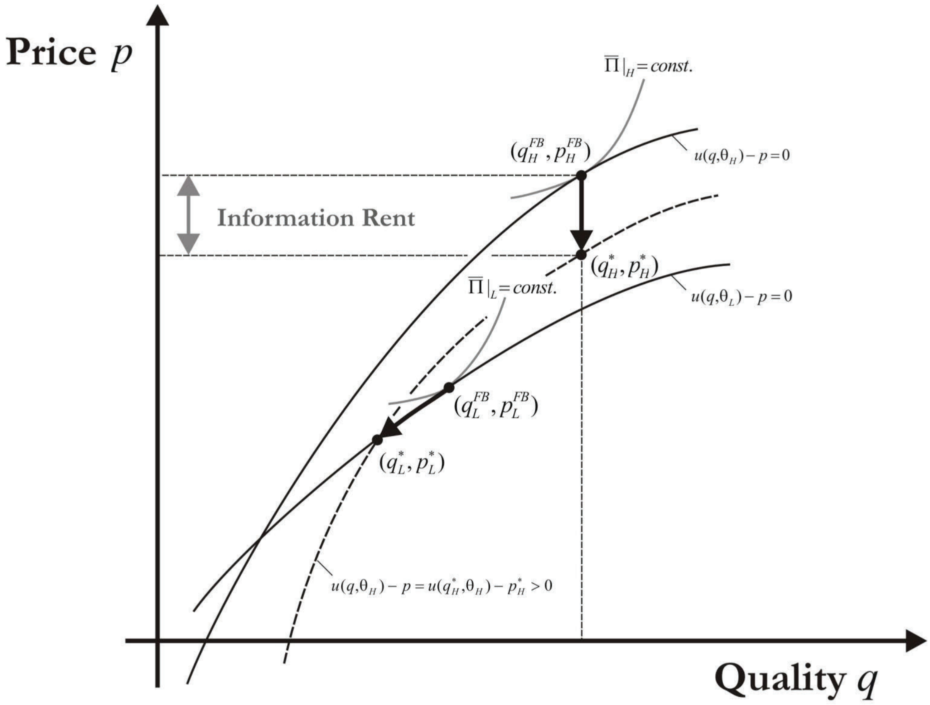
$$q_H^* \in \arg\max_{q_H \geq 0} \left\{ u(q_H, \theta_H) - C(q_H) \right\} \qquad \textbf{(Efficient Quality Level)}$$

**From (IR-L) and (IC-H) we then get**

$$p_L^* = u(q_L^*, \theta_L) \qquad \textbf{(Efficient Price Level)}$$

$$p_H^* = u(q_H^*, \theta_H) - \underbrace{\left(u(q_L^*, \theta_H) - u(q_L^*, \theta_L)\right)}_{\text{Information Rent } (\geq 0)} \qquad \textbf{(Distorted Price Level)}$$

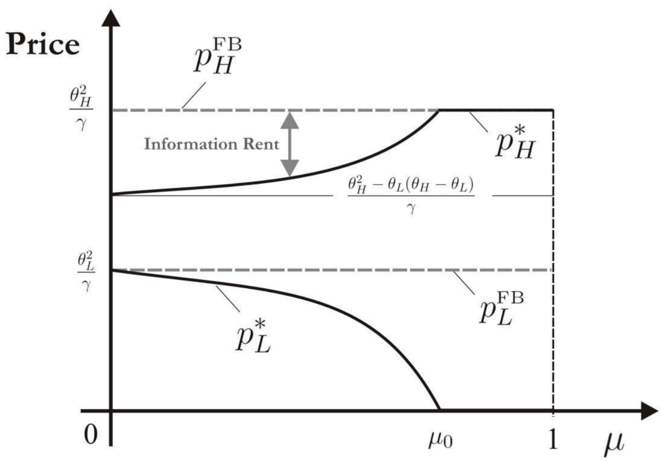
## FIRST-BEST AND SECOND-BEST SOLUTIONS IN THE SCREENING MODEL

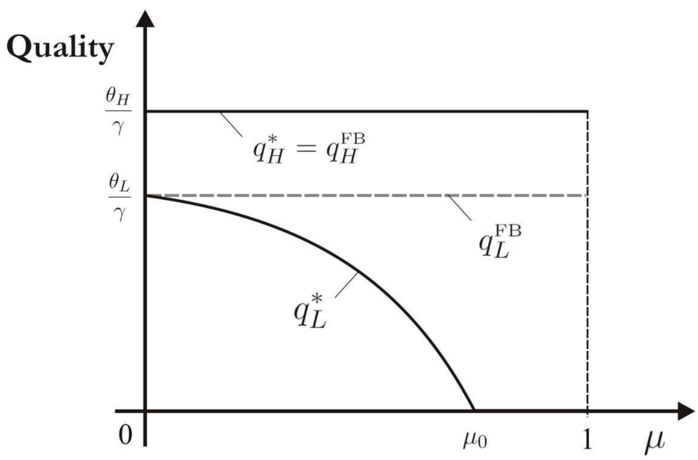





## PRICE AND QUALITY IN THE TWO-TYPE SCREENING MODEL

**Example:** $u(q,\theta) = \theta q$ $\quad C(q) = \gamma q^2 / 2,\ \gamma > 0$



# STUDENT PROJECT (2014): RESIZE DESIGN

## RESIZE DESGIN: OVERVIEW

- **Swedish high-end design furniture**
- **Launched in early 2013**
- **Private customers and Contract customers**
- **Price range: 550€ - 2250€**
- **Sales channels: Retailer (store & online) and own website**

**COMPETITIVE ADVANTAGE:**

- **Unique & authentic design**
- **Passionate people**

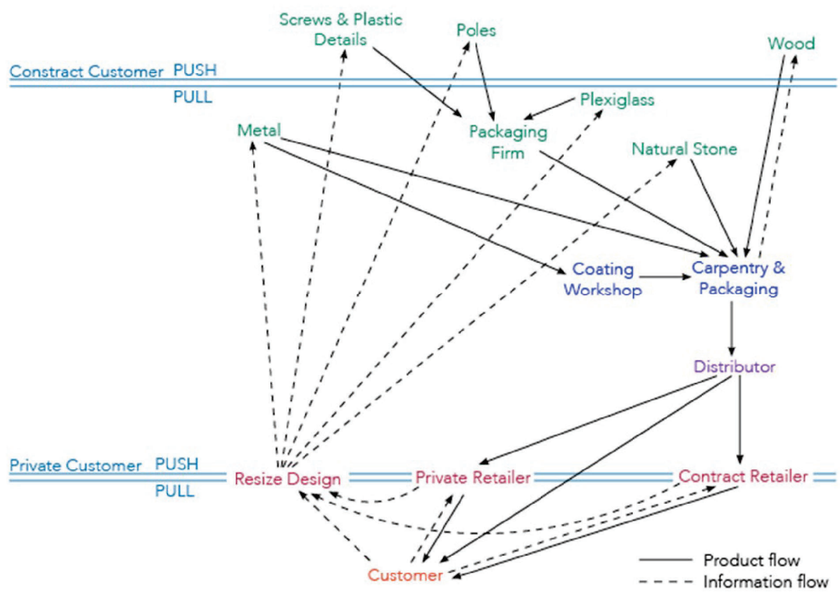
RESIZE DESIGN®

Source: Bredenberg, E., Elofsson, E. (2014) “Resize Design: Generating Value by Developing a Pricing Strategy,” MGT-528 Course Project, EPFL, Lausanne, Switzerland.



# RESIZE DESIGN (Cont’d)

## A WELL-FUNCTIONING SUPPLY NETWORK

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# RESIZE DESIGN (Cont'd)

## HOW CAN WE STRENGTHEN THE COMPETITIVE ADVANTAGE?

**Long Delivery Time:**

Request from retailers

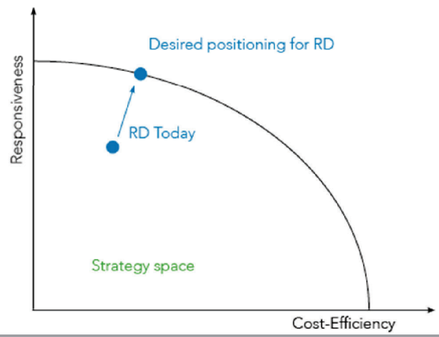
Expensive to keep large stock

**Lack of Pricing Strategy:**

Unclear reason to wide price range

Low margins on some products

Not coherent with brand image



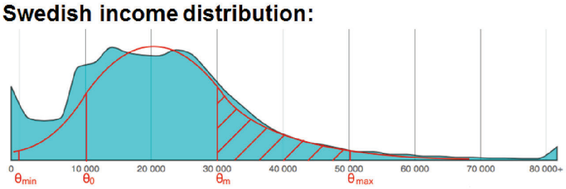

Source: Bredenberg, E., Elofsson, E. (2014) "Resize Design: Generating Value by Developing a Pricing Strategy," MGT-528 Course Project, EPFL, Lausanne, Switzerland.



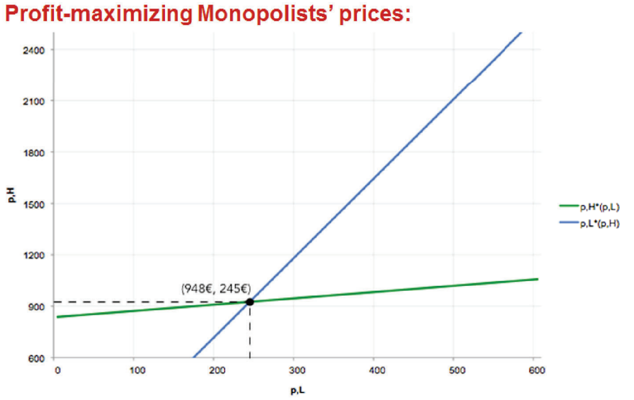
# RESIZE DESIGN (Cont'd)

## THE CEILING PRICE SET THE UPPER LIMIT

**Swedish income distribution:**




**Profit-maximizing Monopolists' prices:**




**Customer's utility:**

$u(q,\theta) = \theta q$ $\quad$ $\theta$ = *marginal utility*, $q$ = *perceived value*

**High-end preferred when:**

$$\theta q_H - p_H > \theta q_L - p_L$$

**Demanded quantities:**

$$Q_L(p_H,p_L) = \int_{\theta_0}^{\theta_m} f(\theta)d\theta = F(\theta_m) - F(\theta_0)$$

$$Q_H(p_H,p_L) = \int_{\theta_m}^{\theta_{max}} f(\theta)d\theta = 1 - F(\theta_m)$$

**Profit functions:**

$$\Pi(p_H,p_L) = (p_L - c_L)(F(\theta_m) - F(\theta_0))$$

$$\Pi(p_H,p_L) = (p_H - c_H)(1 - F(\theta_m))$$

**CEILING PRICE: 948 €**

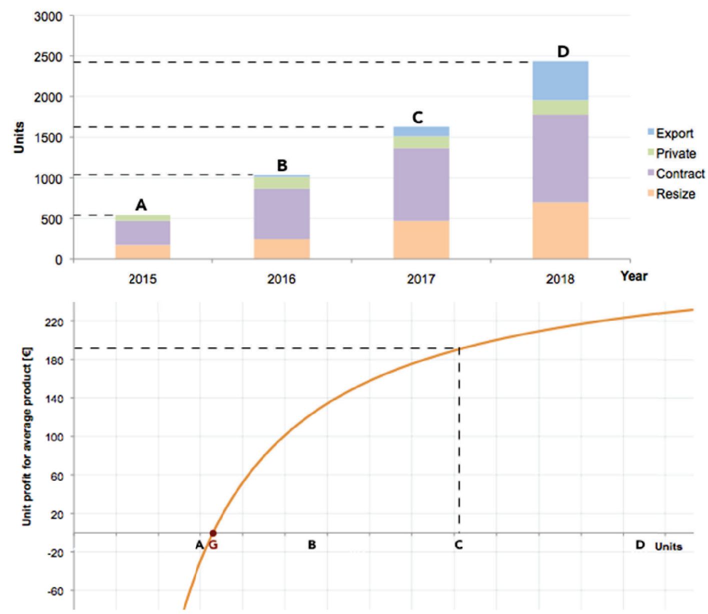
Source: Bredenberg, E., Elofsson, E. (2014) "Resize Design: Generating Value by Developing a Pricing Strategy," MGT-528 Course Project, EPFL, Lausanne, Switzerland.

# RESIZE DESIGN (Cont'd)

## THE FLOOR PRICE ENSURES 28.7% PROFIT MARGIN

**Target sales:**

**Unit profit:**
**(given current rebates to retailers)**




**FLOOR PRICE: 730€**

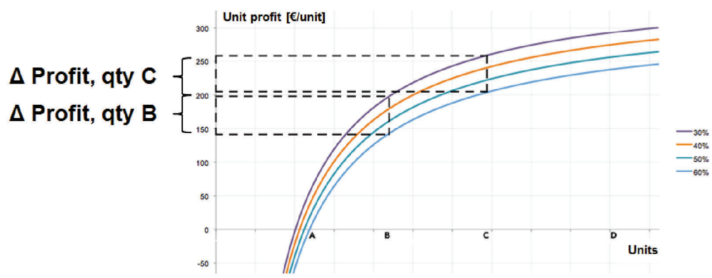
Source: Bredenberg, E., Elofsson, E. (2014) "Resize Design: Generating Value by Developing a Pricing Strategy," MGT-528 Course Project, EPFL, Lausanne, Switzerland.



# RESIZE DESIGN (Cont'd)

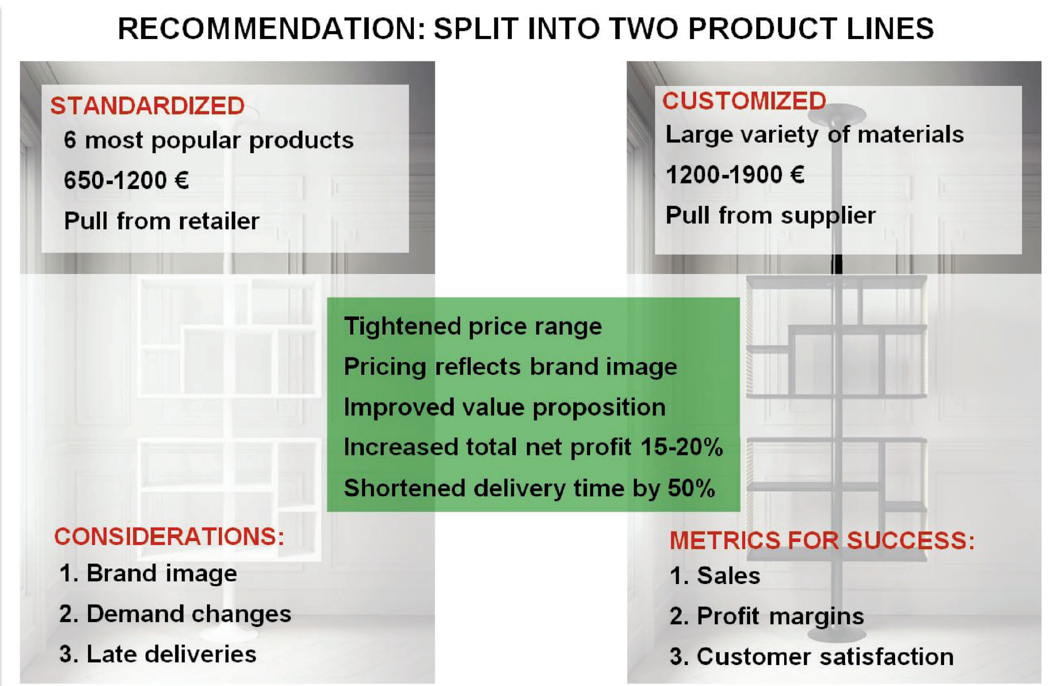
## THE PROFIT MAXIMIZING PRICE ENSURES ~40% MARGIN


**Rebates for private retailers:**




Source: Bredenberg, E., Elofsson, E. (2014) "Resize Design: Generating Value by Developing a Pricing Strategy," MGT-528 Course Project, EPFL, Lausanne, Switzerland.

# RESIZE DESIGN (Cont'd)




Source: Bredenberg, E., Elofsson, E. (2014) "Resize Design: Generating Value by Developing a Pricing Strategy," MGT-528 Course Project, EPFL, Lausanne, Switzerland.



# THIRD-DEGREE PRICE DISCRIMINATION

**For simplicity, let us assume that there are two different consumer groups, 1 and 2, that the seller can distinguish and which can legally be charged different prices for the same product. Let the inverse demand curve of consumer group $i \in \{1,2\}$ be given by $p_i(q_i)$, where $q_i$ is the amount consumed by that group.**

**Given a standard (increasing, convex) cost function C(q), the monopolist then solves the profit-maximization problem**

$$\max_{q_1,q_2 \geq 0} \{p_1(q_1)q_1 + p_2(q_2)q_2 - C(q_1+q_2)\}$$

**which for $q_1, q_2 > 0$ leads to the first-order necessary optimality conditions**

$$p_1(q_1) + q_1 p_1'(q_1) = C'(q_1+q_2)$$

$$p_2(q_2) + q_2 p_2'(q_2) = C'(q_1+q_2)$$

**Hence, at an optimum, the marginal revenues from the two consumer groups are equal to each other and equal to the marginal cost at the combined output.**

## THIRD-DEGREE PRICE DISCRIMINATION (Cont'd)

**More generally, the two consumer groups may not be fully separable. Each group's demand may be influenced by the amount sold to the other group. Then the inverse demand curve of consumer group $i \in \{1,2\}$ is given by $p_i(q_1, q_2)$, where $q_i$ is the amount consumed by that group.**

**Given an increasing, jointly convex cost function $C(q_1,q_2)$, the monopolist then solves the profit-maximization problem**

$$\max_{q_1, q_2 \geq 0} \{ p_1(q_1,q_2)q_1 + p_2(q_1,q_2)q_2 - C(q_1,q_2) \}$$

**which for $q_1, q_2 > 0$ leads to the first-order necessary optimality conditions**

$$p_1(q_1,q_2) + q_1 \frac{\partial p_1(q_1,q_2)}{\partial q_1} + q_2 \frac{\partial p_2(q_1,q_2)}{\partial q_1} = \frac{\partial C(q_1,q_2)}{\partial q_1}$$

$$p_2(q_1,q_2) + q_1 \frac{\partial p_1(q_1,q_2)}{\partial q_2} + q_2 \frac{\partial p_2(q_1,q_2)}{\partial q_2} = \frac{\partial C(q_1,q_2)}{\partial q_2}$$

**At an optimum, the marginal revenue from each of the two consumer groups is equal to the marginal cost of increasing the output for that group (sometimes equal to the marginal cost of increasing output for the other group, e.g., when the cost depends only on $q_1 + q_2$).**



## AGENDA

**Supply-Chain Performance**

**Performance Drivers**

**Performance Measures**

**Optimizing Profit: Price Discrimination**

**Key Concepts to Remember**

# KEY CONCEPTS TO REMEMBER

- ROA Trees
- 7 performance drivers (with key decisions)
- Dimensions of supply chain performance and relation to drivers
- Performance measures (with focus on total supply chain performance)
- 1$^{st}$/ 2$^{nd}$/ 3$^{rd}$ –degree price discrimination