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# Sustainable Supply Chain Management



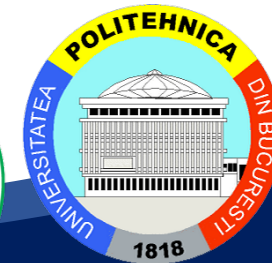
Curriculum Development  
of Master's Degree Program in  
Industrial Engineering for Thailand Sustainable Smart Industry




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# Supply Contracts



Curriculum Development  
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- Significant level of outsourcing in the last few years
- Many leading brand OEMs outsource complete manufacturing and design of their products
- More outsourcing has meant 
  - Search for lower cost manufacturers
  - Development of design and manufacturing expertise by suppliers
- Procurement function in OEMs becomes very important
- OEMs have to get into contracts with suppliers
  - For both strategic and non-strategic components



# Strategic Components

Supply Contract can include the following:

- Pricing and volume discounts.
- Minimum and maximum purchase quantities.
- Delivery lead times.
- Product or material quality.
- Product return policies.



# Supply Contracts

- Consider a 2-stage sequential supply chain: A buyer and a supplier.
- Buyer's activities:
  - generating a forecast
  - determining how many units to order from the supplier
  - placing an order to the supplier so as to optimize his own profit
  - Purchase based on forecast of customer demand
- Supplier's activities:
  - reacting to the order placed by the buyer.
  - Make-To-Order (MTO) policy



# Swimsuit Example

- 2 Stages:
  - a retailer who faces customer demand
  - a manufacturer who produces and sells swimsuits to the retailer.
- **Retailer Information:**
  - Summer season sale price of a swimsuit is \$125 per unit.
  - Wholesale price paid by retailer to manufacturer is \$80 per unit.
  - Salvage value after the summer season is \$20 per unit
- **Manufacturer information:**
  - Fixed production cost is \$100,000
  - Variable production cost is \$35 per unit



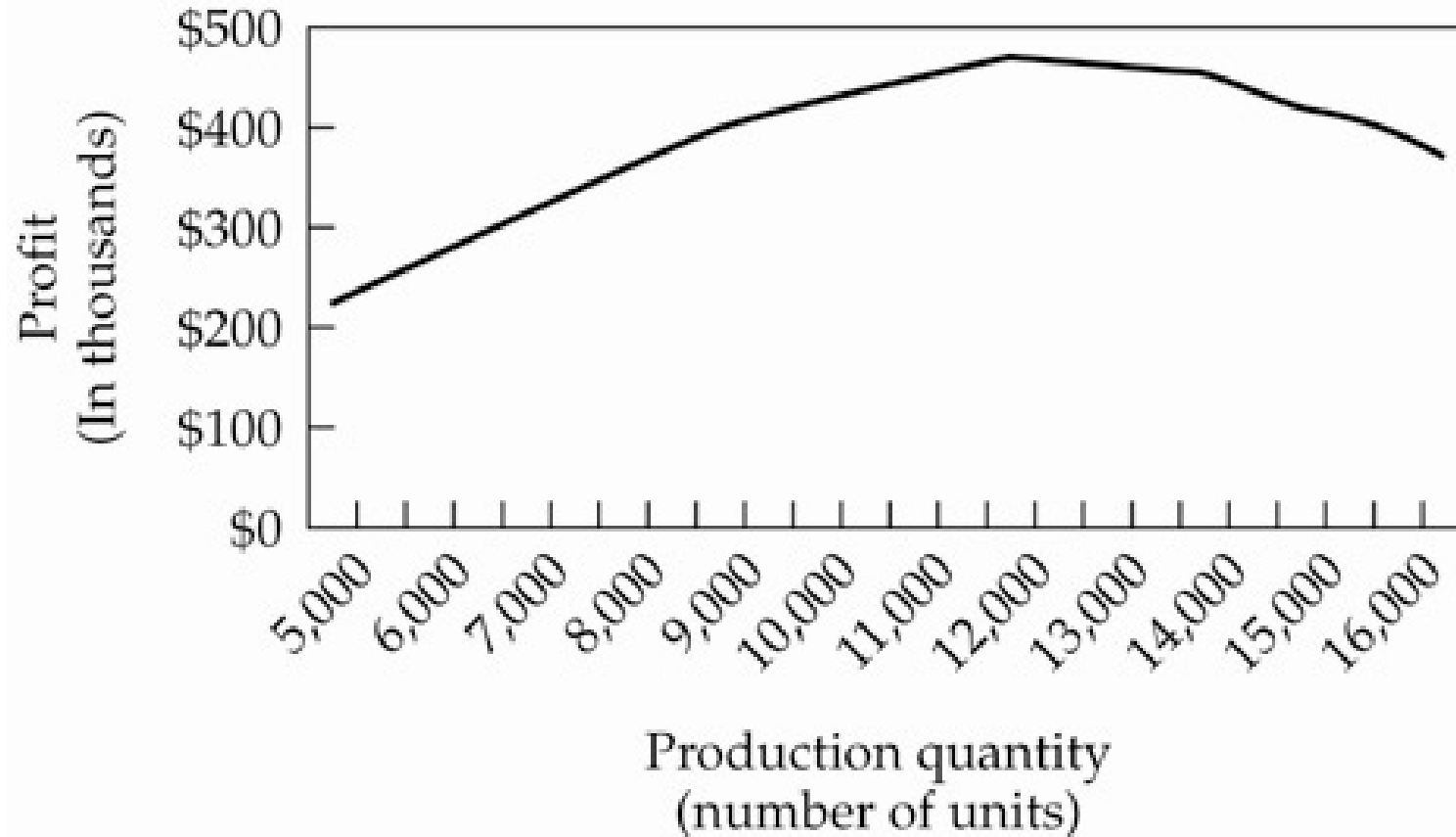


# What Is the Optimal Order Quantity?

- Retailer marginal profit is the same as the marginal profit of the manufacturer, \$45.
- Retailer's marginal profit for selling a unit during the season, \$45, is smaller than the marginal loss, \$60, associated with each unit sold at the end of the season to discount stores.
- Optimal order quantity depends on marginal profit and marginal loss but not on the fixed cost.
- Retailer optimal policy is to order 12,000 units for an average profit of \$470,700.
- If the retailer places this order, the manufacturer's profit is  $12,000(80 - 35) - 100,000 = \$440,000$



# Sequential Supply Chain



**Retailer's expected profit as a function of order quantity**



# Risk Sharing

- In the sequential supply chain:
  - Buyer assumes all of the risk of having more inventory than sales
  - Buyer limits his order quantity because of the huge financial risk.
  - Supplier takes no risk.
  - Supplier would like the buyer to order as much as possible
  - **Since the buyer limits his order quantity, there is a significant increase in the likelihood of out of stock.**
- If the supplier shares some of the risk with the buyer
  - it may be profitable for buyer to order more
  - reducing out of stock probability
  - increasing profit for both the supplier and the buyer.

**Supply contracts enable this risk sharing**



# Buy-Back Contract

- Seller agrees to buy back unsold goods from the buyer for some agreed-upon price.
- Buyer has incentive to order more
- Supplier's risk clearly increases.
- Increase in buyer's order quantity
  - Decreases the likelihood of out of stock
  - Compensates the supplier for the higher risk

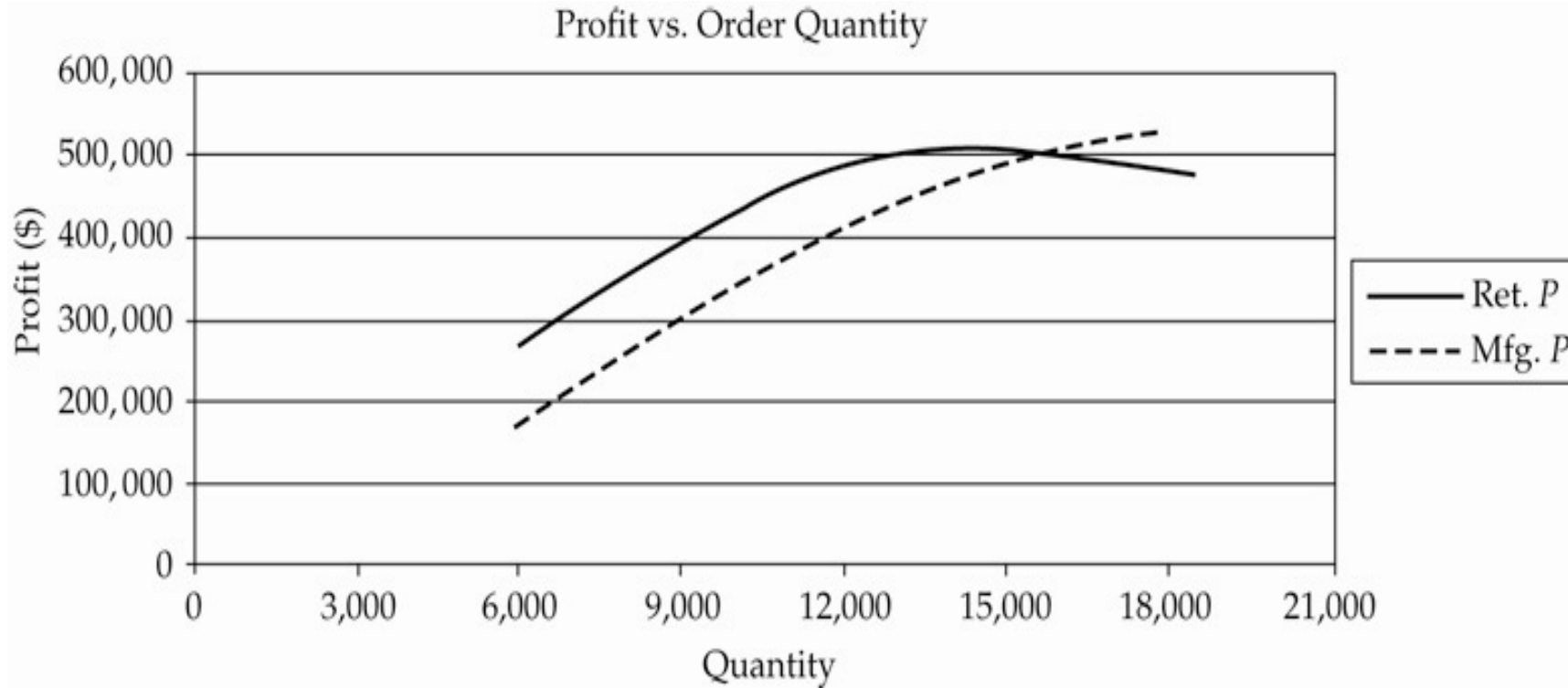


# Buy-Back Contract Swimsuit Example

- Assume the manufacturer offers to buy unsold swimsuits from the retailer for \$55.
- Retailer has an incentive to increase its order quantity to 14,000 units, for a profit of \$513,800, while the manufacturer's average profit increases to \$471,900.
- Total average profit for the two parties  
= \$985,700 (= \$513,800 + \$471,900)
- Compare to sequential supply chain when total profit = \$910,700 (= \$470,700 + \$440,000)



# Buy-Back Contract Swimsuit Example




**Buy-back contract**





# Revenue Sharing Contract

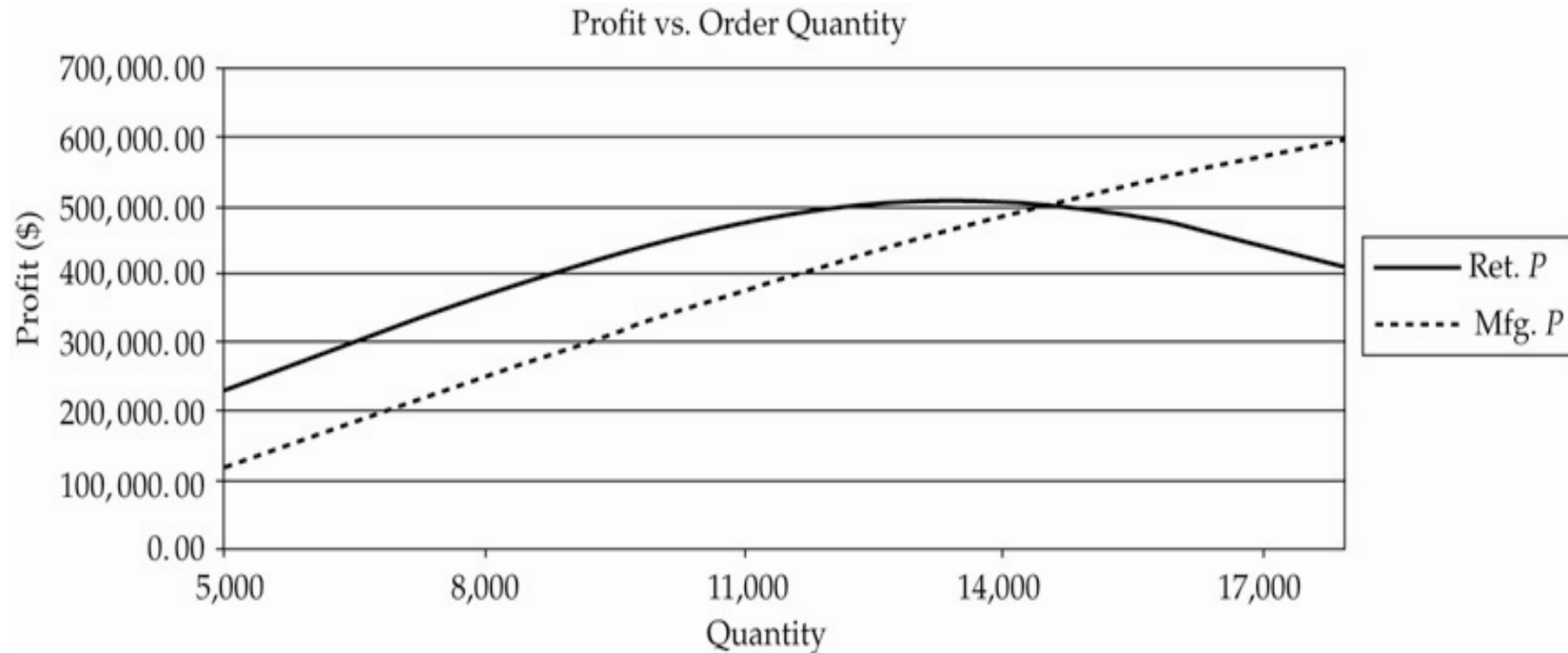
- Buyer shares some of its revenue with the supplier
  - in return for a discount on the wholesale price. 
- Buyer transfers a portion of the revenue from each unit sold back to the supplier



# Revenue Sharing Contract Swimsuit Example

- Manufacturer agrees to decrease the wholesale price from \$80 to \$60
- In return, the retailer provides 15 percent of the product revenue to the manufacturer.
- Retailer has an incentive to increase his order quantity to 14,000 for a profit of \$504,325
- This order increase leads to increased manufacturer's profit of \$481,375
- Supply chain total profit  
= \$985,700 (= \$504,325+\$481,375).

# Revenue Sharing Contract Swimsuit Example



**Revenue-sharing contract**

# Other Types of Contracts

- **Quantity-Flexibility Contracts**

- Supplier provides full refund for returned (unsold) items as long as the number of returns is no larger than a certain quantity.



- **Sales Rebate Contracts**

- Provides a direct incentive to the retailer to increase sales by means of a rebate paid by the supplier for any item sold above a certain quantity.








# Global Optimization Strategy

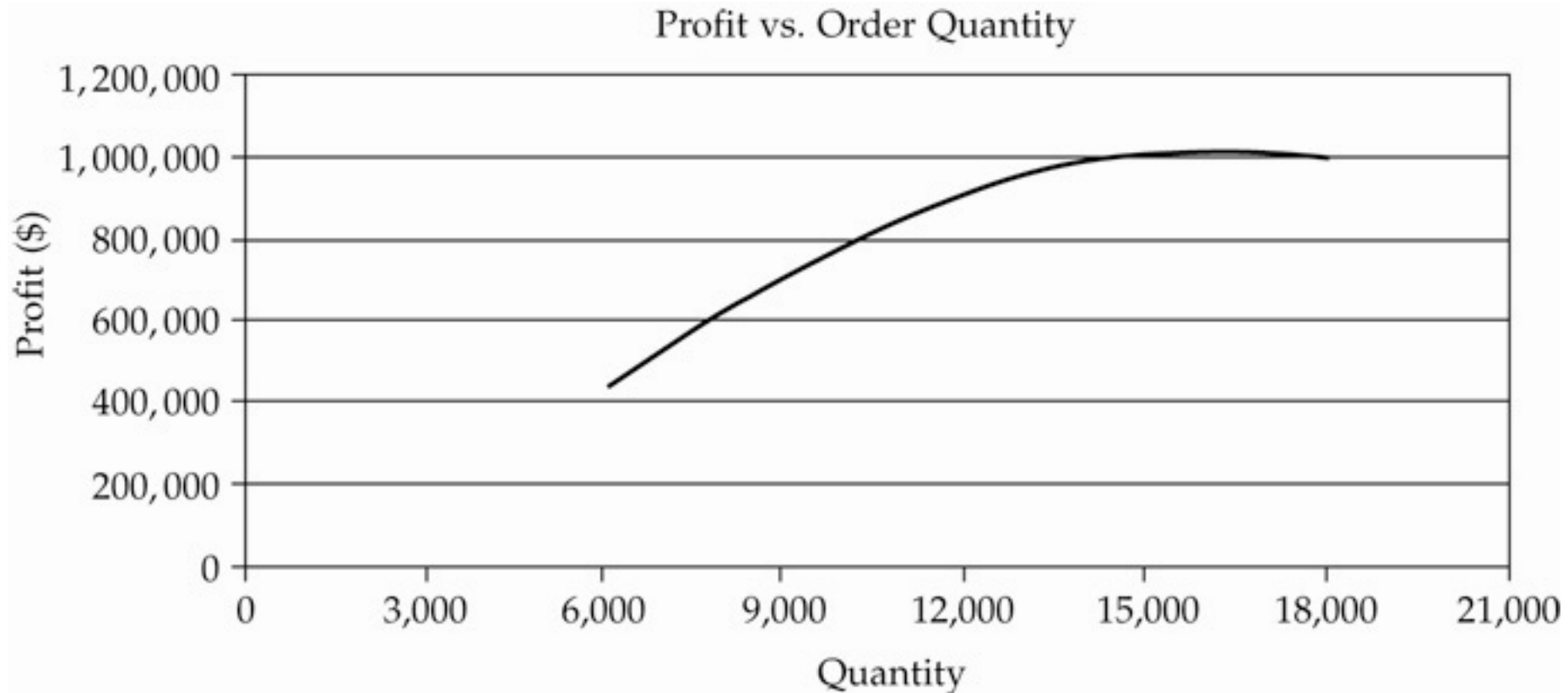
- What is the best strategy for the entire supply chain?
- Treat both supplier and retailer as one entity
- Transfer of money between the parties is ignored



# Global Optimization Swimsuit Example

- Relevant data
  - Selling price, \$125
  - Salvage value, \$20
  - Variable production costs, \$35
  - Fixed production cost.
- Supply chain marginal profit,  $90 = 125 - 35$  
- Supply chain marginal loss,  $15 = 35 - 20$
- Supply chain will produce more than average demand.
- Optimal production quantity = 16,000 units
- Expected supply chain profit = \$1,014,500.


# Global Optimization Swimsuit Example



**Profit using global optimization strategy**



# Global Optimization and Supply Contracts

- Unbiased decision maker is unrealistic
  - Requires the firm to surrender decision-making power to an unbiased decision maker
- Carefully designed supply contracts can achieve as much as global optimization
- Global optimization does not provide a mechanism to allocate supply chain profit between the partners.
  - Supply contracts allocate this profit among supply chain members. 
- Effective supply contracts allocate profit to each partner in a way that no partner can improve his profit by deciding to deviate from the optimal set of decisions.





# Implementation Drawbacks of Supply Contracts

- **Buy-back contracts**

- Require suppliers to have an effective reverse logistics system and may increase logistics costs.
- Retailers have an incentive to push the products not under the buy-back contract.
  - Retailer's risk is much higher for the products not under the buy back contract (competing products!).

- **Revenue sharing contracts**

- Require suppliers to monitor the buyer's revenue and thus increases administrative cost.
- Buyers have an incentive to push competing products with higher profit margins.
  - Similar products from competing suppliers with whom the buyer has no revenue sharing agreement.





# Contracts for Make-to-Stock & Make-to-Order Supply Chains

- Previous contracts examples were with Make-to-Order supply chains
- What happens when the supplier has a Make-to-Stock situation?





# Supply Chain for Fashion Products Ski-Jackets

## Manufacturer produces ski-jackets prior to receiving distributor orders

- Season starts in September and ends by December.
- Production starts 12 months before the selling season
- Distributor places orders with the manufacturer six months later.
- At that time, production is complete; distributor receives firms orders from retailers.
- The distributor sales ski-jackets to retailers for \$125 per unit.
- The distributor pays the manufacturer \$80 per unit.
- For the manufacturer, we have the following information:
  - Fixed production cost = \$100,000.
  - The variable production cost per unit = \$55
  - Salvage value for any ski-jacket not purchased by the distributors= \$20.



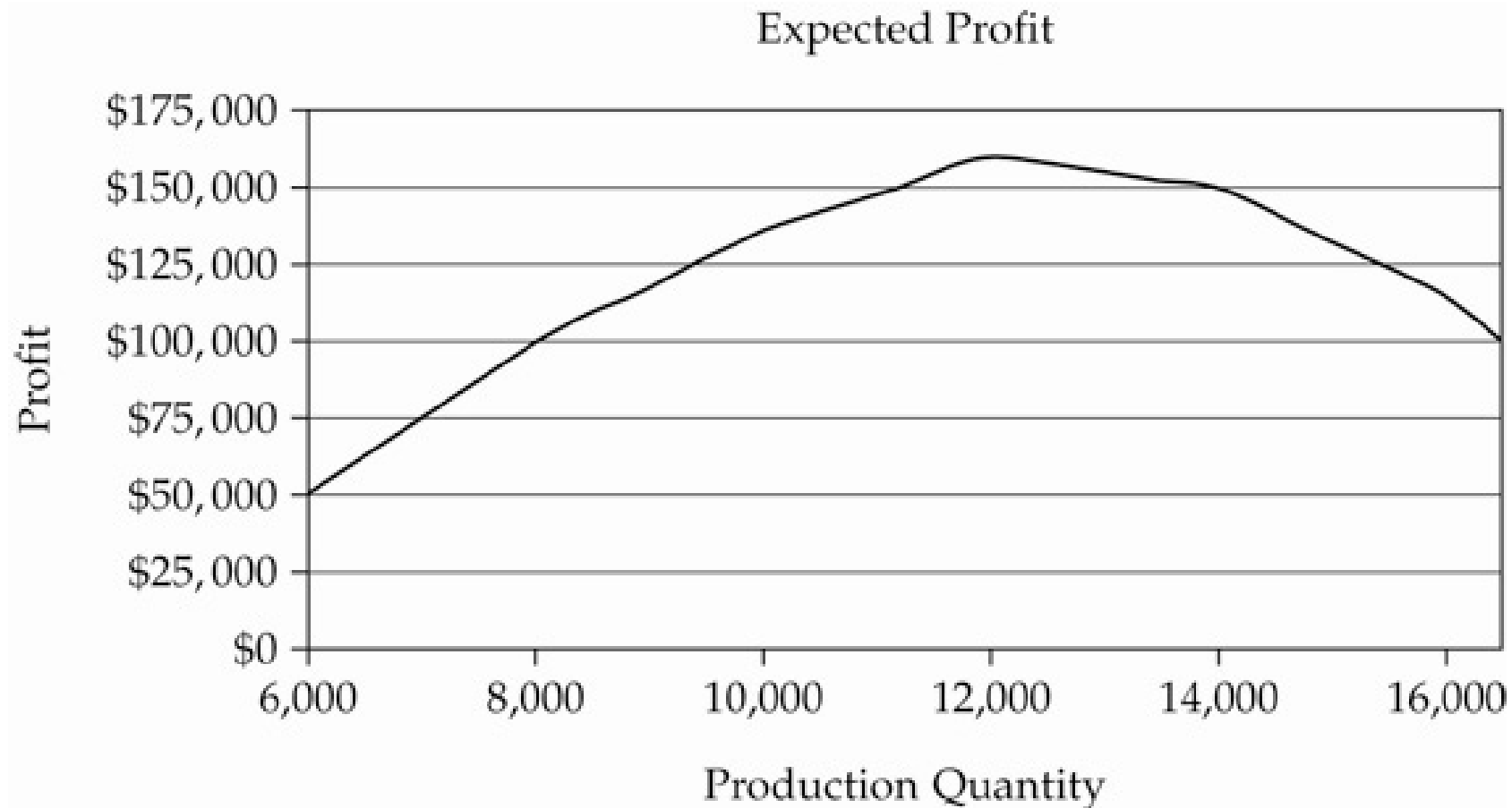
# Profit and Loss

- For the manufacturer
  - Marginal profit = \$25
  - Marginal loss = \$35.
  - Since marginal loss is greater than marginal profit, the distributor should produce less than average demand, i.e., less than 13, 000 units. (Demand pattern: see Ex. 2.3)
- How much should the manufacturer produce?
  - Manufacturer optimal policy = 12,000 units
  - Average profit = \$160,400.
  - Distributor average profit = \$510,300.
- Manufacturer assumes all the risk limiting its production quantity
- Distributor takes no risk





# Make-to-Stock Ski Jackets



**Manufacturer's expected profit**

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# Pay-Back Contract

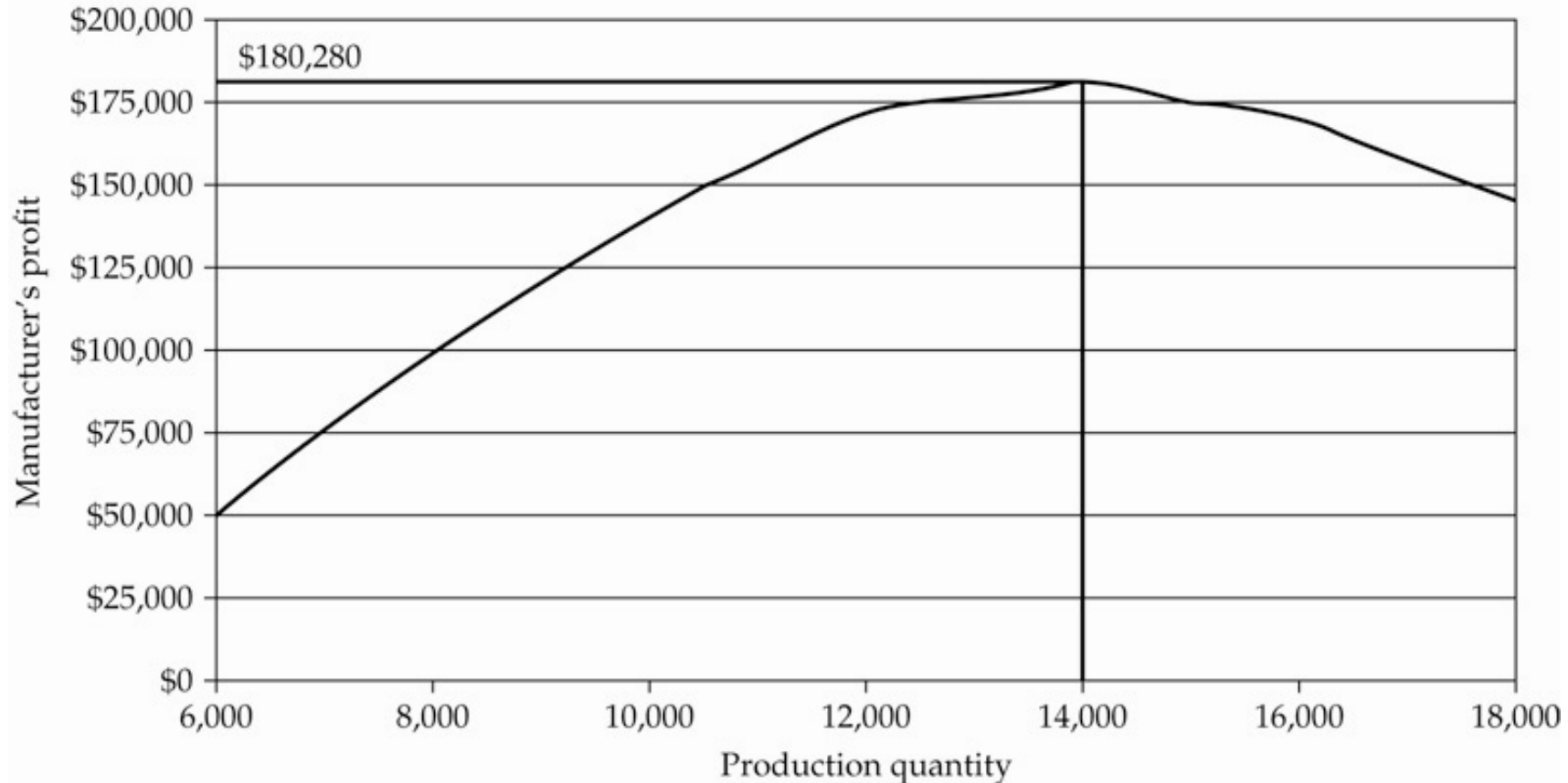
- Buyer agrees to pay some agreed-upon price for any unit produced by the manufacturer but not purchased.
- Manufacturer incentive to produce more units
- Buyer's risk clearly increases.
- Increase in prod. quantities has to compensate the distributor for the increase in risk.



# Pay-Back Contract Ski Jacket Example

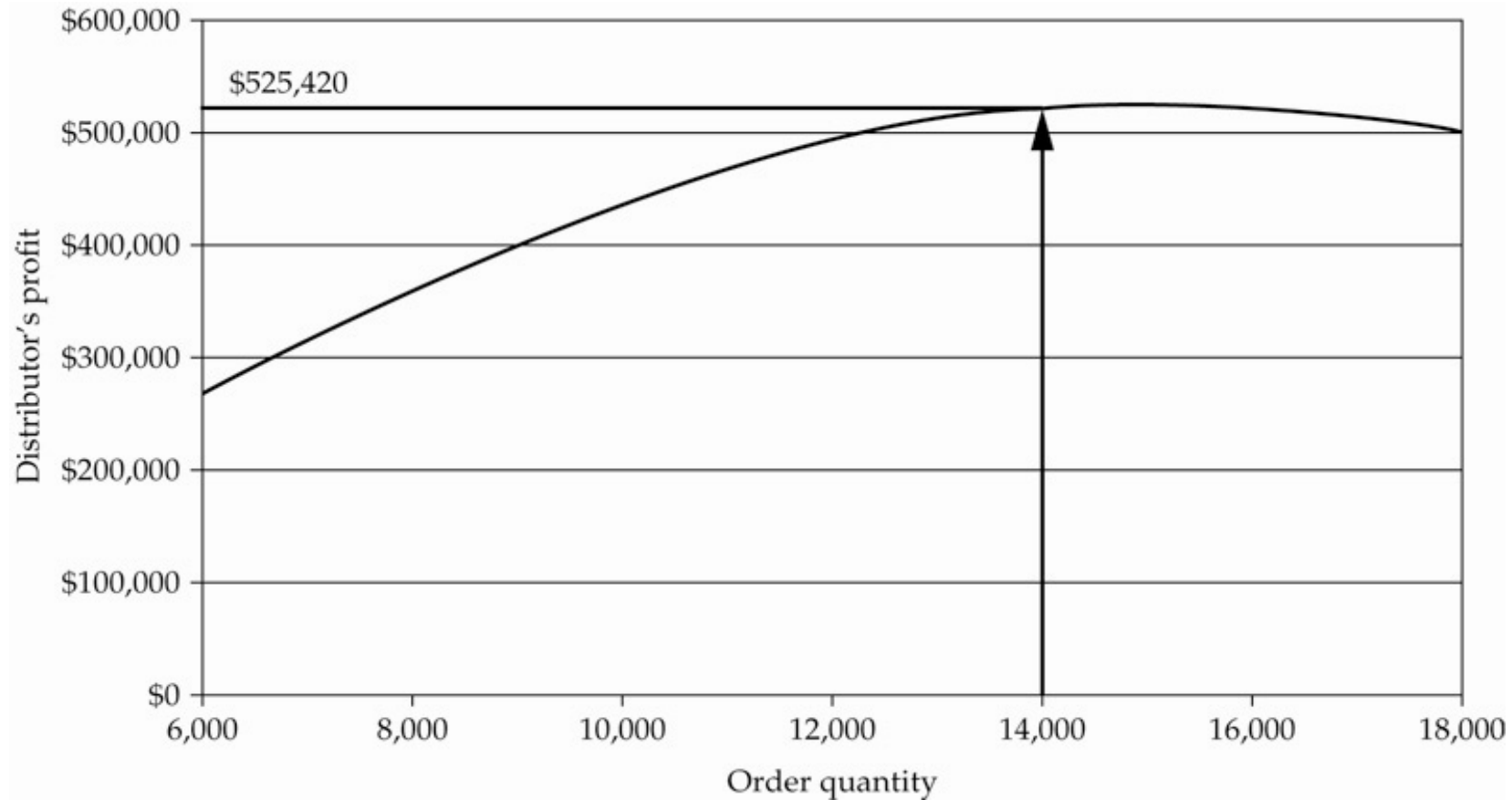
- Assume the distributor offers to pay \$18 for each unit produced by the manufacturer but not purchased.
  - Manufacturer marginal loss =  $55 - 20 - 18 = \$17$
  - Manufacturer marginal profit = \$25.
  - Manufacturer has an incentive to produce more than average demand.
  - Manufacturer increases production quantity to 14,000 units
  - Manufacturer profit = \$180,280
  - Distributor profit increases to \$525,420.
- Total profit = \$705,400**
- Compare to total profit in sequential supply chain  
= \$670,000 (= \$160,400 + \$510,300)

# Pay-Back Contract Ski Jacket Example




**Manufacturer's average profit (pay-back contract)**

# Pay-Back Contract Ski Jacket Example (cont)



**Distributor's average profit (pay-back contract)**

# Cost-Sharing Contract

- Buyer shares some of the production cost with the manufacturer, in return for a discount on the wholesale price. 
- Reduces effective production cost for the manufacturer
  - Incentive to produce more units

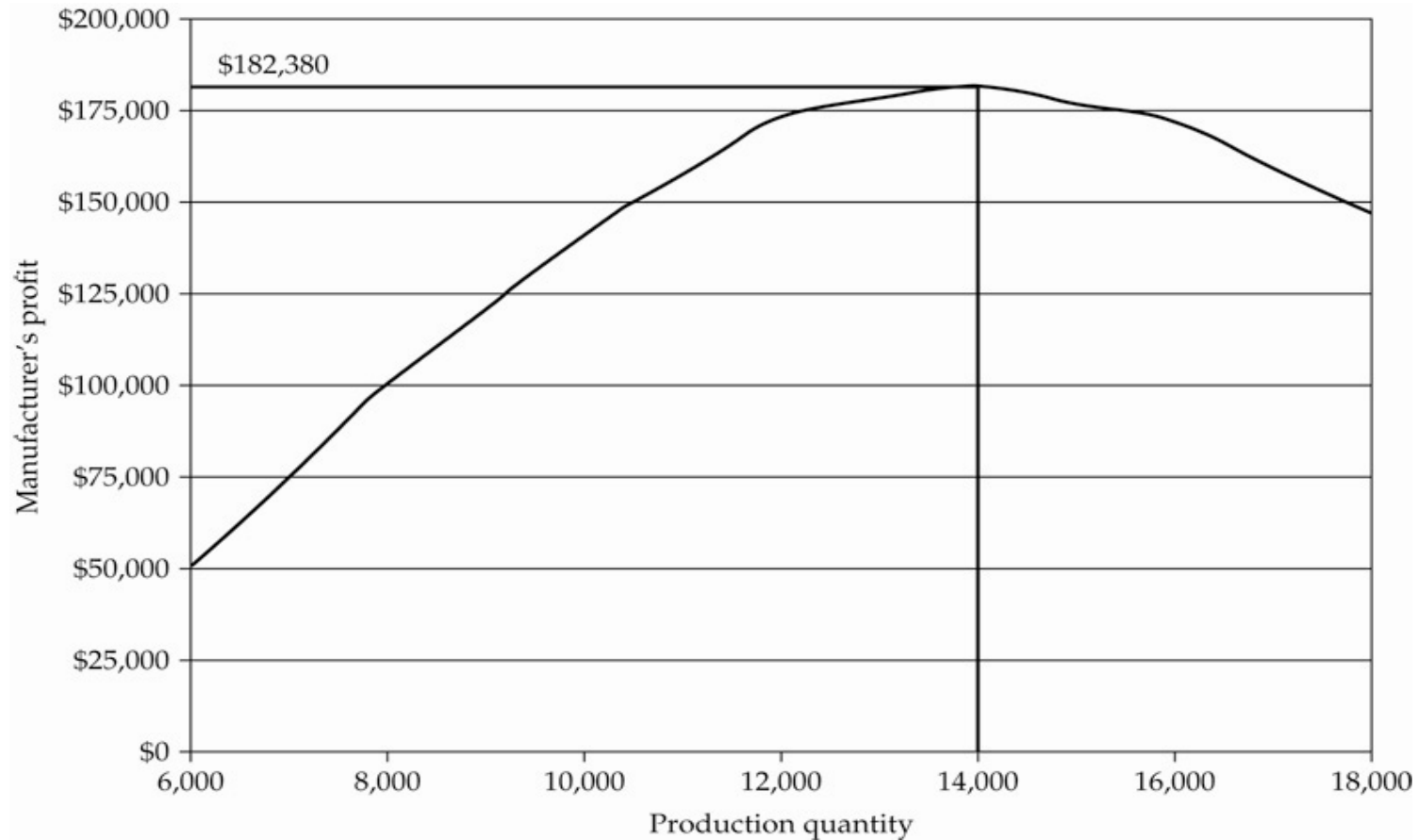
# Cost-Sharing Contract Ski-Jacket Example

- Manufacturer agrees to decrease the wholesale price from \$80 to \$62
- In return, distributor pays 33% of the manufacturer production cost
- Manufacturer increases production quantity to 14,000
- Manufacturer profit = \$182,380
- Distributor profit = \$523,320
- The supply chain total profit = \$705,700

**Same as the profit under pay-back contracts**



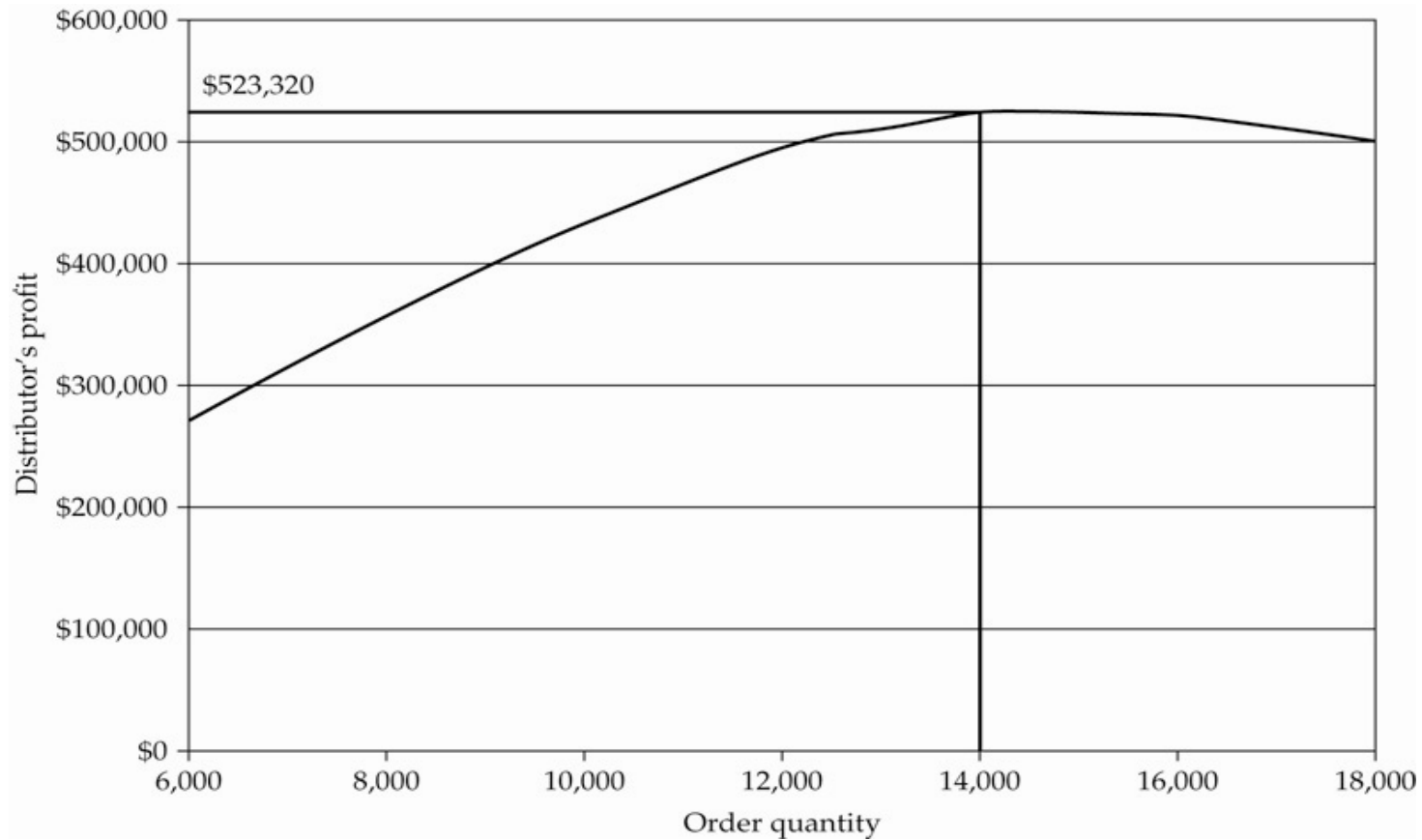
# Cost-Sharing Contract Ski-Jacket Example



**Manufacturer's average profit (cost-sharing contract)**



# Cost-Sharing Contract Ski-Jacket Example (cont)



**Distributor's average profit (cost-sharing contract)**

# Implementation Issues

- Cost-sharing contract requires manufacturer to share production cost information with distributor, something manufacturers are reluctant to do
- So, how? → Agreement between the two parties:
  - Distributor purchases one or more components that the manufacturer needs.
  - Components remain on the distributor books but are shipped to the manufacturer facility for the production of the finished good.

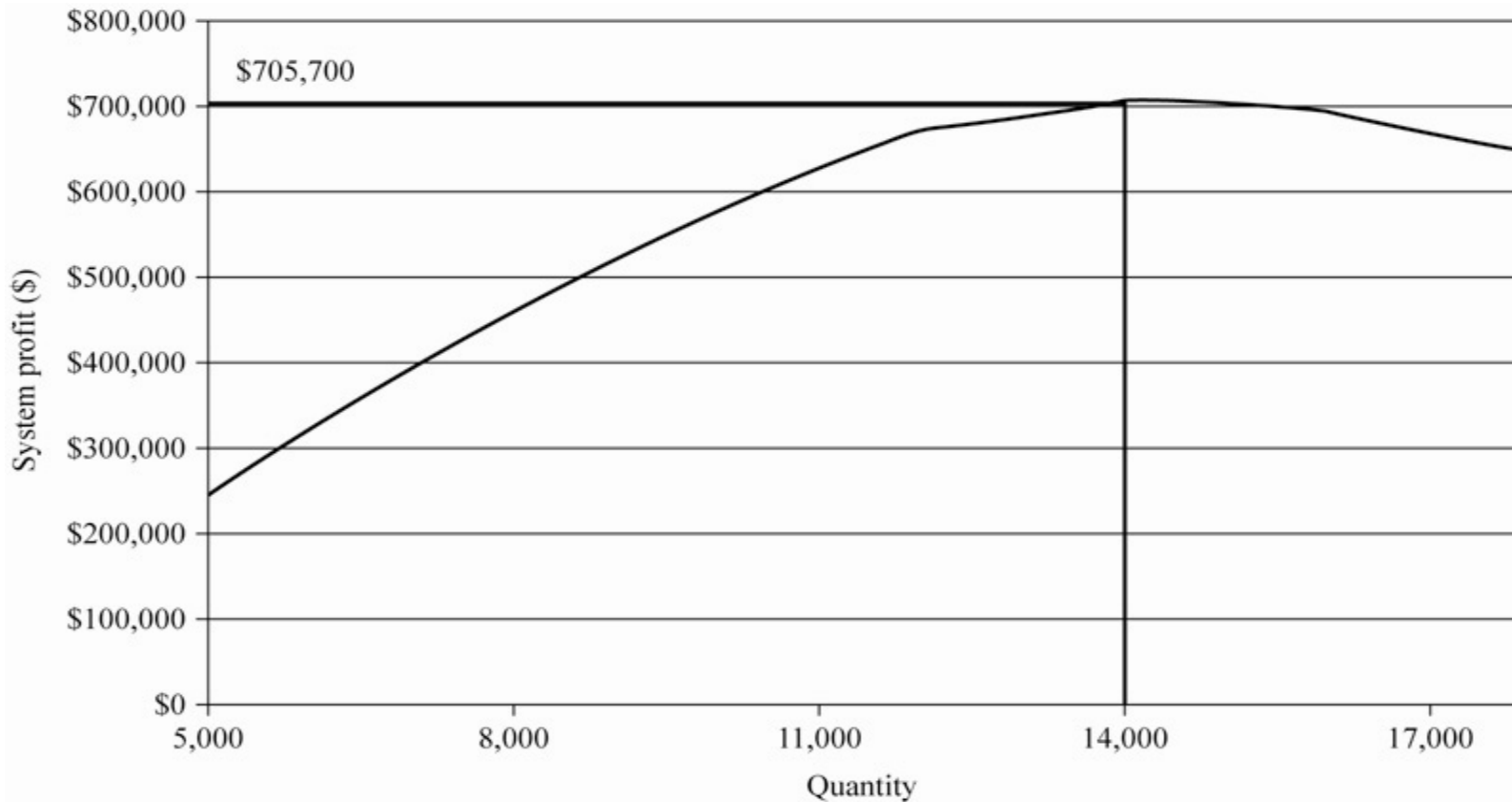


- Relevant data:
  - Selling price, \$125
  - Salvage value, \$20
  - Variable production costs, \$55
  - Fixed production cost. \$100,000
- Cost that the distributor pays the manufacturer is meaningless
- Supply chain marginal profit,  $70 = 125 - 55$
- Supply chain marginal loss,  $35 = 55 - 20$ 
  - Supply chain will produce more than average demand.
- Optimal production quantity = 14,000 units
- Expected supply chain profit = \$705,700

**Same profit as under pay-back and cost sharing contracts**



# Global Optimization



## Global optimization






# Contracts with Asymmetric Information

- Implicit assumption so far: Buyer and supplier share the same forecast
- However, inflated forecasts from buyers is a reality
- How to design contracts such that the information shared is credible?



# Two Possible Contracts

- Capacity Reservation Contract
  - Buyer pays to reserve a certain level of capacity at the supplier
  - A menu of prices for different capacity reservations provided by supplier
  - Buyer signals true forecast by reserving a specific capacity level
- Advance Purchase Contract 
  - Supplier charges special price before building capacity
  - When demand is realized, price charged is different
  - Buyer's commitment to paying the special price reveals the buyer's true forecast



# Contracts for Non-Strategic Components

- Variety of suppliers
- Market conditions dictate price
- Buyers need to be able to choose suppliers and change them as needed
- Long-term contracts have been the tradition
- Recent trend towards more flexible contracts
  - Purchase supply now or wait for better market condition in the future
  - Consider effective hedging strategies against unfavorable situations (i.e., shortages)




# Long-Term Contracts

- Also called *forward* or *fixed commitment contracts*
- Contracts specify a fixed amount of supply to be delivered at some point in the future
- Supplier and buyer agree on both price and quantity
- Buyer bears no financial risk
- Buyer takes huge inventory risks due to:
  - *uncertainty in demand*
  - *inability to adjust order quantities.*





# Option Contracts

- Buyer pre-pays a relatively small fraction of the product price up-front
- Supplier commits to reserve capacity up to a certain level.
- Initial payment is the *reservation price* or *premium*. 
- If buyer does not *exercise* option, the initial payment is lost.
- Buyer can purchase any amount of supply up to the option level by:
  - paying an additional price (*execution price* or *exercise price*)
  - agreed to at the time the contract is signed
  - Total price (reservation plus execution price) typically higher than the unit price in a long-term contract.

# Option Contracts

- Provide buyer with flexibility to adjust order quantities depending on realized demand
- Reduces buyer's inventory risks.
- Shifts risks from buyer to supplier. Supplier is now exposed to customer demand uncertainty.





# Spot Purchase

- Buyers look for additional supply in the open market.
- May use independent e-markets or private e-markets to select suppliers.
- Focus:
  - Using the marketplace to find new suppliers
  - Forcing competition to reduce product price.



- Portfolio approach to supply contracts
- Buyer signs multiple contracts at the same time
  - optimize expected profit
  - reduce risk.
- Contracts
  - differ in price and level of flexibility
  - hedge against inventory, shortage and spot price risk.
  - Meaningful for commodity products
    - a large pool of suppliers
    - each with a different type of contract.



# Appropriate Mix of Contracts

Low Price + Low Flexibility vs. Reasonable Price + Better Flexibility

- How much to commit to a long-term contract?
  - **Base commitment** level.
- How much capacity to buy from companies selling option contracts?
  - **Option** level.
- How much supply should be left uncommitted?
  - **Additional supplies in spot market if demand is high**
- Hewlett-Packard's (HP) strategy for electricity or memory products
  - **About 50% procurement cost invested in long-term contracts**
  - **35% in option contracts**
  - **Remaining is invested in the spot market.**





# Risk Trade-Off in Portfolio Contracts

- If demand is much higher than anticipated
  - Base commitment level + option level < Demand,
  - Firm must use spot market for additional supply.
  - Typically the worst time to buy in the spot market
    - **Prices are high due to shortages.**
- Buyer can select a trade-off level between price risk, shortage risk, and inventory risk by carefully selecting the level of long-term commitment and the option level.
  - For the same option level, the higher the initial contract commitment, the smaller the price risk but the higher the inventory risk taken by the buyer.
  - The smaller the level of the base commitment, the higher the price and shortage risks due to the likelihood of using the spot market.
  - For the same level of base commitment, the higher the option level, the higher the risk assumed by the supplier since the buyer may exercise only a small fraction of the option level.



# Risk Trade-Off in Portfolio Contracts

		Low	High
		Base commitment level	
Option level	High	Inventory risk (supplier)	N/A*
	Low	Price and shortage risks (buyer)	Inventory risk (buyer)

\*For a given situation, either the option level or the base commitment level may be high, but not both.