ISOM 2700: Operations Management
Session 8.2 Coordinating Supply Chain: Risk-sharing Contracts

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Risk Management and Operational Hedging

- What is risk?
  - Undesirable consequences of uncertainty
  - Variance

- Two types of risk
  - **Operational risk:** the risk of a mismatch between supply and demand, which reduces expected profit flows
  - **Financial risk:** the risk associated with finance, including financial transactions that include company loans in risk of default

Video: Supply Chain Risk

Risk Management and Operational Hedging

- Hedging: to mitigate these risks:
  - **Operational hedging** are constructions in supply chains to reduce operational risks that may increase expected profits as well as reduce its variance

  - **Financial hedging** are constructions with financial instruments to reduce the variance of profits

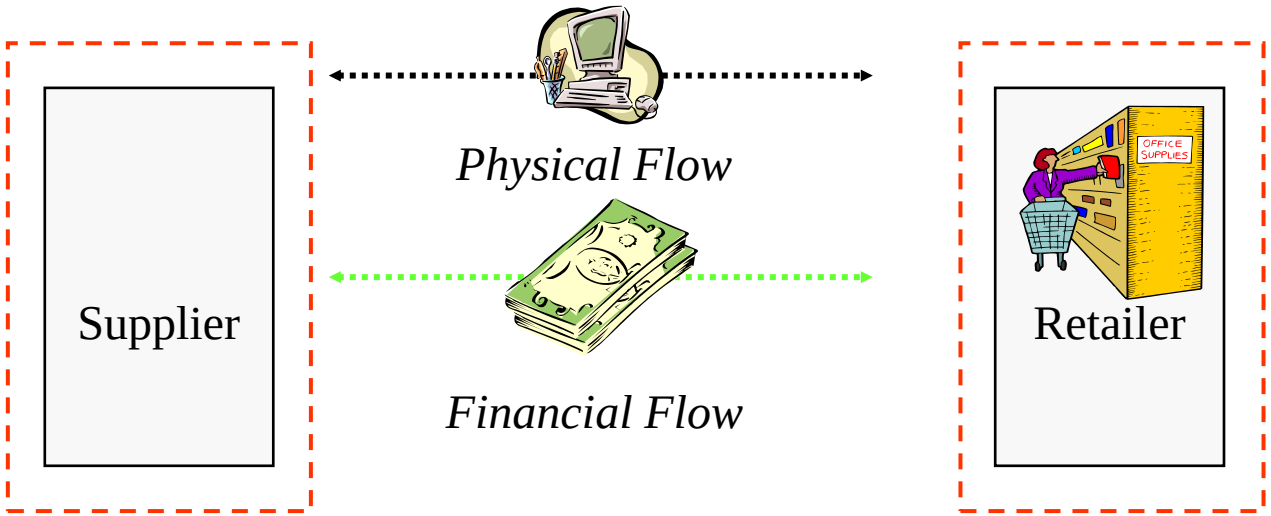
Outline

- **Hedging operational risk via contracts**
  - Wholesale price contract
  - Revenue sharing contract
  - Returns contract

What is a Contract?

- A contract is a set of rules to control / modify the goods/cash flows in the supply chain

- To be effective, the contract should be verifiable and enforceable.



Double marginalization

- Suboptimal supply chain performance occurs because …
  - Each firm makes decisions based on their own margin, not the supply chain's margin.
  - This is called ***double marginalization***.

Example: Umbra Visage (UV)

- Zamatia makes sunglass at a cost of $35 and sells them to UV for $75.
- UV sells the sunglasses to customers for $115 and salvages left over inventory for $25 per unit.
- Customer demand is normal with mean 250 and standard deviation 125.

Example: Umbra Visage (UV)

- Optimal Decisions for UV:
  - C_u = 115 - 75 = 40, C_o =75 - 25 = 50
  - Critical ratio = 40 / 90 = 0.44

- Optimal Decisions for the entire Supply chain:
  - C_u = 115 - 35 = 80, C_o =35 - 25 = 10
  - Critical ratio = 80 / 90 = 0.89

Supply chain's critical ratio is much higher than UV's critical ratio!

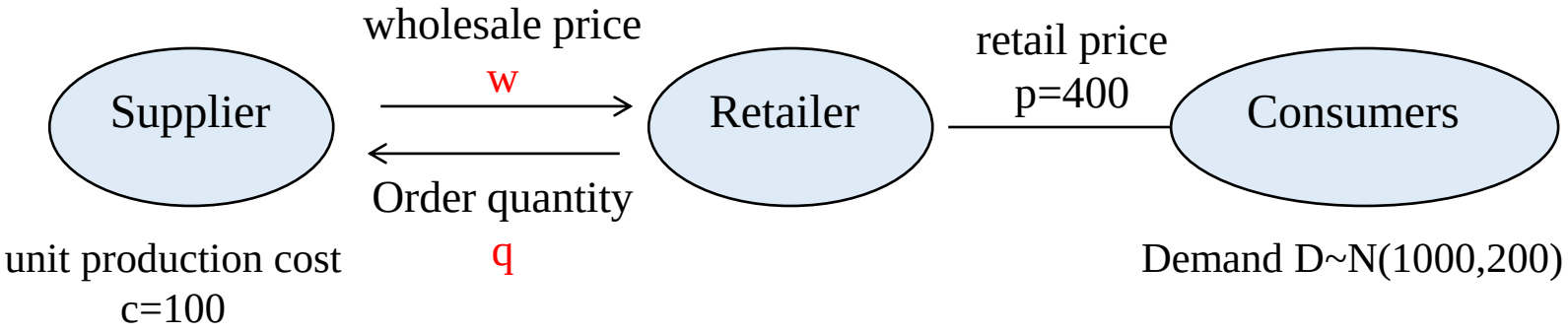
The wholesale price contract

- The supplier charges a fixed wholesale price w for every unit delivered to the retailer

- Given the wholesale price, the retailer decides how many units to order

Game I: wholesale price contract

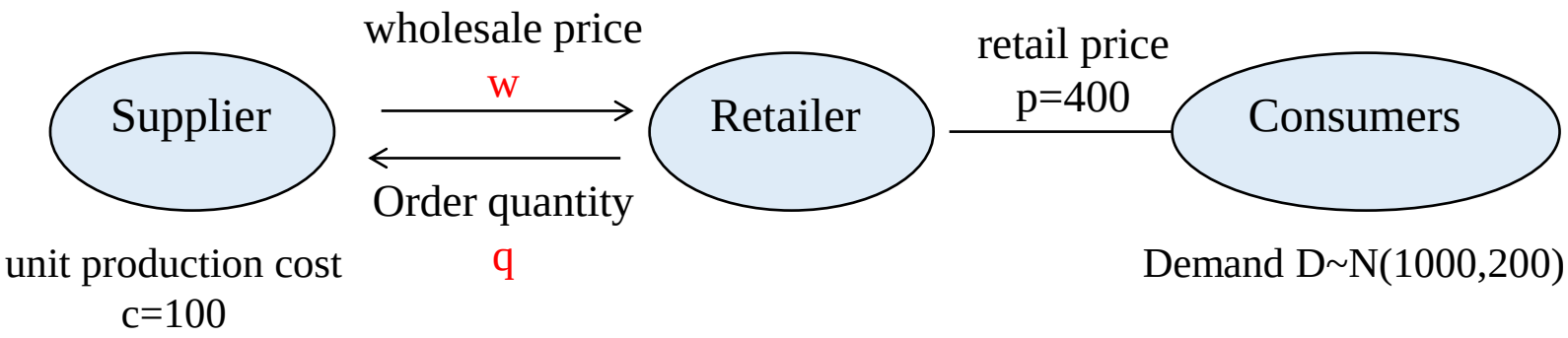
- A supplier produces a product at per unit cost $100, and sells it to a retailer at the wholesale price w, which is the supplier's decision
- The retailer decides how many units of products to order, q, before the sales season
- The uncertain demand D~N(1000,200) is realized
- The retail price is $400 and each unit of leftover inventory has zero salvage value



Game I: wholesale price contract

Procedure of Excel Simulation

- **Step 1.** Setup the excel spreadsheet
- **Step 2.** *Supplier*: Determine the wholesale price w
- **Step 3.** *Retailer*: Determine how many units to order q
- **Step 4.** Report the supplier and the retailer's expected profits over 300 simulation runs



Game I: Discussion

- The most profitable supplier?
- The highest total profit?
- What's the best possible outcome (first-best profit)?
- Did anyone achieve the best possible outcome?

Double Marginalization under Wholesale Price Contract: w=300

Centralized Supply Chain (first-best outcome)

- Cost of over production: Co=c=100
- Cost of under production: Cu=p-c=400-100=300
- Critical fractile: Cu/(Co+Cu)=300/400=0.75
- Supply chain's optimal production quantity: norminv(0.75,1000,200) =1135

Decentralized Supply Chain under wholesale price contract

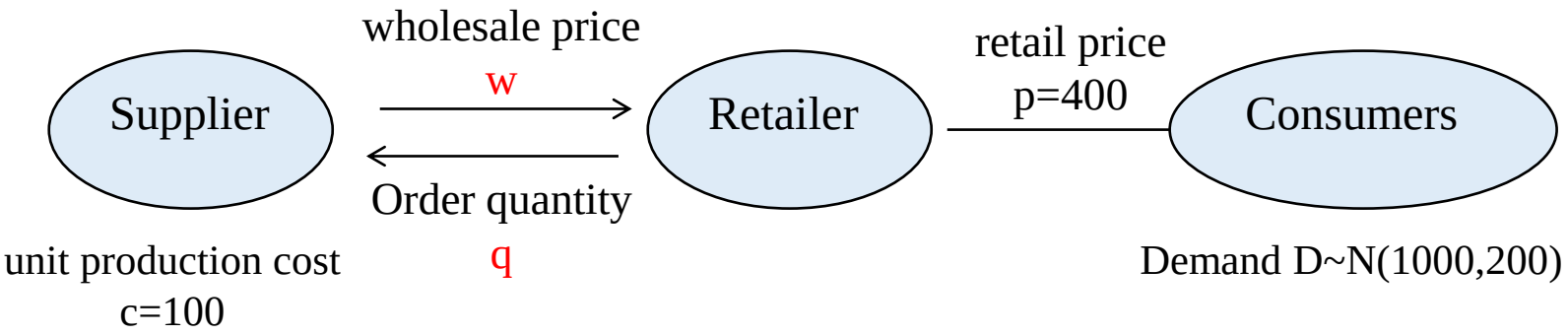
- Cost of over ordering: Co=w=300
- Cost of under ordering: Cu=p-w=400-300=100
- Critical fractile: Cu/(Co+Cu)=100/400=0.25
- The retailer's optimal order quantity: norminv(0.5,1000,200) =865

The retailer orders less than the supply chain optimum.

The revenue sharing contract

- The supplier charges a fixed price w for every unit delivered to the retailer
- For each unit of sales to an end consumer, the retailer pays the supplier a fixed percentage share y of the retail price to the supplier
- The retailer decides how many units of products to order before the sales season

Game II: revenue sharing contract



For every unit of sales, retailer gets 400(1-y) and supplier gets 400y

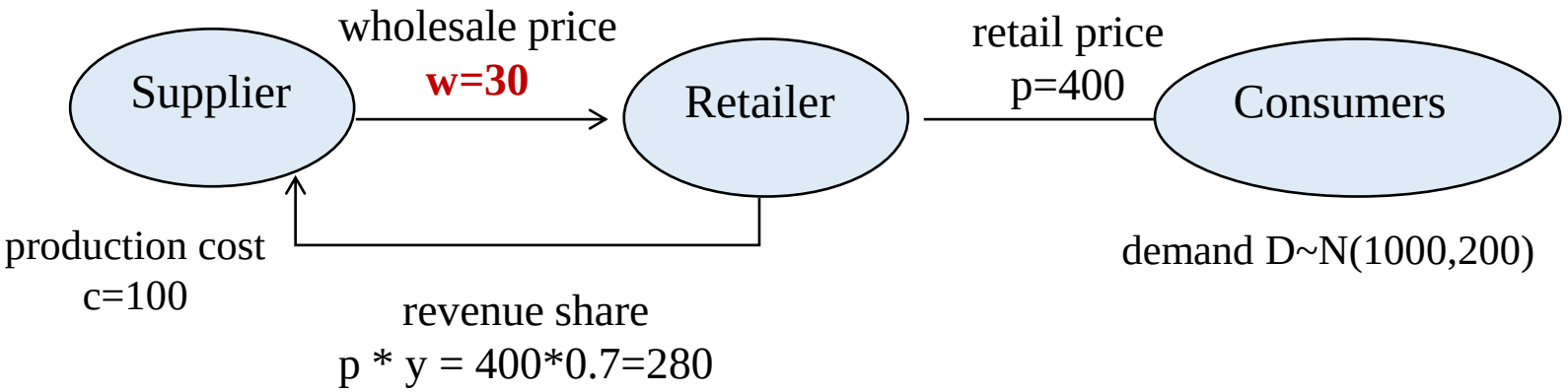
Procedure of Excel Simulation

- Step 1. Setup the excel spreadsheet
- Step 2. Supplier: Determine the wholesale price w and revenue share percentage y
- Step 3. Retailer: Determine how many units to order using Newsvendor formula
- Step 4. Report the supplier and the retailer's average profits over 300 simulation runs

Discussion of Game II

- The most profitable supplier?
- Is the best possible outcome achieved?
- How to achieve the best possible outcome?

Selling to Retailer under Revenue Sharing Contract: w=30, y=0.7



For every unit of sales: retailer gets \$400*(1-0.7)=\$120
supplier gets \$400*0.7=\$280.

What is the retailer's optimal order quantity under the above revenue sharing contract?

Achieving Coordination under Revenue Sharing Contract: w=30, y=0.7

- Cost of over ordering: Co=w=30
- Cost of under ordering: Cu=p(1-y)-w=400(1-0.7)-30=90
- Critical fractile: Cu/(Co+Cu)=90/120=0.75
- The retailer's optimal order quantity: norminv(0.75,1000,200)=1135

Achieving Win-Win Outcome

	Wholesale Price	Revenue Sharing
Supplier's Profit	173020	195003
Retailer's Profit	75524	83573
Supply chain's profit	248544	278576

- Both the supplier and the retailer are strictly better off under the revenue sharing contract than under the wholesale price contract.
- Revenue sharing contract allows the decentralized supply chain to achieve the same profit as the centralized supply chain.

How did we pick w=30 and y=0.7?

Key idea: let the critical file of the retailer under decentralized supply chain equal to the first-best critical fractile

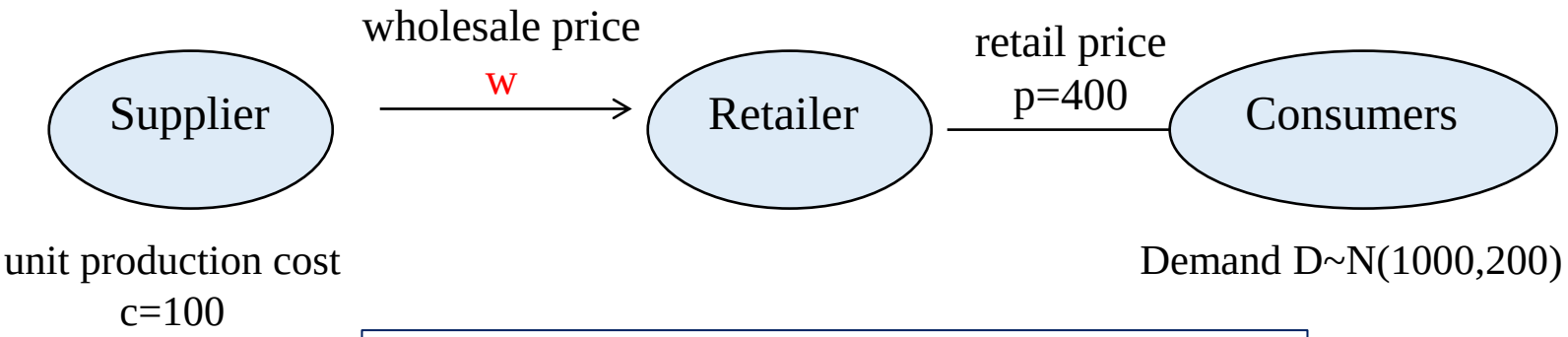
- the wholesale price can be considered as an internal transfer; does not impact supply chain's total profit
- **What matters is: retailer will order the optimal quantity as the first-best outcome**

The returns contract

- The supplier charges a fixed price w for every unit delivered to the retailer

- For each unit of leftover inventory, the supplier pays the retailer a fixed refund r to the retailer

Game III: returns contract



For every unit of unsold inventory, retailer gets r from the supplier

Procedure of Excel Simulation

- Step 1. Setup the excel spreadsheet
- Step 2. Supplier: Determine the wholesale price w and return refund r
- Step 3. Retailer: Determine the optimal order quantity using Newsvendor formula
- Step 4. Report the supplier and the retailer's average profits over 300 simulation runs

Discussion of Game III

- Is the best possible outcome achieved?

- How to achieve the best possible outcome?

Selling to Retailer under Returns Contract

Production cost c= $100
Retail price p= $400
Wholesale price **w= $300**
The supplier refund the retailer **r=$266.67** for every unsold unit

What is the retailer's optimal order quantity?

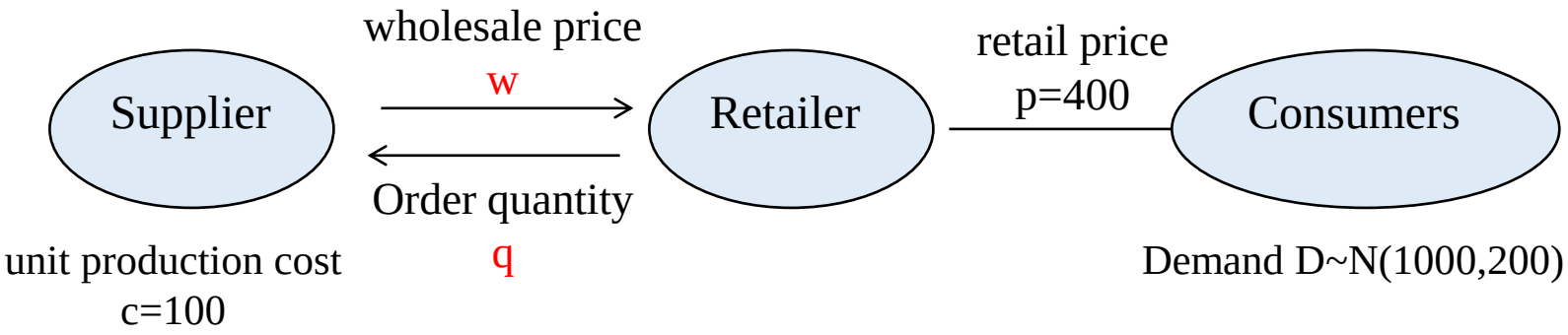
- Cost of overordering: Co=w-r=300-266.67=33.33
- Cost of underordering: Cu=p-w=400-300=100
- Critical fractile: Cu/(Co+Cu)=100/(100+33.33)=0.75
- The retailer's optimal order quantity:
  norminv(0.75,1000,200) =1135 units

Achieving Win-Win Outcome

	Wholesale Price Contract	Returns Contract
Supplier's Profit	173020	195003
Retailer's Profit	75524	83573
Total profit	248544	278576

- Returns contract allows demand risks to be shared among supply chain members
- Returns contract achieves not only supply chain coordination, but also win-win outcome for both the supplier and the retailer.

Summary



	Integrated Firm	Wholesale Price Contract	Revenue Sharing Contract	Returns Contract
Underage cost	p-c	p-w	p(1-y)-w	p-w
Overage cost	c	w	w	w-r
First-best outcome?	Yes	No	Yes, if y is chosen appropriately	Yes, if r is chosen appropriately

Summary

$S = \min(D, Q)$: the sales when ordering quantity is Q and demand is D

	Integrated Firm	Wholesale Price Contract	Revenue Sharing Contract	Returns Contract
Underage cost	$p - c$	$p - w$	$p(1-y) - w$	$p - w$
Overage cost	c	w	w	$w - r$
Critical ratio	$\frac{p-c}{p}$	$\frac{p-w}{p}$	$\frac{P(1-y)-w}{p(1-y)}$	$\frac{p-w}{p-r}$
Retailer profit	NA	$Sp - Qw$	$Sp(1-y) - Qw$	$Sp - Qw + (Q-S)r$
Supplier profit	NA	$Q(w-c)$	$Q(w-c) + Spy$	$Q(w-c) - (Q-S)r$
First-best outcome?	Yes	No	Yes, if y is chosen appropriately	Yes, if r is chosen appropriately

Takeaway

When designing contracts, think about…

- **Total profit pie**
  - What behavior would **maximize system-wide efficiency** (e.g., retailer setting a lower retail price, stocking a larger quantity)?
  - How can contract **provide incentives** for this behavior (e.g., lower marginal cost of acquisition, manufacturer bears portion of risk of overstocking by accepting returns)?
  - Who is at the best position to absorb risks?
- **How to split pie**
  - Contract terms must be set so that they are attractive to both firms

Video: Problem Walkthrough