

Cooperation on Purchasing

Modeling and Analysis of Group Purchasing Organizations

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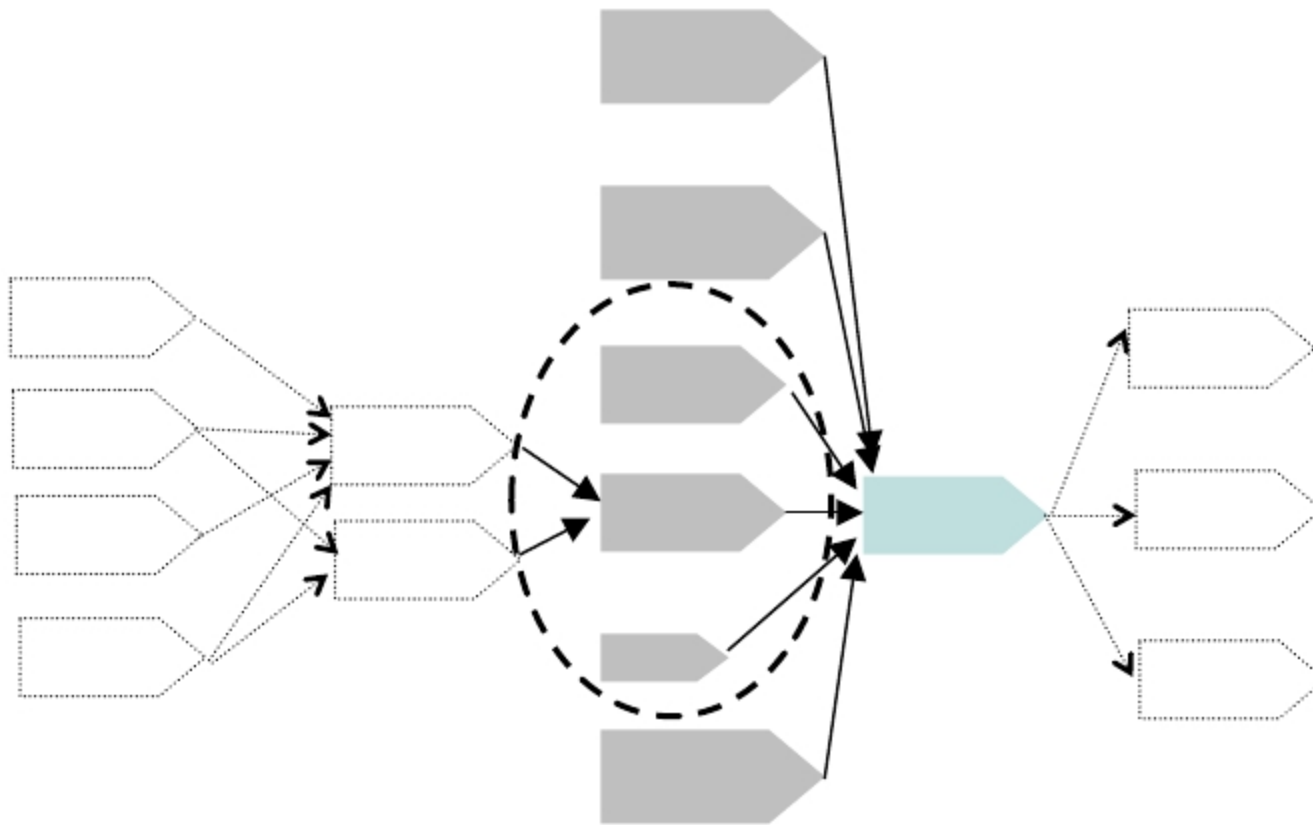
Oktay Karabağ

College of Engineering

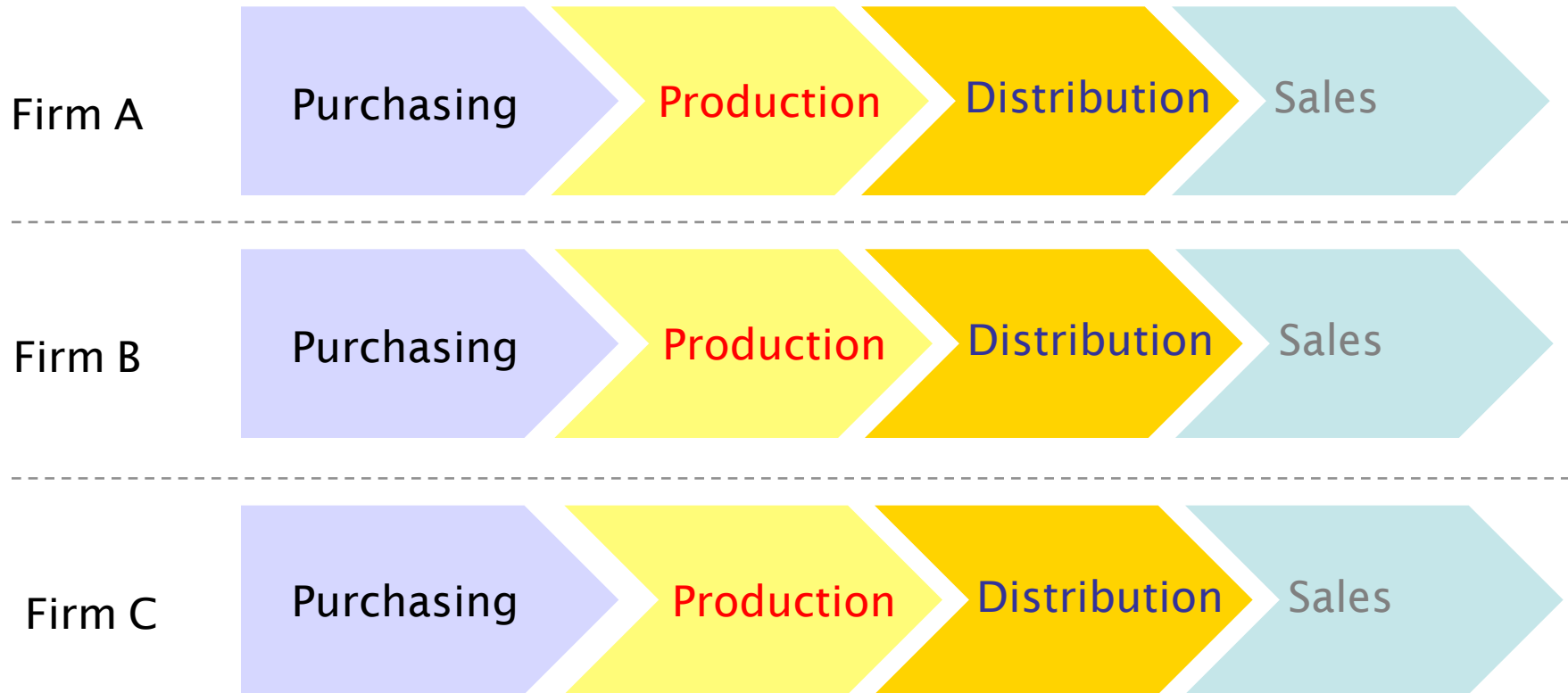


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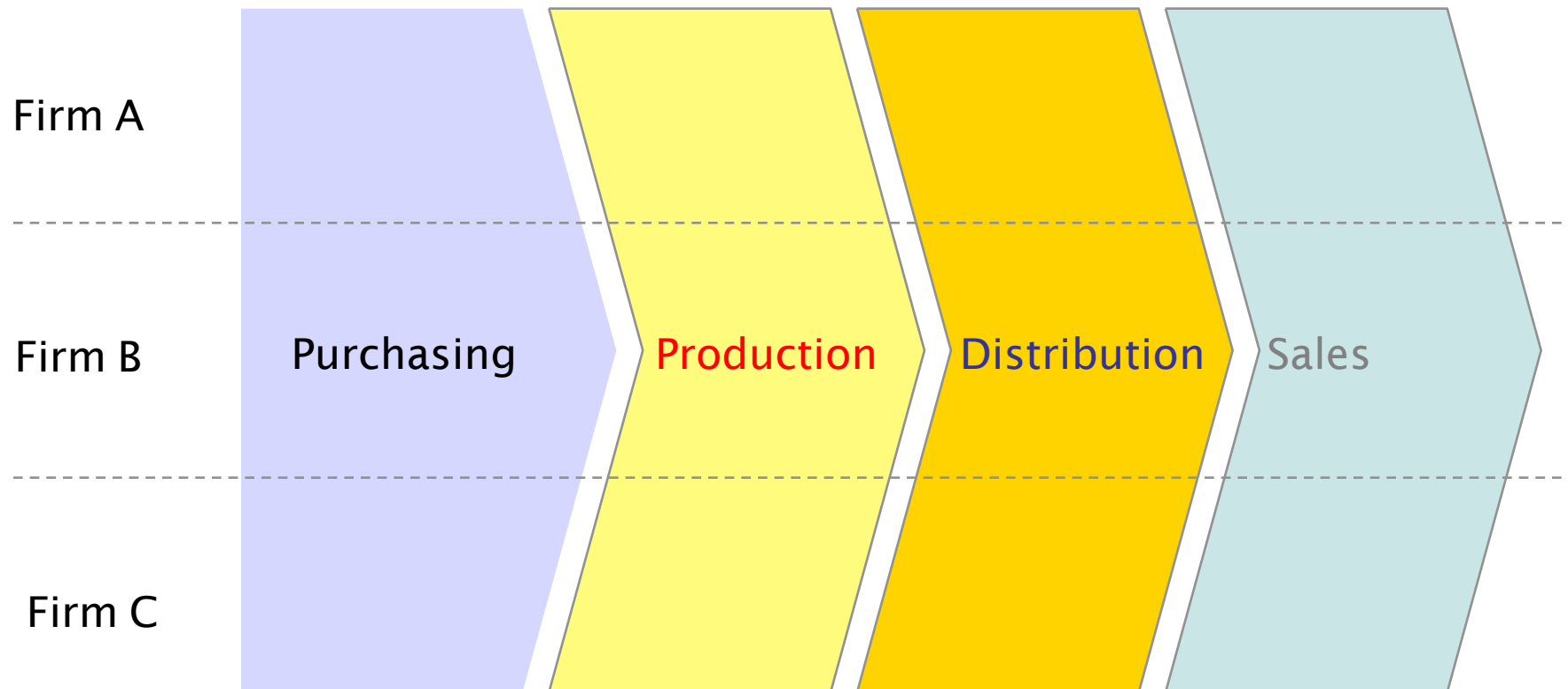
Cooperation of independent firms allows them to benefit from an opportunity in a market that neither of the firms can exploit on its own



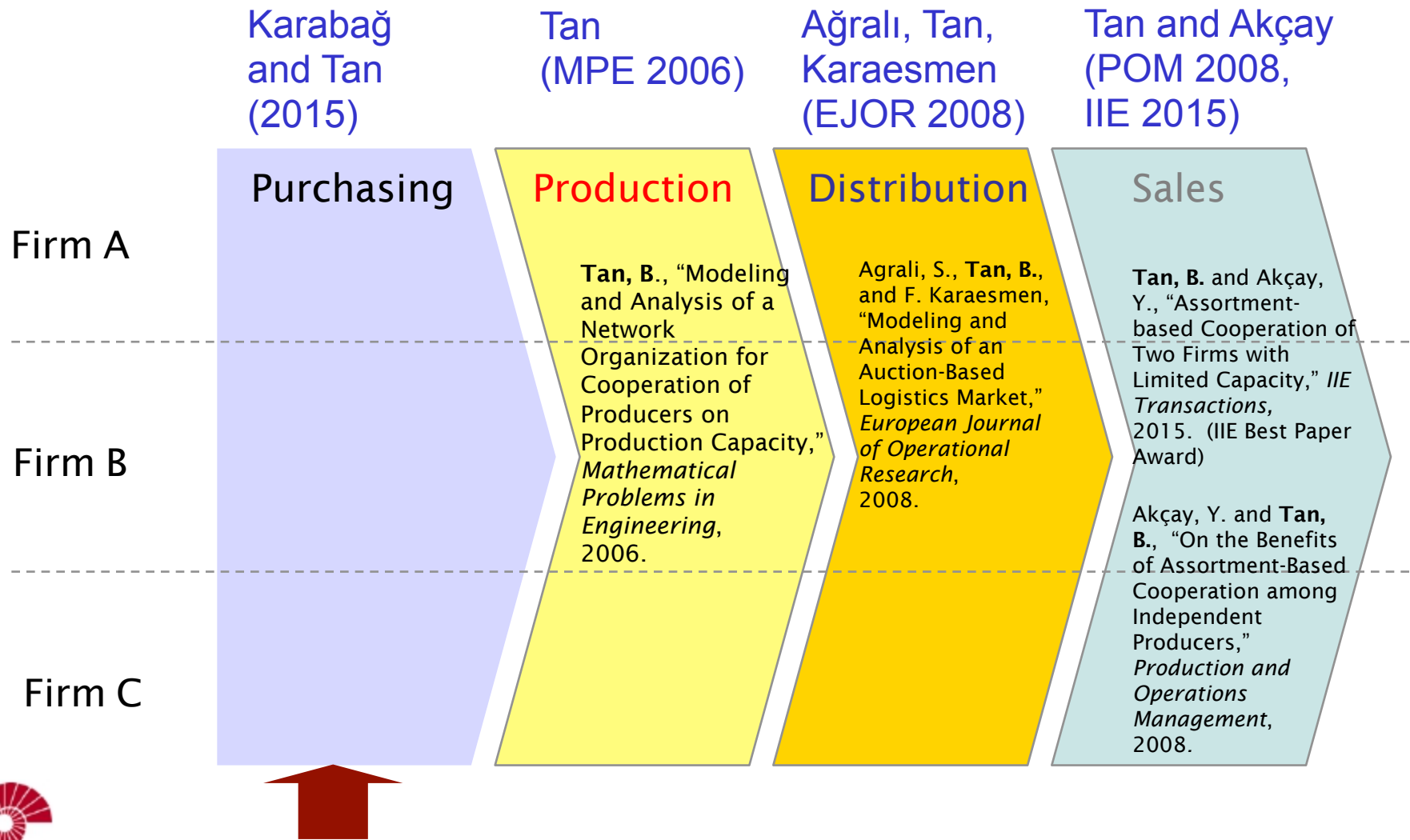
Cooperation-based business models can be implemented in purchasing, production, distribution, and sales



Cooperation-based business models can increase the competitiveness of firms



This study extends cooperation on production, distribution, and sales to **purchasing**



Cooperation is a viable business model for SMEs as well as for large companies

Project at Zer

Koç Group

82000 employees

Revenue ~\$50 Billion

100 companies

Ford, Fiat, LG, B&Q,

Beko, TUPRAS,

Sumitome, Kagome,

Caryle, Aygaz,

Unicredit ,...



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 Zer

Zer: The Power of Cooperation

This case was prepared by Professor Barış Tan with the research assistance of Koray Gökçe and Başak Eken at Koç University, Istanbul, Turkey as the basis for class discussion rather than to illustrate either effective or ineffective handling of a managerial situation.

All interpretations of this analysis reflect only the views of the authors. The cooperation of Zer is gratefully acknowledged.

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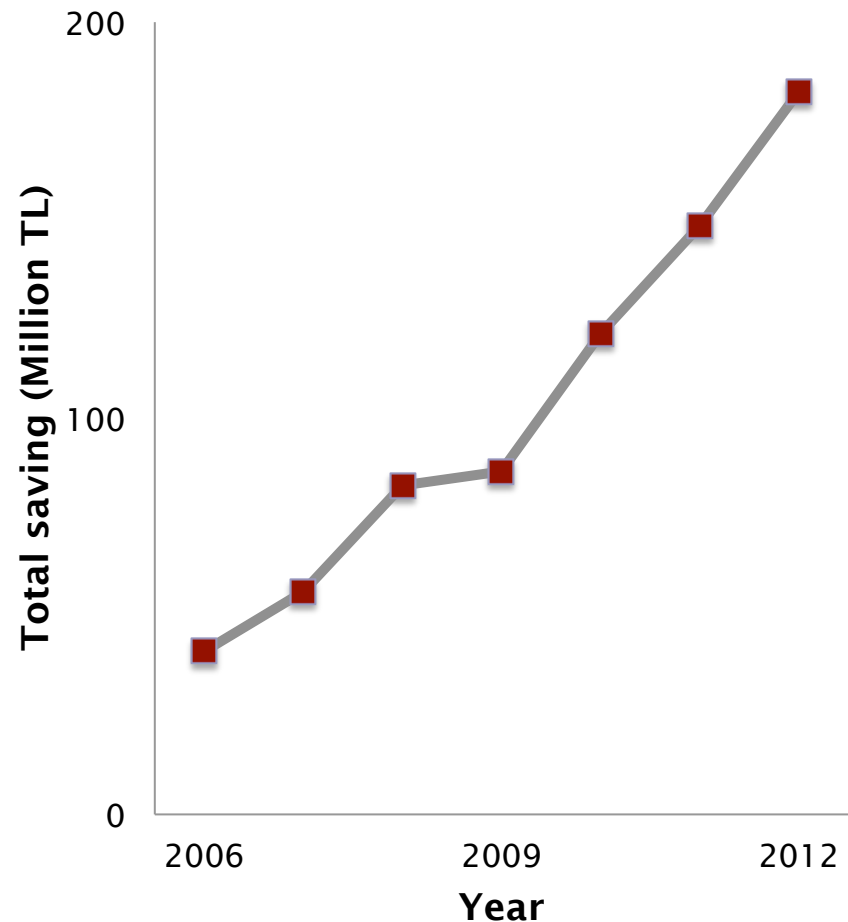
Zer Central Services uses a cooperation-based business model

Joint indirect material and services procurement

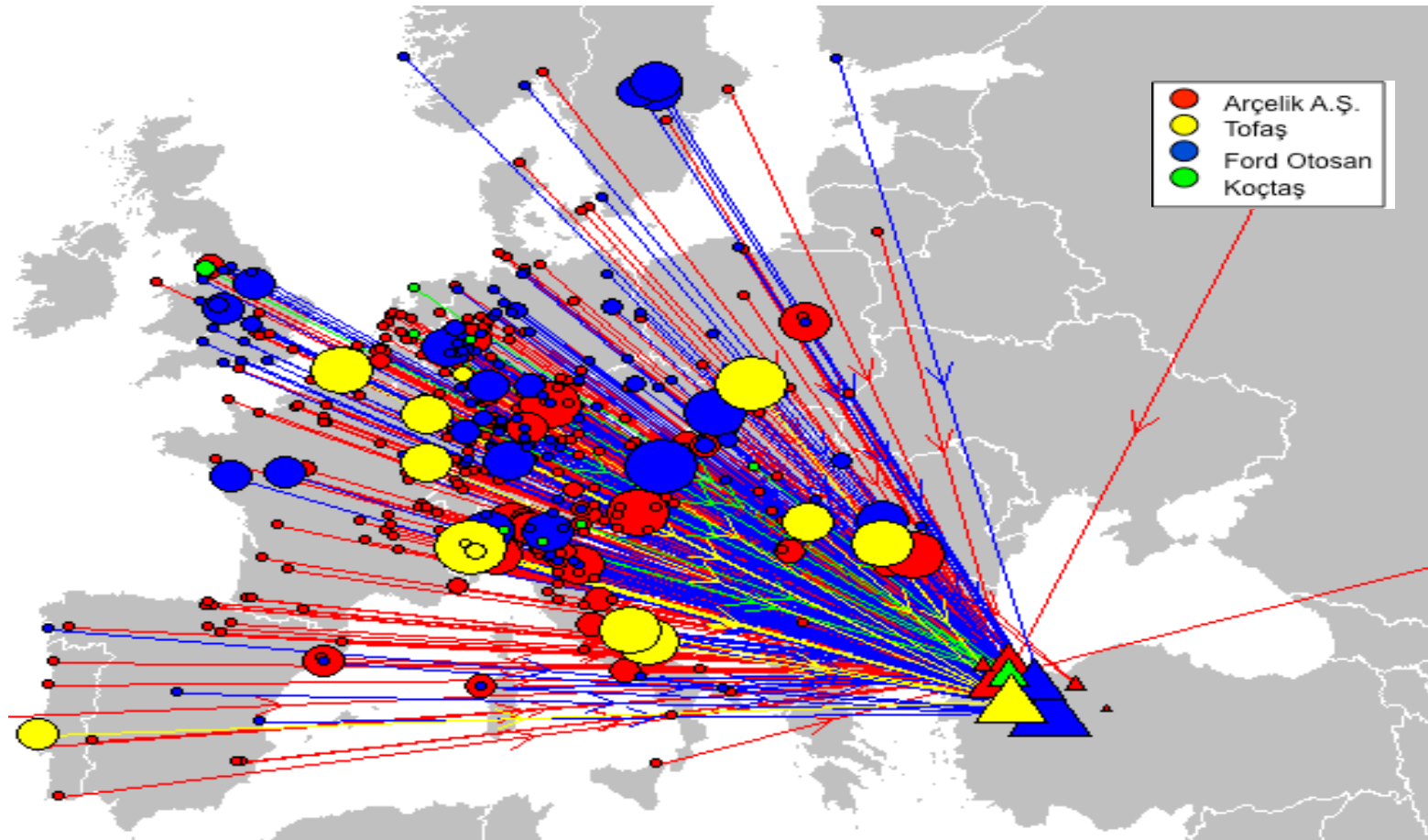
Logistics procurement and supply chain management

Joint media procurement

Group Purchasing Organization



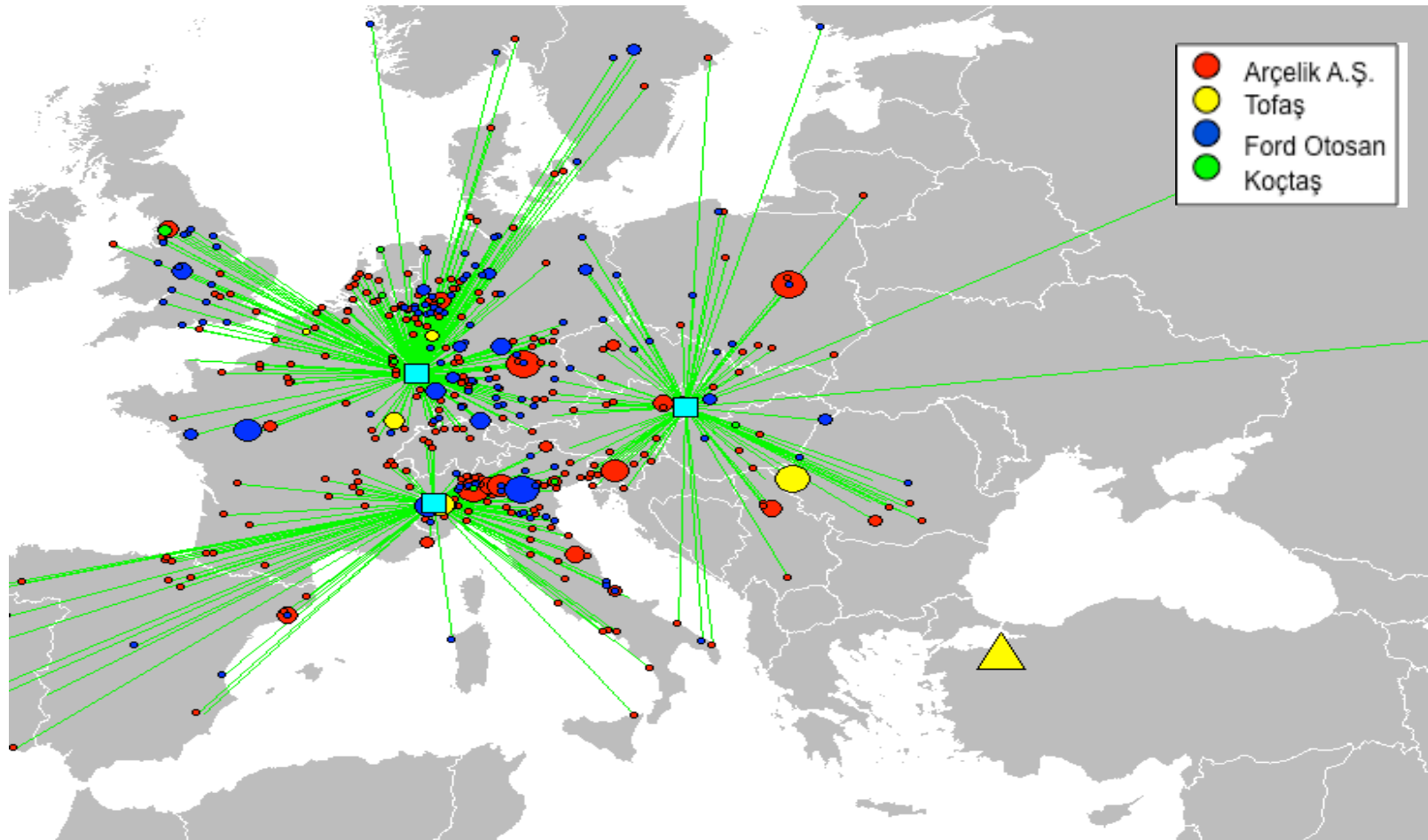
Zer: Logistics cooperation among different companies improves operations



Import Routes Before Cooperation



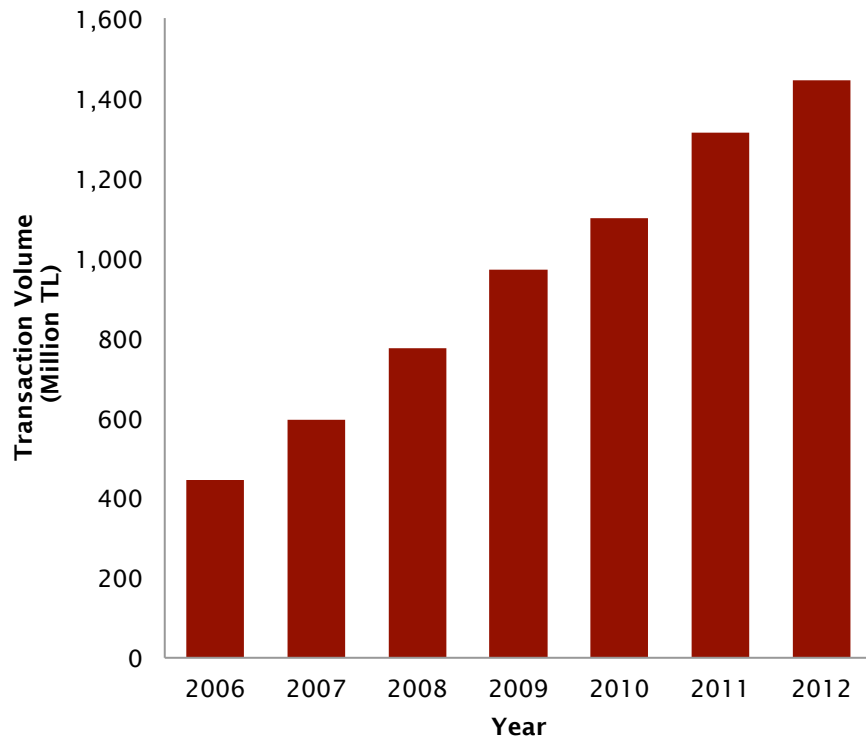
Zer: Cooperation leads to a more efficient supply chain structure



Logistics Network Using Hubs After Cooperation



Zer: Group Purchasing Organization for Indirect Material, Services, and Media



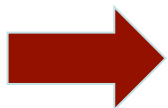
Company	Work	Cost Reduction (%)
Company 1	Industrial Gas	50
Company 2	Food and Hygiene Products	20
Company 3	Industrial Gas	19
Company 4	Food and Hygiene Products	15
Company 5	Industrial Gas	12
Company 1	Packaging	11
Company 6	Scrap	6



Group Purchasing Organizations

Group purchasing organization (GPO) is an entity that is created to leverage the purchasing power of a group of businesses to obtain discounts from suppliers based on the collective buying power of the GPO members.

Vertical Group Purchasing Organization
Industrial manufacturing, Healthcare,
Foodservice/grocery



Horizontal Group Purchasing Organization
Indirect, non-strategic spend



Literature

GPOs:

Nollet et. al. (2003)
Tella et. al. (2005)

Retailers
and GPOs:

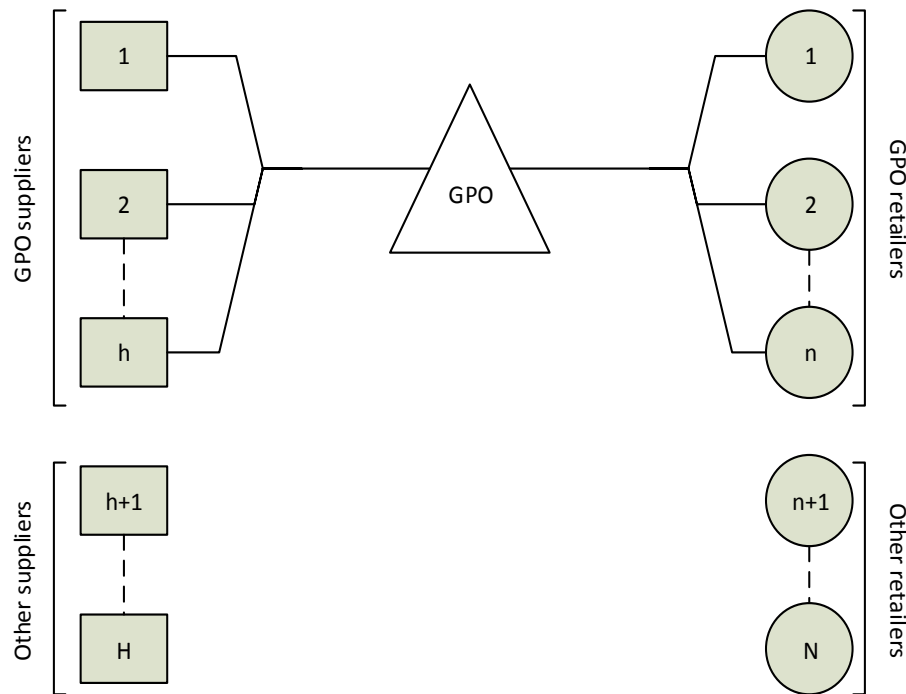
Saha et. al. (2011)
Chen and Roma (2011)
Li (2012)

Retailers,
Suppliers, and
GPO

Hu et. al. (2011)
Wang and Luo (2015)



Modelling and Analysis of the Operation of **Group Purchasing Organizations**



- **H suppliers** and **N retailers** in the market
- **h suppliers** and **n retailers** work with the **GPO** that offers a **quantity discounted price** to retailers and organizes an **auction** for the suppliers
- **Sales price** of the retailers is fixed
- **Purchasing price** from the suppliers in the second period is random
- **The total demand** in the market is random
- Suppliers have **fixed capacity**

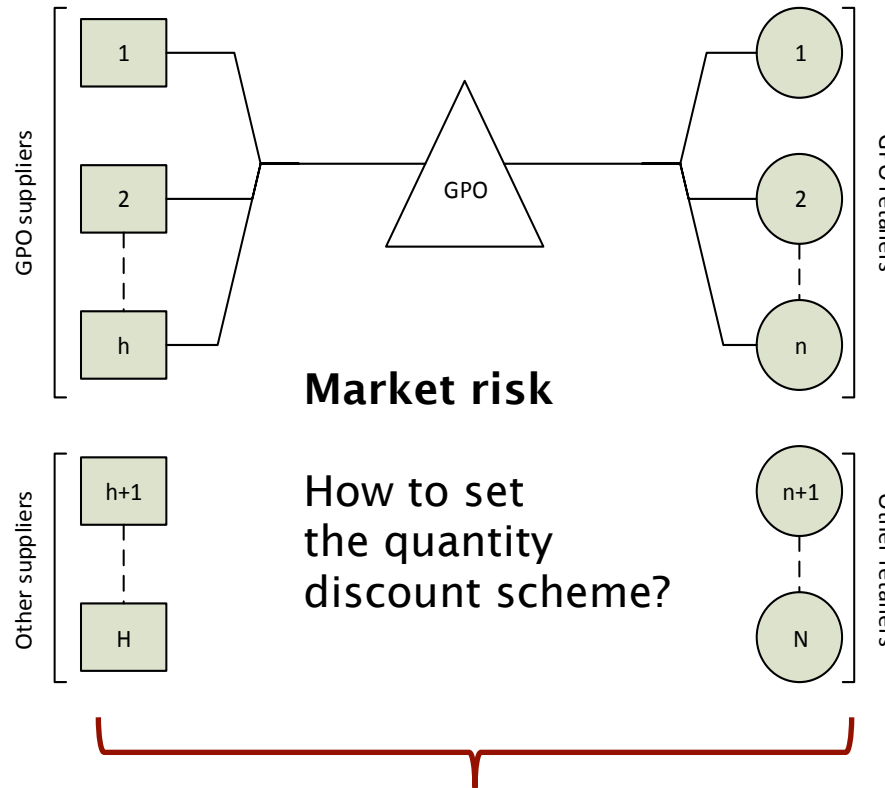


Modelling and Analysis of the Operation of Group Purchasing Organizations

Price and Demand Risk

How to set the capacity for GPO?

How much to bid for the auction?



Price risk

How much to purchase through GPO?

When is cooperation on procurement beneficial?

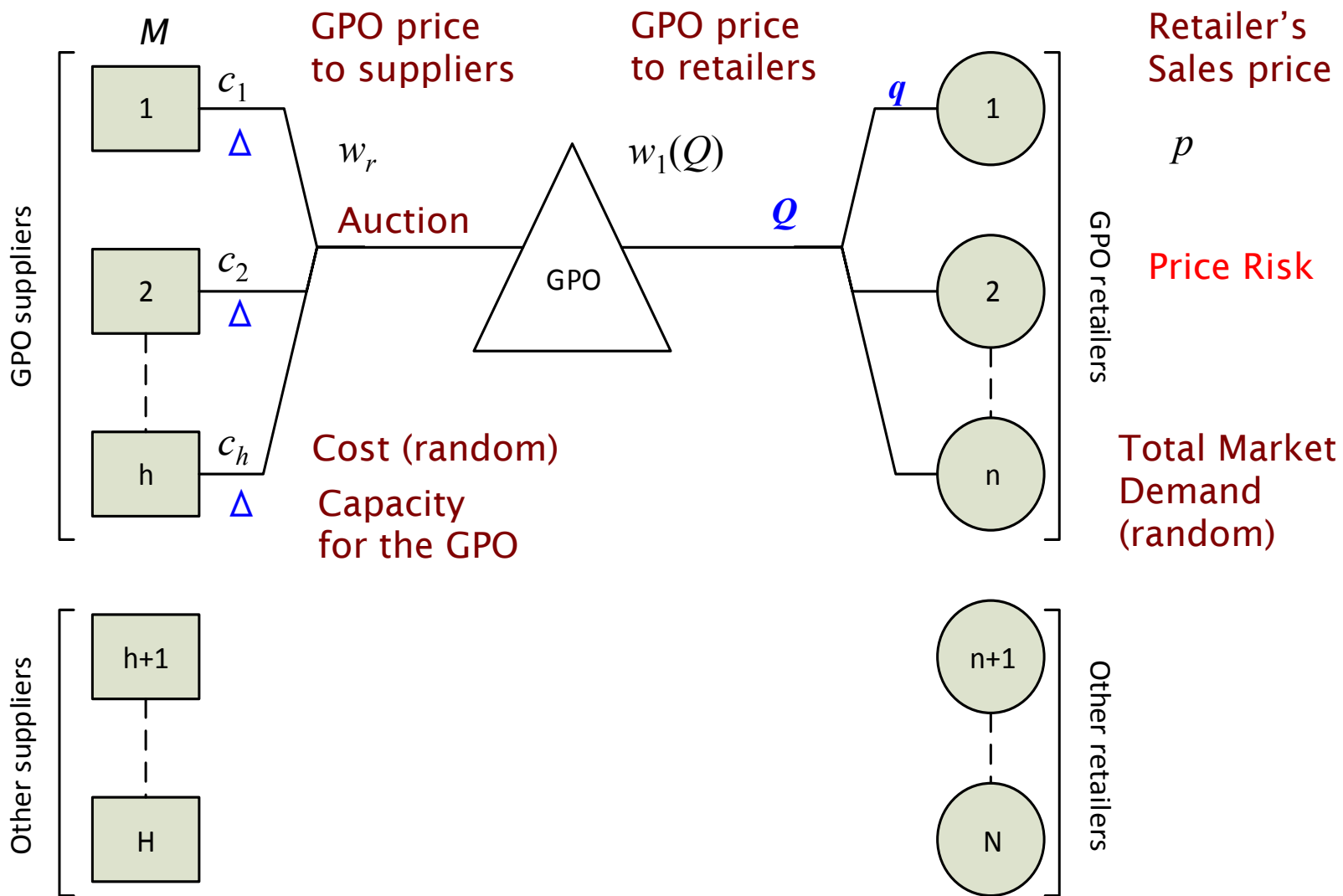
Who benefits from GPO?



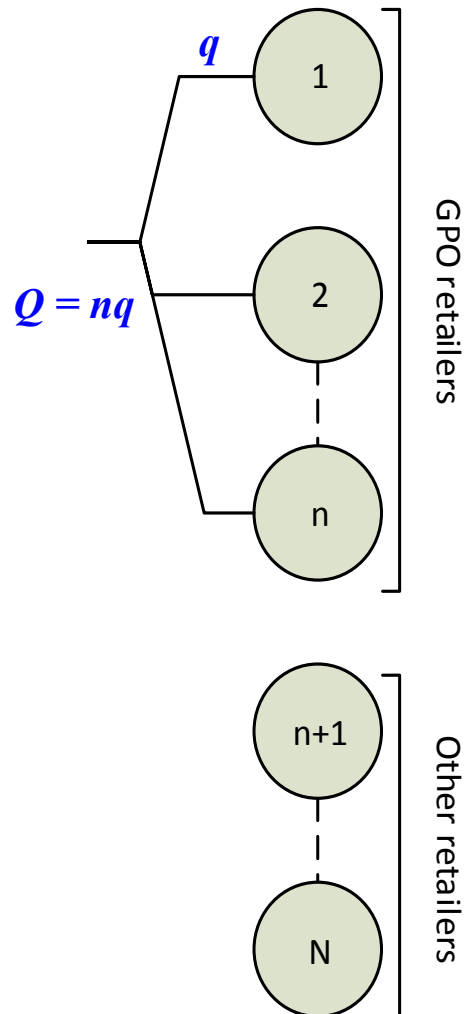
Modelling and Analysis of the Operation of Group Purchasing Organizations

Second period price (random)
 w_2

Price and Demand Risk



Retailer determines how much to purchase from the GPO in the first period



Retailer's Profit
Sales price
Retailer's Demand
Second period price

↓
↓
↓
↓

$$E[\pi_r(q)] = pE[D_r] - w_r q - E[\text{Max}(D_r - q, 0)]E[w_2]$$

↑
↑

Quantity to be bought from the GPO in the first period
Price to be paid to the GPO per unit

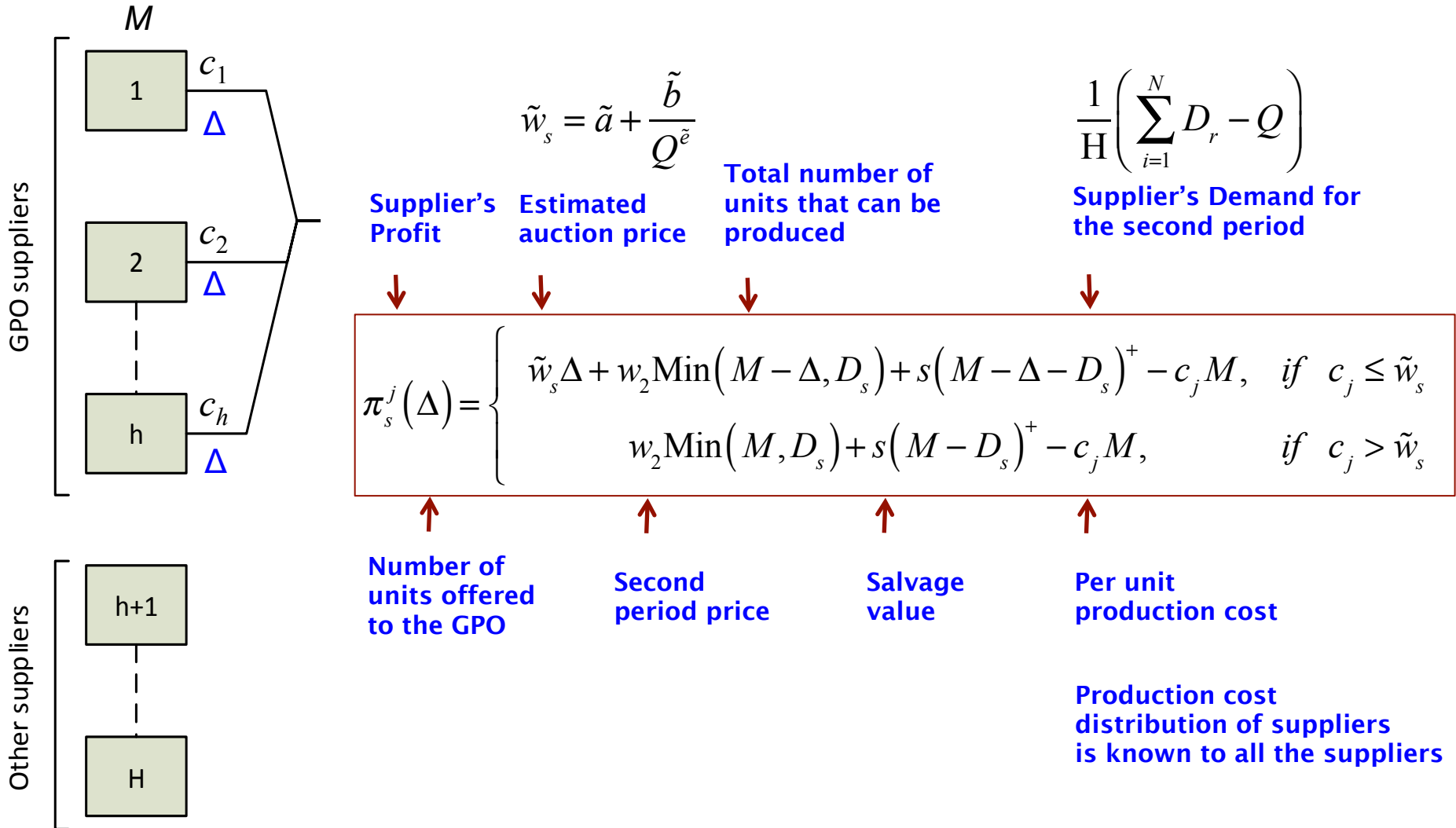
$w_r = a + \frac{b}{Q^e}, \quad be > 0$

$$q^* = \begin{cases} F_r^{-1}\left(\frac{E[w_2] - a}{E[w_2]}\right) & E[w_2] \geq a > 0 \\ 0 & \text{otherwise} \end{cases}$$

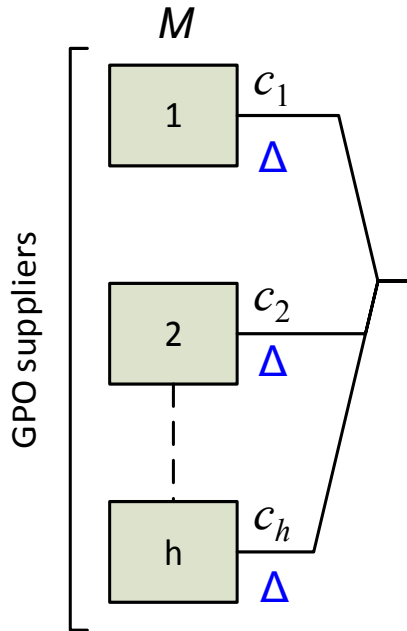
If $q^* = 0$ GPO dissolves



Supplier determines how much of its capacity to offer to the GPO



Supplier determines how much of its capacity to offer to the GPO



$$\pi_s^j(\Delta) = \begin{cases} \tilde{w}_s \Delta + w_2 \text{Min}(M - \Delta, D_s) + s(M - \Delta - D_s)^+ - c_j M, & \text{if } c_j \leq \tilde{w}_s \\ w_2 \text{Min}(M, D_s) + s(M - D_s)^+ - c_j M, & \text{if } c_j > \tilde{w}_s \end{cases}$$

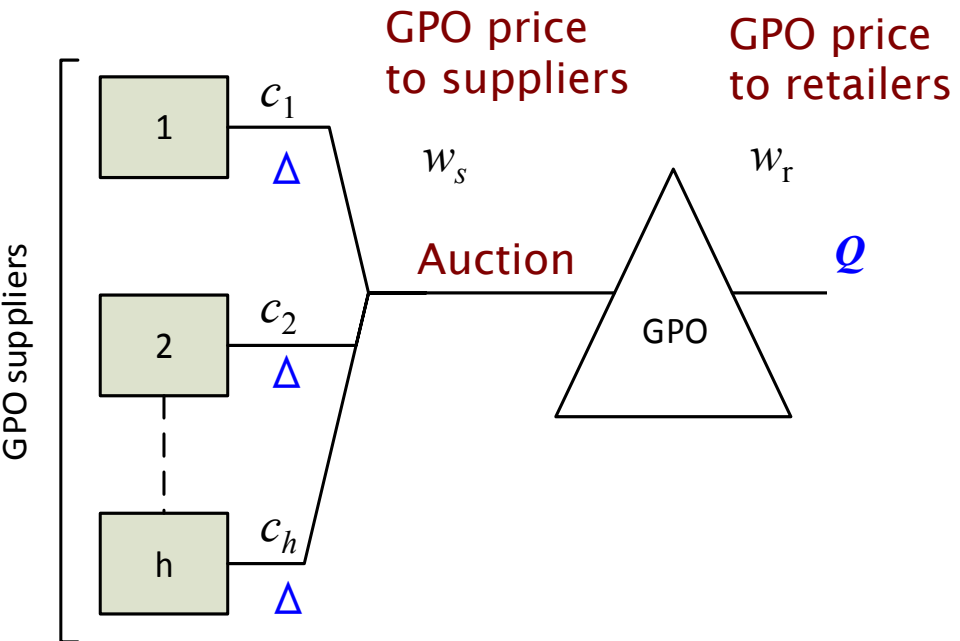
$$\text{Max}_{\Delta} E[\pi_s^j(\Delta)]$$

Optimal number of units to be offered to the GPO

$$\Delta^* = \begin{cases} M & \text{if } \text{Max}\{s, E[w_2]\} \leq E[\tilde{w}_s] \\ M - F_s^{-1}\left(\frac{E[w_2] - E[\tilde{w}_s]}{E[w_2] - s}\right) & \text{if } s \leq E[\tilde{w}_s] \leq E[w_2] \\ 0 & \text{otherwise} \end{cases}$$



The GPO organizes a **uniform price reverse auction** to select the suppliers and determine the price to be paid to the suppliers



h_a suppliers participate in the auction

Each participating supplier bids its actual cost (Δ, c_j)

k suppliers with the lowest bids are selected $k = \lceil Q/\Delta \rceil$

Each winning supplier is paid the lowest losing bid $w_s = c_{(k+1)}$

If $k+1$ suppliers do not submit bids GPO dissolves

$$E[\pi_g] = Q(w_r - E[w_s])$$

Expected profit of the GPO

Expected value of the $(k+1)$ th smallest of h_a uniform random variables



Zer: Promena Auction Platform

PROMENA Genel veriler e-ihale Yapısı **e-ihale Ayarları** e-ihale Durumu e-ihale Kokpiti e-ihale Analizi e-ihale Sonuçlandırma

Proje Etiket Test e-ihale Proje durumu Teklif verme kapalı Kullanıcı rolü Proje Yöneticisi

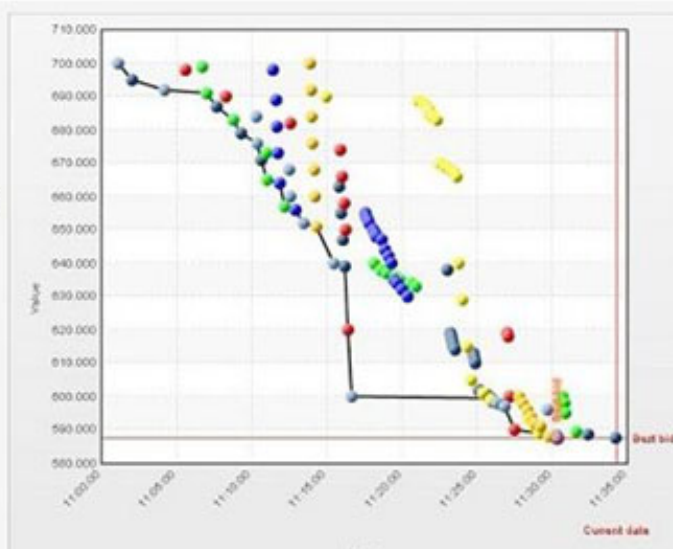
e-ihale tanımı Rekabet ayarları Kilometre taşları ve uzatmalar Başlangıç fiyatları Fiyat analizi Teklif kutusu düzeni

e-ihale sonuçlarını dışarı aktar Çeviri

İhale ayarları

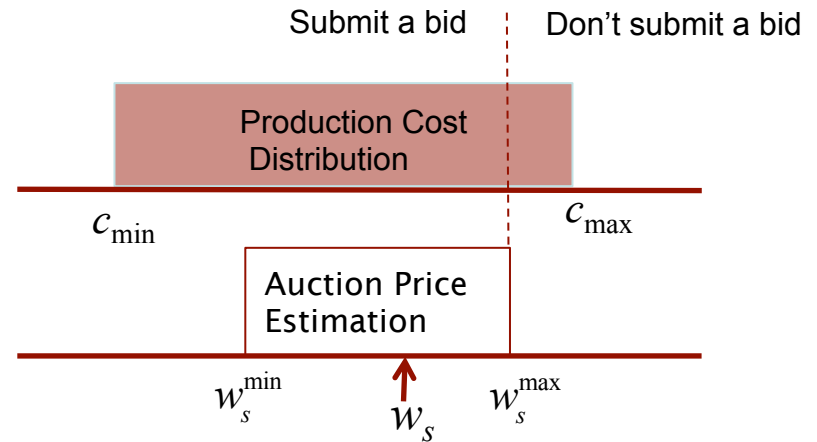
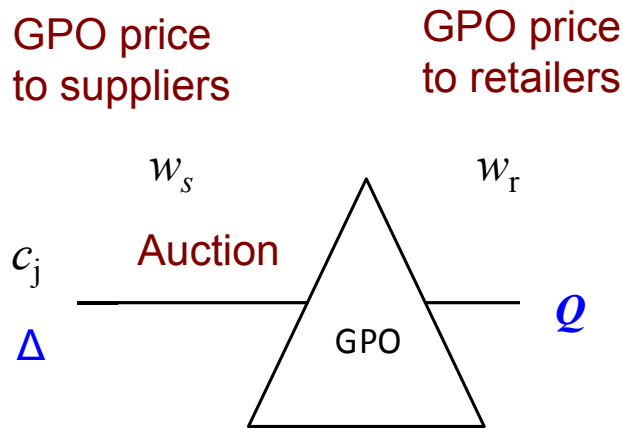
İhale türü	Dinamik	Dinamik ihale Bu tip ihale formatında tedarikçiler kendi sıralamalarını veya bir renk görürler (Yeşil = En iyi teklif, Kırmızı = En iyi olmayan teklifler). Tedarikçiler, tekliflerini revize ederken, kendi tekliflerinin altında teklif vermek zorundadırlar.
Teklif mantığı	Kendi teklifi	
İhale yönü	Aşağı	Dinamik ihale tipi satış için de kullanılabilir. Bu durumda teklif verme yönü "yukarı" şeklinde seçilmelidir.
Teklif girişi	Mutlak değer	
Teklif değeri görüntüsü	Dönüştürülen	
En iyi satır ögesi	Aşağı	
Minimum değişikliği hesapla	<input checked="" type="checkbox"/>	
"Başa geç" hesapla	<input checked="" type="checkbox"/>	
Teklif değeri olarak "0"ı reddet	<input checked="" type="checkbox"/>	

Sayfa geribildirimi





A supplier decides to **participate in the auction** if its maximum estimate of the auction price is lower than its cost



$\text{Prob}[c_j < w_s^{\max}] > 0 \rightarrow$ Supplier j submits a bid

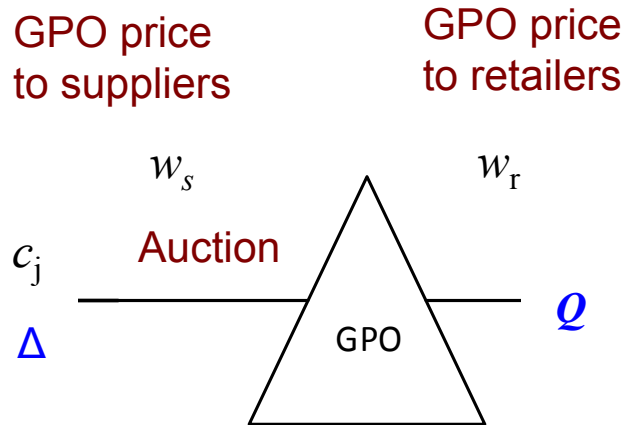
Distribution of the number of bidders h_a is binomial

$$\text{Prob}[h_a = m] = \binom{h}{m} p_a^m (1 - p_a)^{h-m}$$

$$p_a = \text{Prob}[c_j < w_s^{\max}] = \frac{w_s^{\max} - c_{\min}}{c_{\max} - c_{\min}}$$



The **expected auction price** is the smallest losing bid when the required number of suppliers participate in the auction



Expected auction price:

Expected value of the $(k+1)$ th smallest of h_a uniform random variables where h_a is binomially distributed and $h_a \geq k+1$

$$E\left[c_{(k+1)} \mid c_{(1)} < \dots < c_{(k+1)} < w_s^{\max}, h_a \geq k+1\right] \quad k = \lceil Q/\Delta \rceil$$

$$E[w_s] = 1 - \frac{p_a^{k+1} (1-p_a)^{n-k}}{(k+1) \int_0^{p_a} x^k (1-x)^{n-k-1} dx} \left(\frac{k+1}{n+1} \right) (c_{\max} - c_{\min}) + c_{\min}$$

$$E[\pi_g] = Q(w_r - E[w_s])$$



Analytical Model of the GPO

Number of suppliers,
retailers, and GPO
members in the market

Demand distribution

Second period supplier
price distribution

Retailers sales price

GPO discount scheme

Suppliers cost distribution

Suppliers auction price
estimate distribution

Suppliers capacity

Retailers' GPO
ordering policy

Suppliers GPO
capacity setting
policy

Expected profits of
suppliers,
retailers, and GPO



Analytical Results on the Effects of Cooperation: GPO is beneficial for the **retailer**

when the following condition holds

$$q^* \left(1 - \frac{w_r}{E[w_2]} \right) > \int_0^{q^*} F_r(x) dx$$

If the expected wholesale price in the second period is greater than the wholesale discount scheme offered by GPO, GPO is always beneficial for the retailer

$$E[w_2] > w_r$$



Analytical Results on the Effects of Cooperation: GPO is beneficial for the **supplier**

when the following condition holds

$$\left(E[\tilde{w}_s] - E[w_2]\right)\Delta^* + \left(s - E[w_2]\right) \int_{M-\Delta^*}^M F_s(x) dx > 0$$

If the estimated auction price is greater than the expected wholesale price in the second period and the salvage value, GPO is always beneficial for the supplier

$$E[\tilde{w}_s] \geq \text{Max}\{s, E[w_2]\}$$



Numerical Experiments

Effect of the price uncertainty with respect to GPO price

Effect of the amount of demand captured by the GPO with respect to total demand

Retailer Order Quantity

Supplier capacity offered to GPO

Realized Price

Profits



Special Case with Normal Demand Distribution leads closed form solutions

Retailer Profit and Order Quantity

$$E[\pi_r(q)] = p\mu_r - w_r q - E[w_2] \sigma_r \eta\left(\frac{q - \mu_r}{\sigma_r}\right)$$

$$q^* = \begin{cases} \mu_r + \sigma_r \Phi^{-1}\left(\frac{E[w_2] - a}{E[w_2]}\right) & E[w_2] \geq a > 0 \\ 0 & \text{otherwise} \end{cases}$$

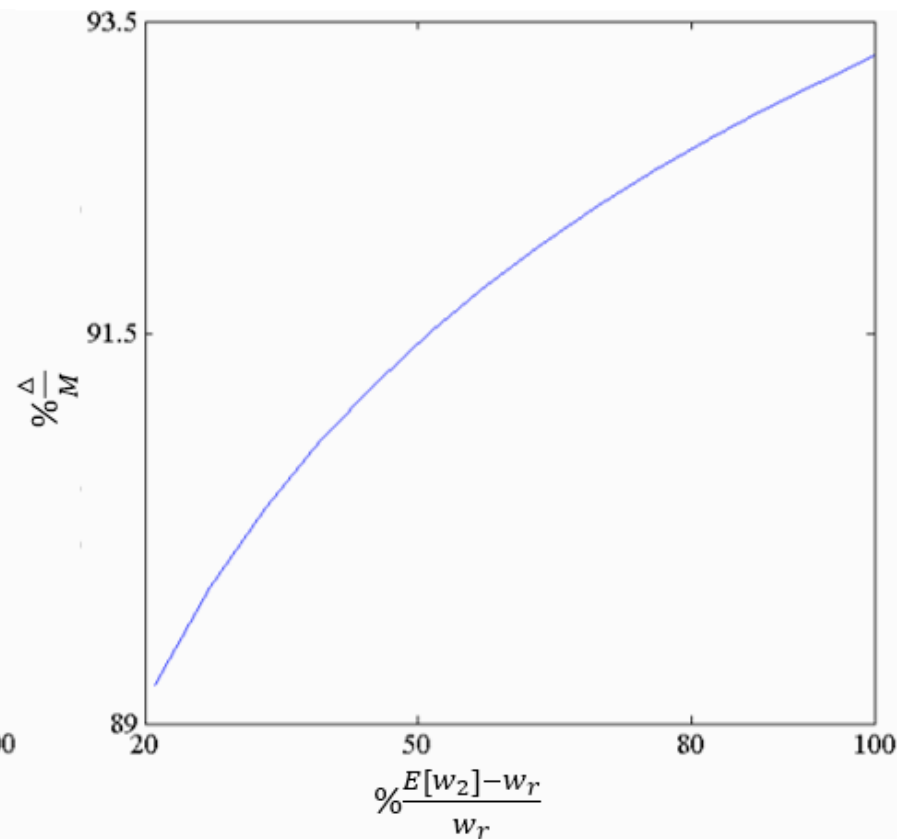
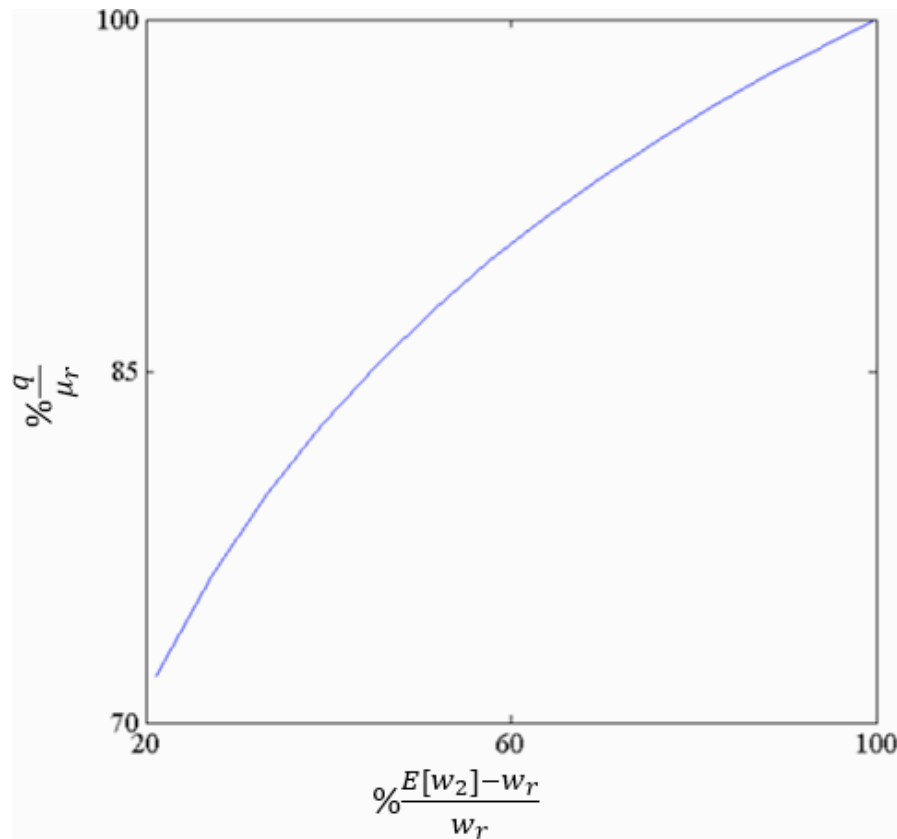
Supplier Profit and Order Quantity

$$E[\pi_s^j(\Delta)] = p_a \left\{ E[\tilde{w}_s] \Delta + E[w_2] \mu_s - E[w_2] \sigma_s \eta\left(\frac{M - \Delta - \mu_s}{\sigma_s}\right) + s \sigma_s \eta\left(-\frac{M - \Delta - \mu_s}{\sigma_s}\right) \right\} \\ + (1 - p_a) \left\{ E[w_2] \mu_s - E[w_2] \sigma_s \eta\left(\frac{M - \mu_s}{\sigma_s}\right) + s \sigma_s \eta\left(-\frac{M - \mu_s}{\sigma_s}\right) \right\} - c_j M$$

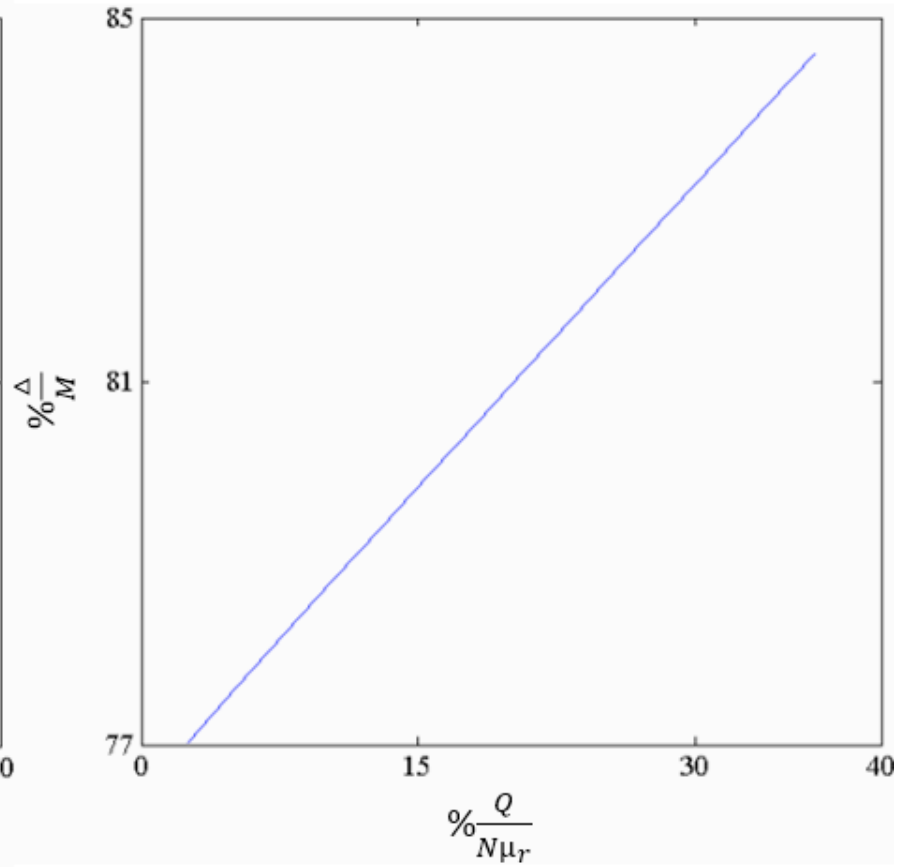
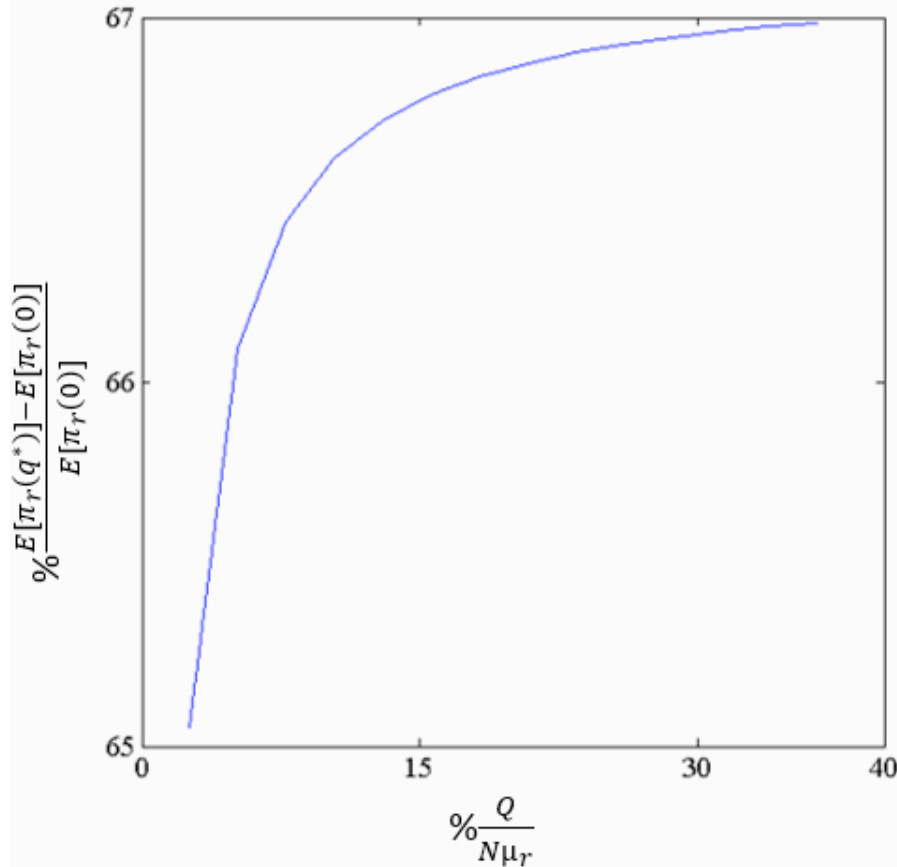
$$\Delta^* = M - \frac{1}{H} (N\mu_r - Q) - \frac{1}{H} (\sqrt{N}\sigma_r) z_\alpha, \quad \text{where } \alpha = \frac{E[w_2] - E[\tilde{w}_s]}{E[w_2] - s} \text{ and } s \leq E[\tilde{w}_s] \leq E[w_2].$$



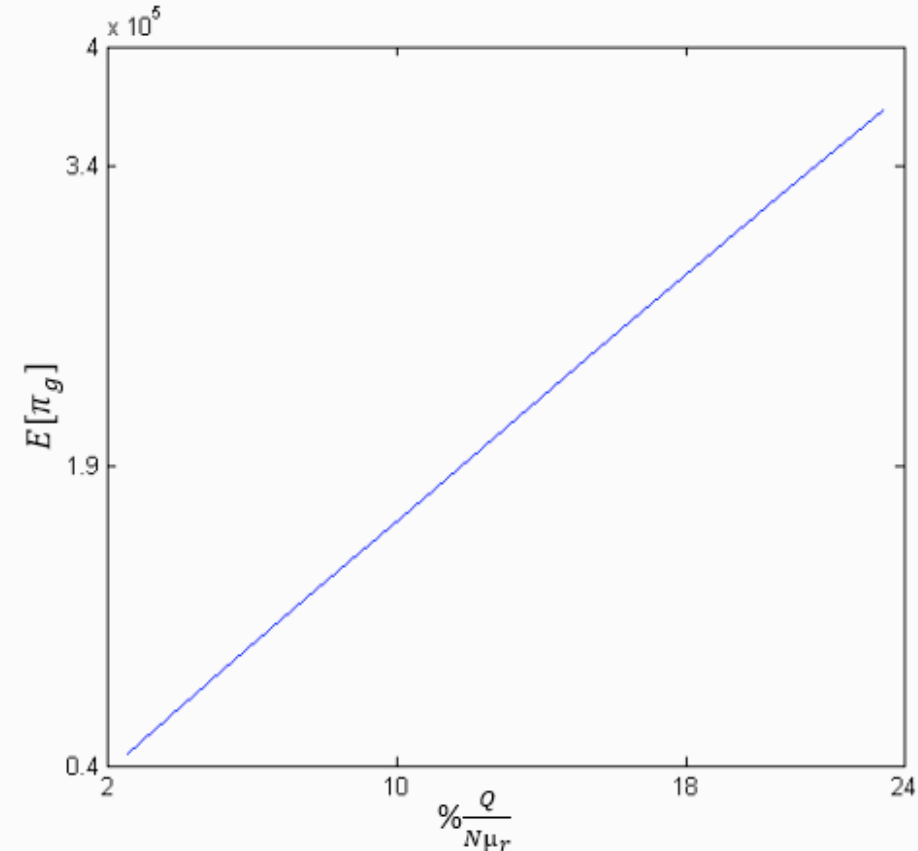
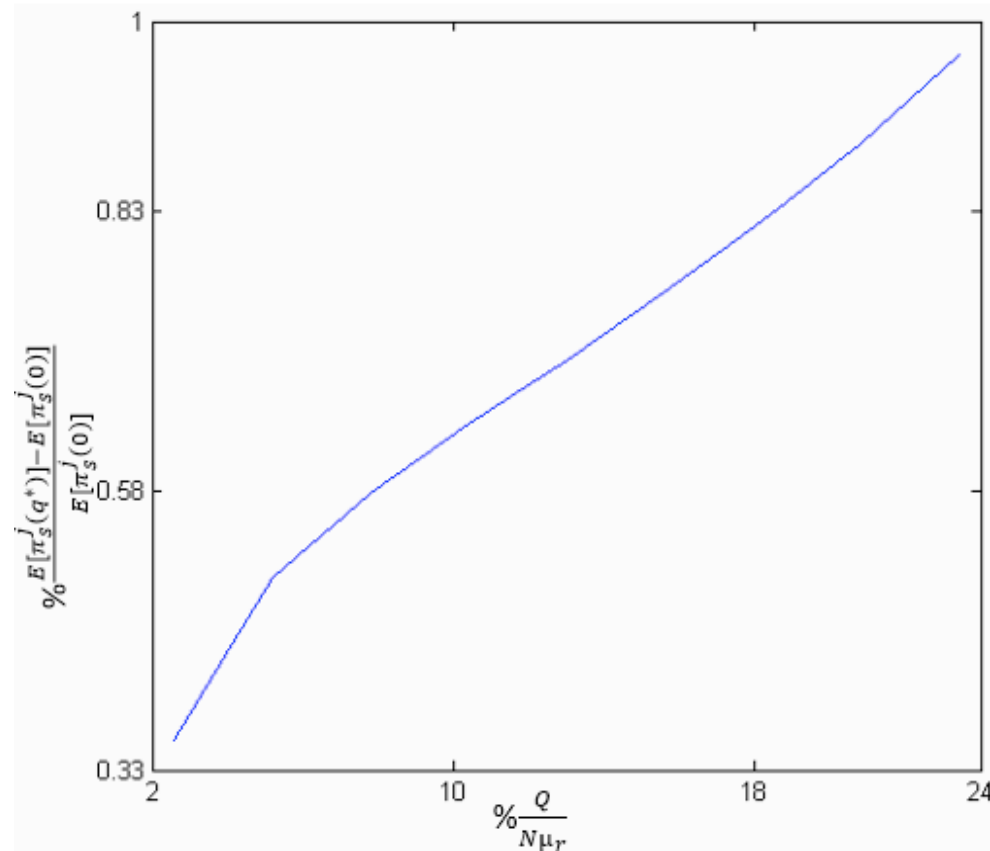
Effect of the **expected second period price** on the **retailer's quantity** purchased from the GPO and the **supplier's capacity** offered to the GPO



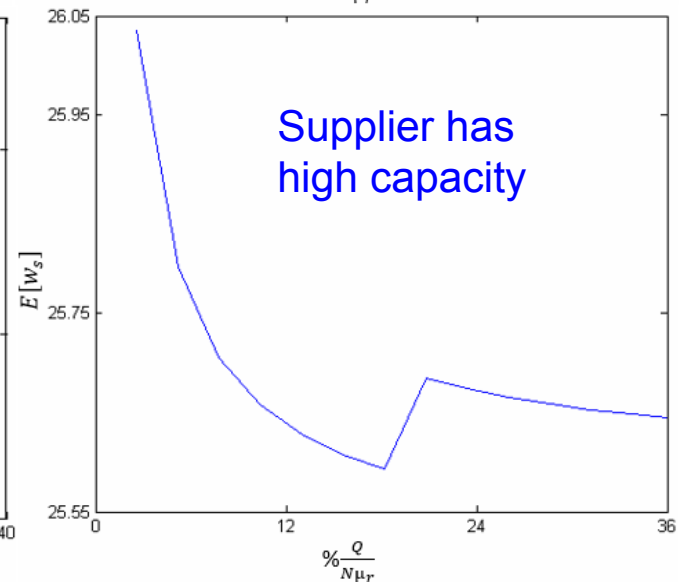
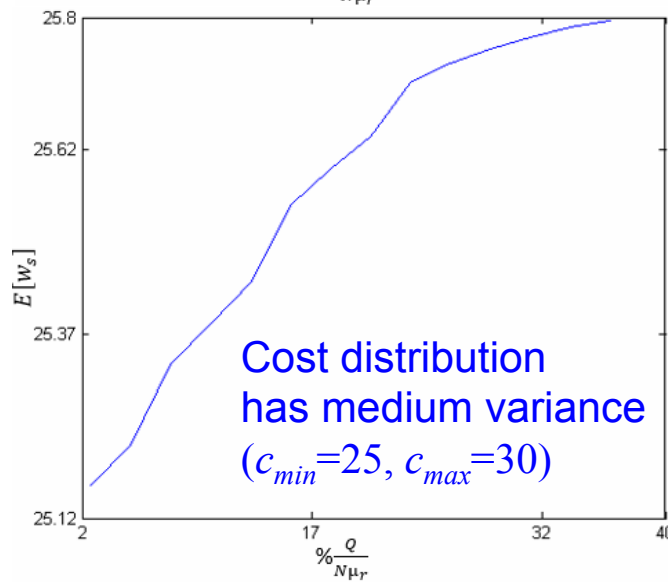
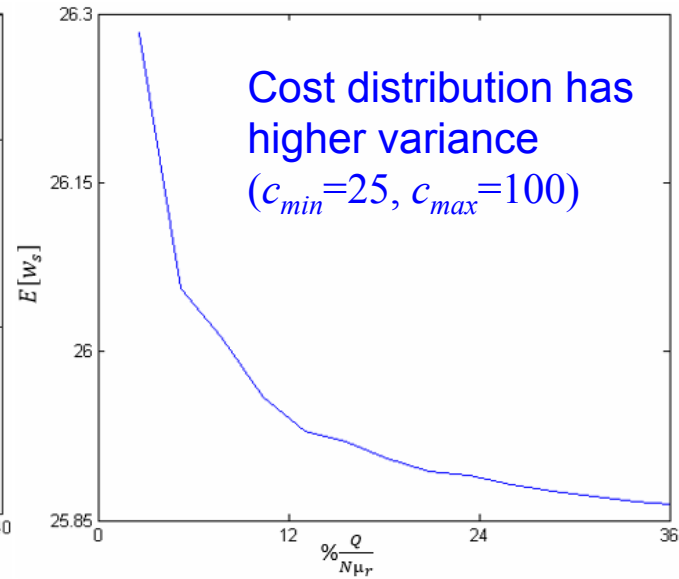
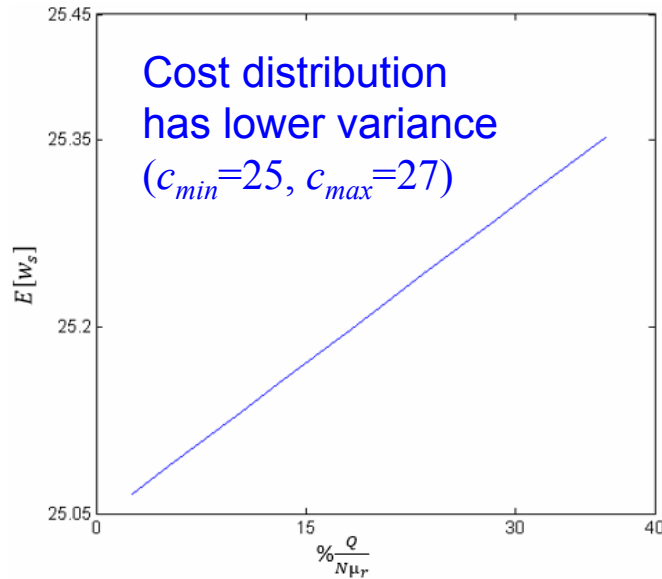
Effect of increasing **total demand** procured from the GPO on the **retailer's profit** and the **supplier's capacity** offered to the GPO



Effect of **increasing total demand** procured from the GPO on the **supplier's profit** (based on its estimate) and on the **GPO's profit**



Effect of increasing **total demand** procured from the GPO on the **Expected Auction Price**



Conclusions

Using Group Purchasing Organizations will be **beneficial** for suppliers and retailers under **the right conditions**

Suppliers can **mitigate price and demand uncertainty** by working with a GPO

Retailers can mitigate **price uncertainty** by working with a GPO

GPO can **make a profit** by setting the **discount scheme** in the right way



Ongoing Work

Analyzing the effects of GPOs on other suppliers and retailers

Using different structures and contracts for GPO

Considering a GPO representing retailers vs a GPO representing suppliers vs a GPO as an intermediary

Comparing GPO performance with these centralized solutions



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