Emergence of a Multiple-Sourcing Strategy in a Buyer-Supplier Network: Effects of different Quantity-Quality and Quantity-Price Trade-Offs

1) Problem definition and research question
2) Research gap and Method
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Presenter Resume

Education

- Alpen-Adria Universitaet Klagenfurt
  Geography and Regional Research, Bachelor and Master (2006 – 2010)
- Alpen-Adria Universitaet Klagenfurt
  Business Administration and Management, Bachelor and Master (2009 – 2014)
- University of North Carolina at Greensboro
  Business Administration, Entrepreneurship (2011)

Work experience

- Controller (Intern): DZ BANK AG, Hong Kong, SAR China (2012 – 2013)
- ERP Consultant: Skiline Media GmbH, Klagenfurt, Austria (2013 – 2014)
- Senior Lecturer: Alpen-Adria Universitaet, Klagenfurt, Austria (2015 – 2019)
- Consultant: m27 Fedas Management GmbH, Graz, Austria (2019)
- Controller: Leftshiftone Software GmbH, Graz, Austria (2019 – present)
- Senior Lecturer (ext.): Alpen-Adria Universitaet, Klagenfurt, Austria (2019 – present)

Research interest

- Management Systems, Controlling, Agent-based simulation

Problem definition and research question

- Diversified supplier portfolio as strategic decision for protection against possible failures and errors (Federgruen/Yang, 2009)
- Challenge/objective for companies: Allocation of the planned procurement volume in the required quality and price to the selected suppliers (Kawtummachai/Hop, 2005)
- Exemplary parameters in the literature: price, quality, on-time delivery (z.B. Xiang et al., 2012)

How do different procurement volumes affect the buyer's supplier structure when
(1) the suppliers are heterogeneous with respect to the quantity-quality and quantity-price trade-offs,
(2) the buyer pursues a multiple-sourcing strategy, and
(3) the buyer learns its own quality-price preferences based on its supplier environment?

Research Gap and Method

- Research gap:
  - Consideration of the quantity-quality and quantity-price trade-off in the allocation of procurement volumes
  - Analysis of the resulting effects on the supplier structure in a buyer-supplier model
  - Consequences of different allocation parameters for the supplier structure

- Agent-based simulation because of the following characteristics/advantages:
  - In particular: Illustration of heterogeneous agents
  - Reflects interactions between different individuals and their environment
  - Allows investigation of complex problems
  - Representation of processes/time: Change of supplier structure over time

  (Davis et al., 2007; Deckert/Klein, 2010)

Model overview (1)

Setting simulation input parameters

- Agents: **1** buyer, $\boldsymbol{m}$ suppliers
- Volume: procurement volume $\boldsymbol{X_t}$ ∀ t∈{1,…,T}
- Supplier: supplier volume $\boldsymbol{x_{i,t}}$ ∀ i∈{1,…,m}
  initial supplier volume $\boldsymbol{x^S_{i,t_1}}$
  initial quality $\boldsymbol{q^S_{i,t_1}}$
  initial price $\mathbf{p}^{\boldsymbol{S}}_{\boldsymbol{i,t_1}}$
  supplier experience curve effect $\boldsymbol{L_i}$
  market price $\boldsymbol{p^M}$
- Buyer: market price $\boldsymbol{p^M}$
  quality-price preference ($\boldsymbol{\alpha_t}$)
  variation in quality $\boldsymbol{\theta q^B_i} \sim \mathbb{N}\left(\mu_{\theta_{q_i^B}}, \sigma^2_{\theta_{q_i^B}}\right)$

Model overview (2)

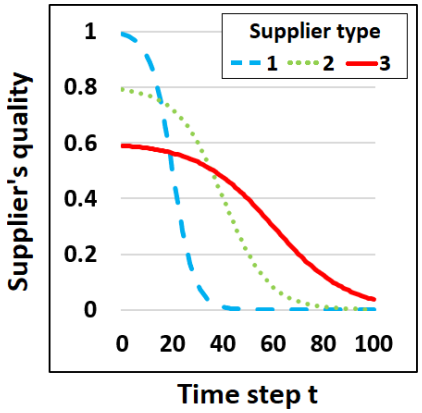
Setting simulation input parameters

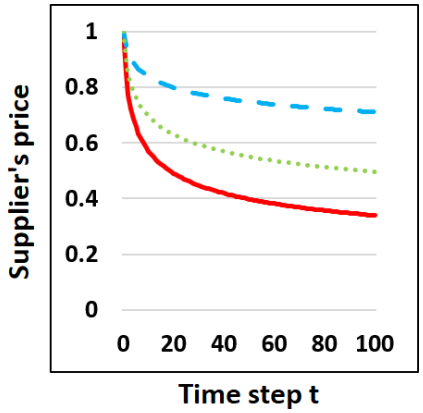
↓

Buyer requests quality and price for initial procurement volume

$$q_{i,t}^{S}(x_{i,t}^{S}) = H_i - \frac{H_i - G_i}{1 + C_i * e^{-k_i * x_{i,t}^{S}}}$$

$$p_{i,t}^{S}(x_{i,t}) = p^{M} * (x_{i,t}^{S} + 1)^{\frac{\log(1-L_i)}{\log(2)}}$$



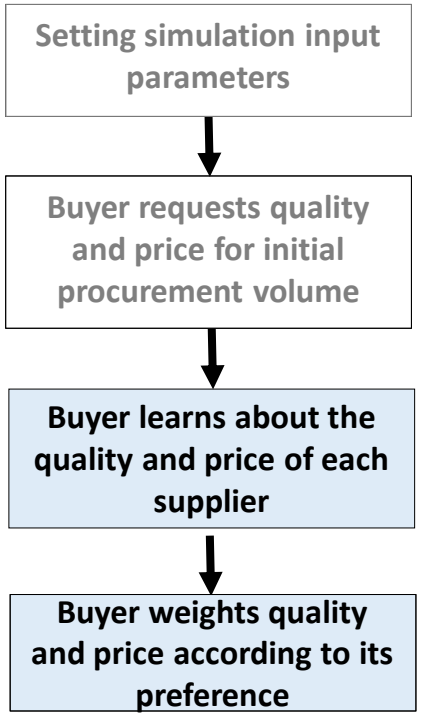


- Buyer allocates procurement volume equally to suppliers

$$x_{i,t_1}^{S} = \frac{X}{m} \qquad X = \sum_{i=1}^{m} x_{i,t}^{S} = 1$$

- Buyer requests each supplier to submit an offer for allocated initial procurement volume $\boldsymbol{x_{i,t_1}^{S}}$
- Each supplier is characterized by a quality and price curve
- Identification of quality and price curve is only carried out once – does not change for one simulation

Model overview (2)



- Buyer imperfectly observes the quality of the suppliers

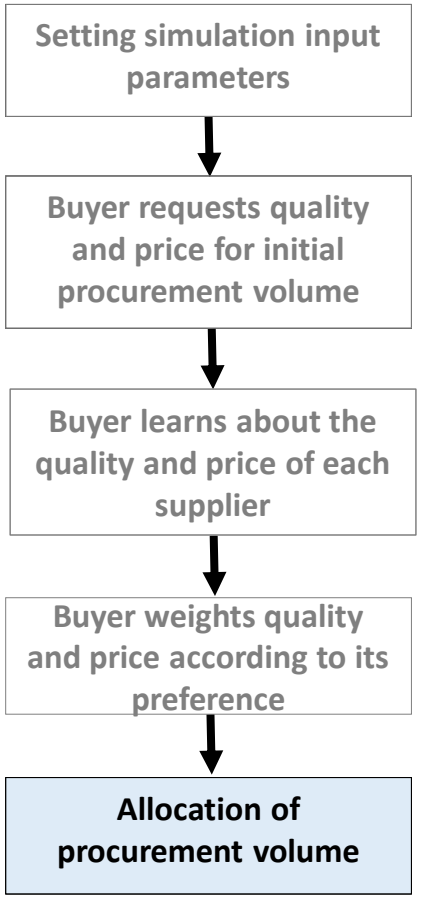
$$q^B_{i,t} = q^S_{i,t} + Q_{i,t}$$

- Buyer‘s quality-price preference

$$w_{i,t} = \alpha_t * q^B_{i,t} + (1 - \alpha_t) * \frac{p^M - p^S_{i,t}}{p^M}$$

- α_t is learned by the buyer using temporal difference learning

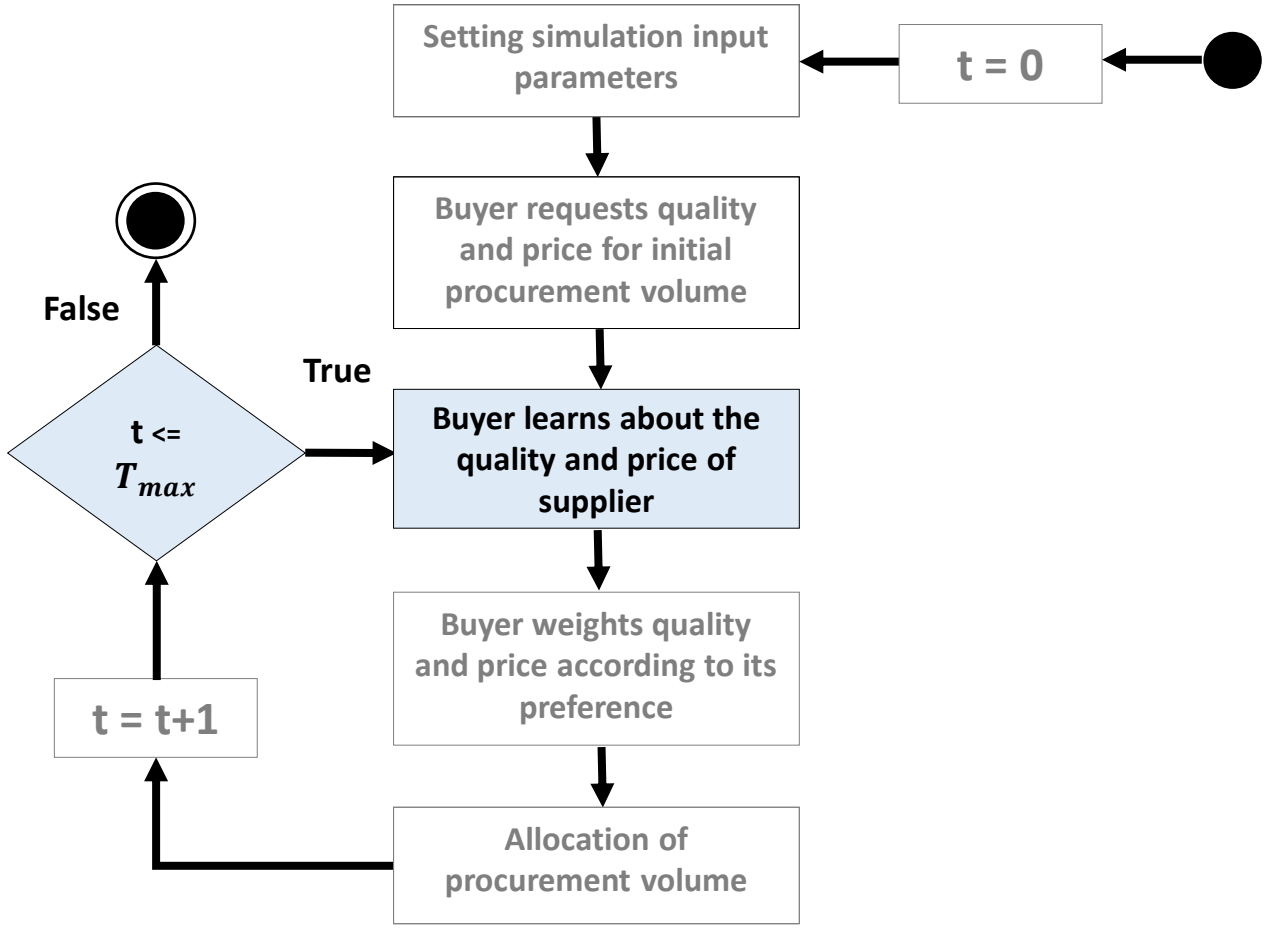
Model overview (2)



- Buyer weights observed quality and price according to its preference
- Buyer allocates procurement volume proportionally to all suppliers depending on their individual weights

$$x_{i,t+1}^{S} = \frac{w_{i,t}}{\sum_{i=1}^{m} w_{i,t}} X$$

Model overview (2)



Parametrization

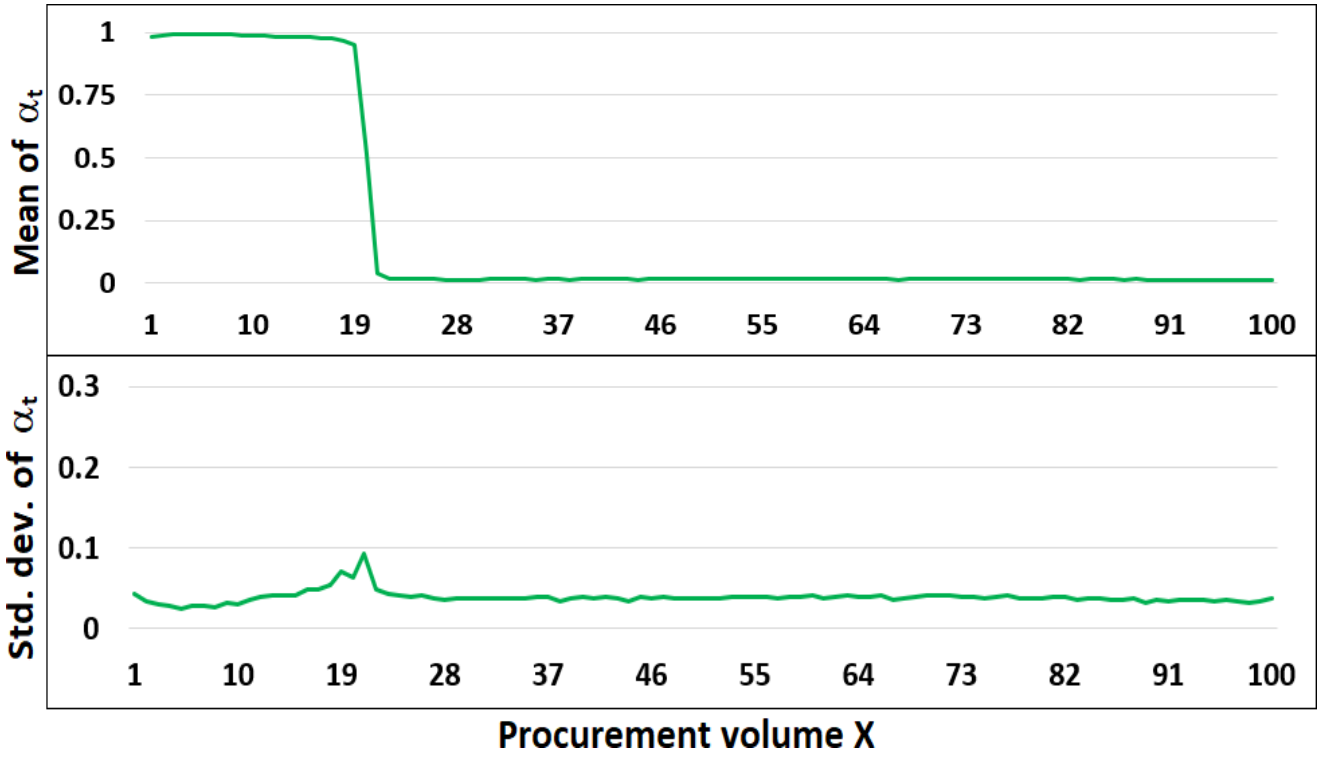
Exogenous parameters	Values/Types
Time steps to learn the parameter α_t	$T_L = 100$
Time steps to stabilize the allocation	$T_S = 10$
Time steps to evaluate the outcome	$T_E = 10$
Number of sim. runs	$N = 1000$
Number of suppliers	$m = 3$
Market price	$p^M = 1$
Retail price	$p^R = 1$

Supplier Type	Type 1	Type 2	Type 3
Supremum of $q_{i,t}^S$	$H_1 = 1.0$	$H_2 = 0.8$	$H_3 = 0.6$
Infimum of $q_{i,t}^S$	$G_1 = 0.0$	$G_2 = 0.0$	$G_3 = 0.0$
$q_{i,t}^S(x_{i,t}^S = 0)$ (in %)	$C_1 = 99$	$C_2 = 79$	$C_3 = 59$
Logistic growth rate	$k_1 = 0.23$	$k_2 = 0.109$	$k_3 = 0.068$
Inflection point	$x_1^{IP} = 20$	$x_2^{IP} = 40$	$x_3^{IP} = 59$
Relative price reduction	$L_1 = 0.05$	$L_2 = 0.10$	$L_3 = 0.15$

Action space	$A = \{0.0, 0.1, \dots, 1.0\}$
Discount factor	$\gamma = 0$
Procurement volume	$X \in \{1, 2, \dots, 100\}$
Buyer's precision of quality measurement	$\sigma \in \{0, 0.01, 0.02, \dots, 0.10\}$

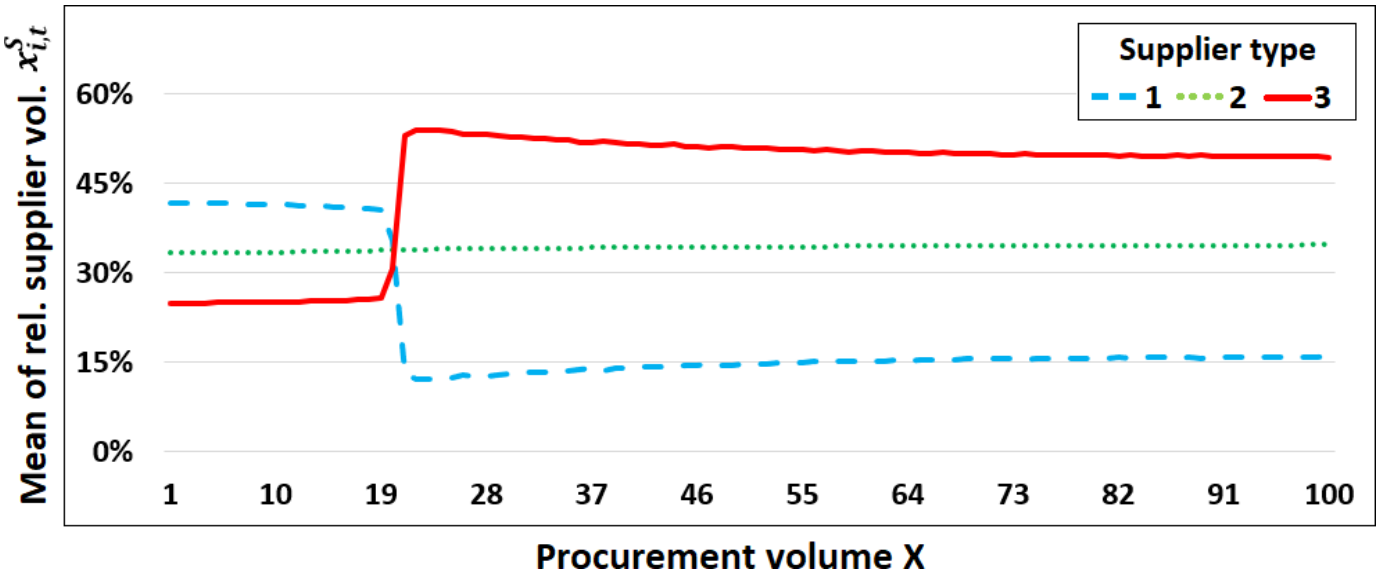
Results of our perfect scenario with $\sigma = 0$ (1)

- Buyer's quality-price preference



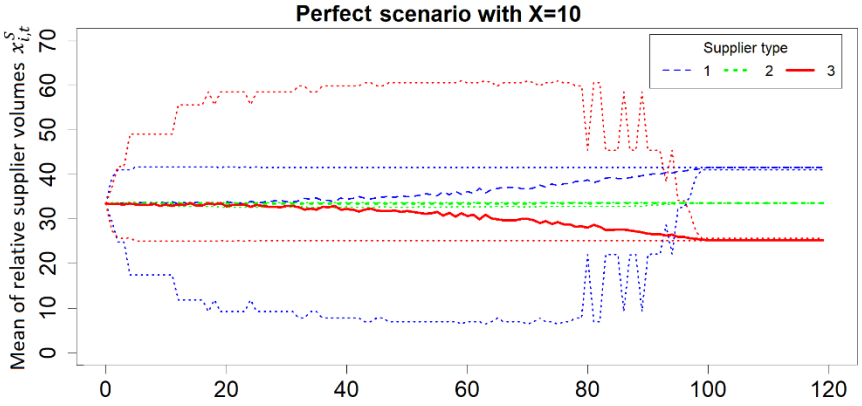
Results of our perfect scenario with $\sigma = 0$ (2)

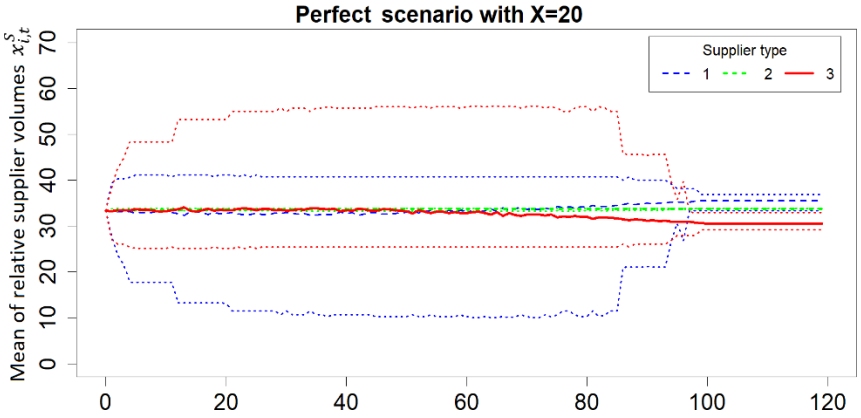
- Buyer's supplier structure

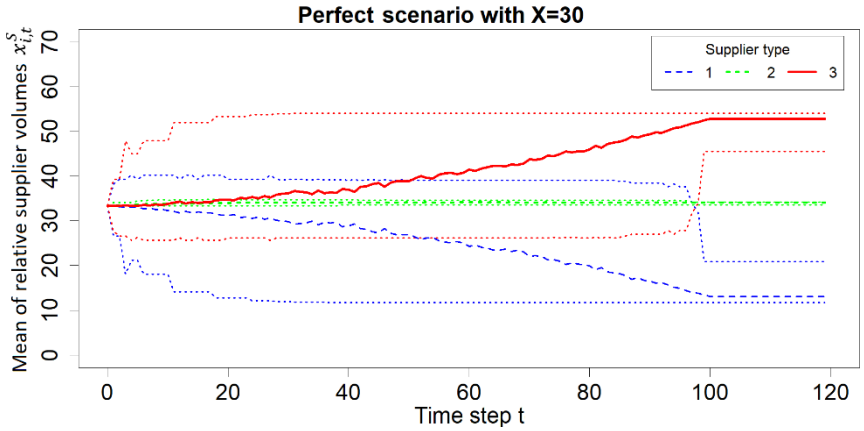


Results of our perfect scenario with $\sigma = 0$ (3)

- Simulation results over time

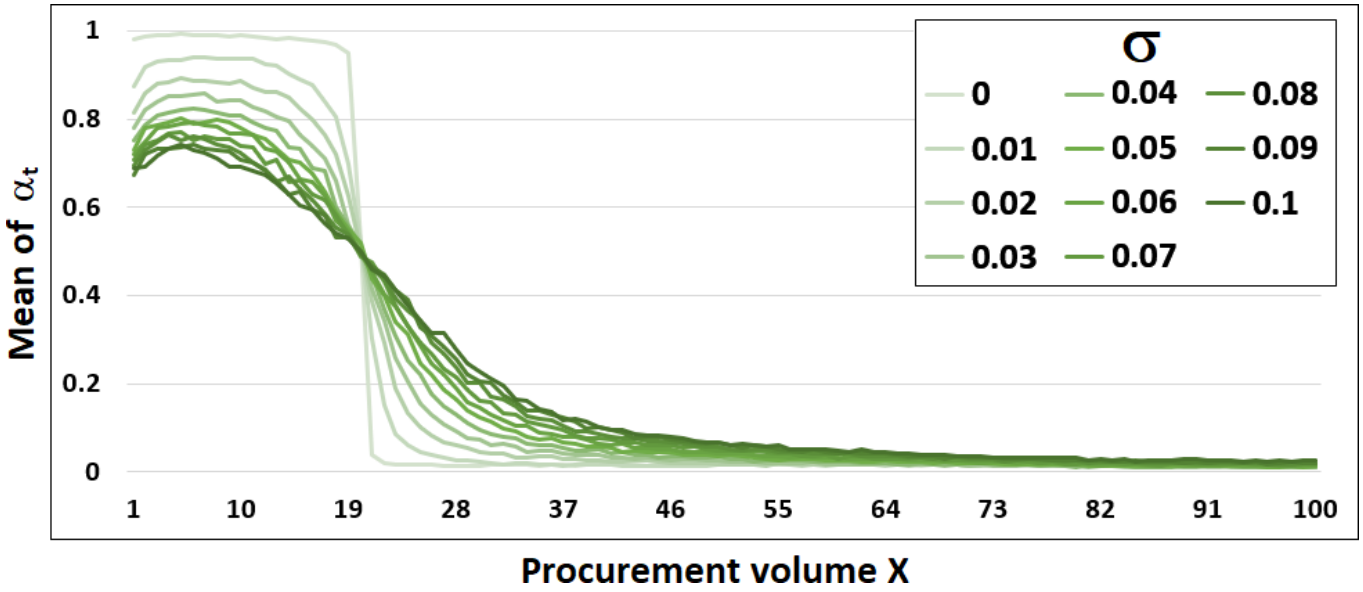






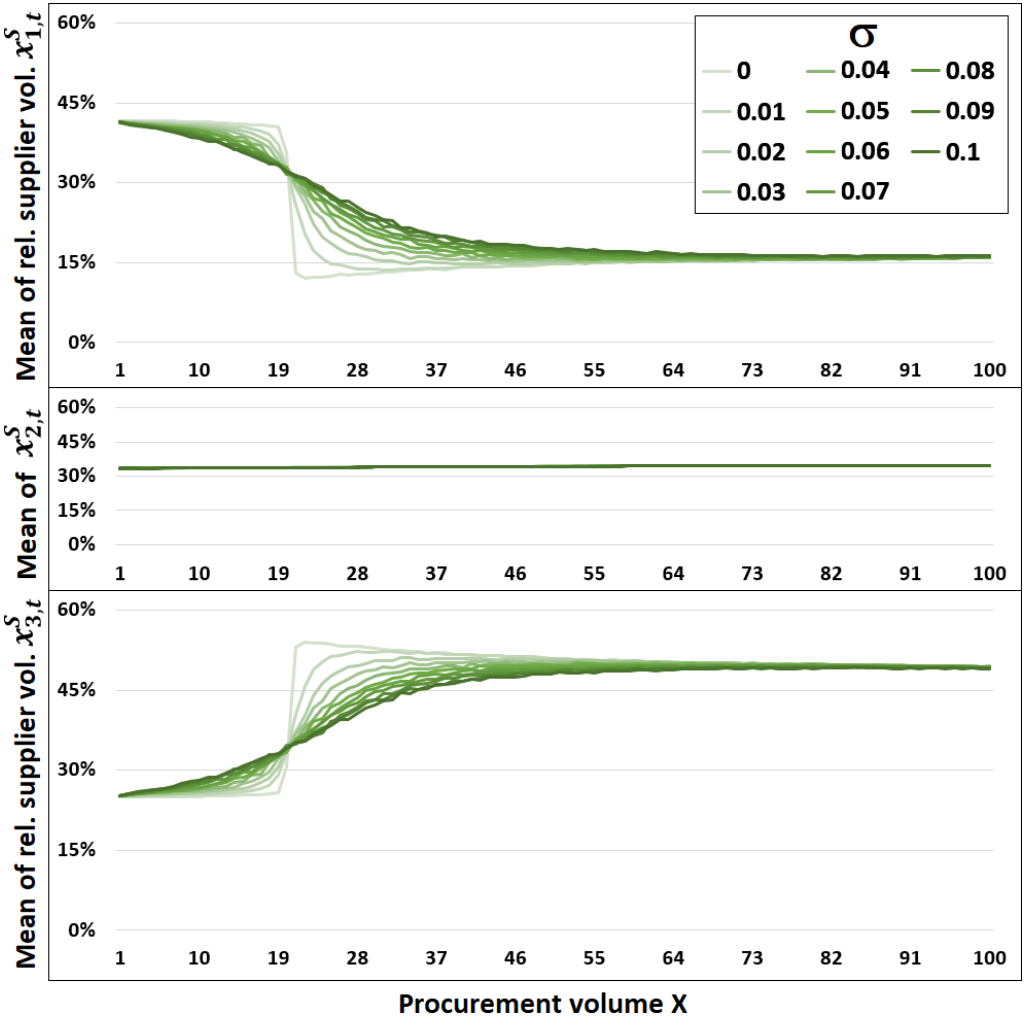
Results of our imperfect scenarios with $\sigma > 0$ (1)

- Buyer's quality-price preference



Results of our imperfect scenarios with $\sigma > 0$ (2)

- Buyer's supplier structure



Conclusion

- Findings:
  - For small (high) procurement volumes the buyer puts more emphasis on quality (price)
  - We identify a tipping point, at which the buyer puts equal emphasis on price and quality
  - With a poorer precision of the quality measurement system and a lower procurement volume the buyer orders less from high-quality suppliers
  - With a large procurement volume and a perfect quality measurement system the buyer separates the different suppliers much faster

- Limitations:
  - Limited number of suppliers and constant supplier parameters over time
  - Buyer only makes decisions based on the suppliers‘ quality and price
  - Suppliers do not interact/communicate between each other

Literature (presentation)

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