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Forecasts and Order Decisions: Reactions to Demand Variability

M. Sinan Gönül
Newcastle Business School
Northumbria University

Dilek Önkal
Newcastle Business School
Northumbria University

Ayşe Kocabıyıkoğlu
Sabanci Business School
Sabancı University

C. Itır Göğüş
Faculty of Business Administration
Bilkent University

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THE OUTLINE

- The newsvendor problem
- The literature
- Experimental design (conditions, participants)
- Results
- Discussion & concluding remarks

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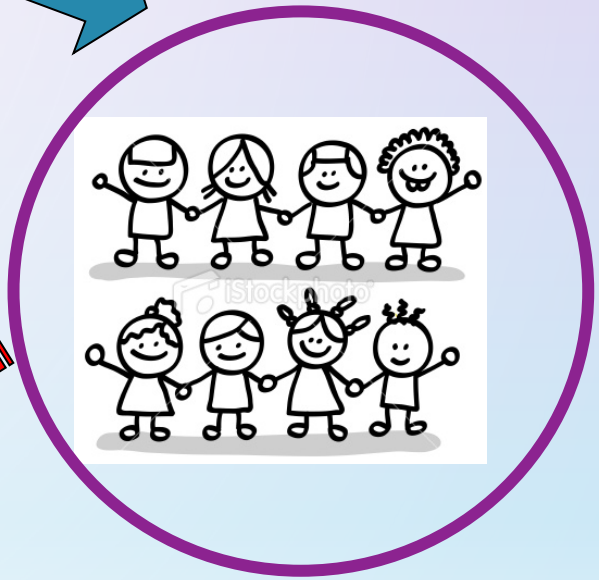
The Newsvendor Problem

*Buy from **c** /unit*

*Sell at **p** /unit*



Decision:

How many to "**order**"?

Unsold units are scrapped
Unmet demand is lost

Demand Forecasting

Uncertain Demand

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THE LITERATURE

REVIEWS ON NEWSVENDOR PROBLEM

- PORTEUS (2000), BENDOLY ET AL. (2006), GİNO & PISANO (2008), LOCH & WU (2008), BENDOLY ET AL. (2010)

BEHAVIOURAL NEWSVENDOR PROBLEM

- SCHWEITZER & CACHON (2000), BENZİON ET AL. (2008), BOLTON & KATOK (2008), BENZION ET AL. (2010), GAVIRNENI & ISEN (2010), BOLTON ET AL. (2012), LAU & BEARDEN (2012), FELIER ET AL. (2013), KREMER ET AL. (2013), MORITZ ET AL. (2013), REN & CROSON (2013), VERICOURT ET AL. (2013), LONG & NASIRY (2014), OCKENFELS AND SELTEN (2014), RUDI & DRAKE (2014), KOCABIYIKOĞLU ET AL. (2015), ONKAL ET AL. (2020)

Behavioural Findings

Behavioral newsvendor studies:

- Actual vs. normative decision making
  - Normative order quantity : $Pr(Demand \geq x^*)=c/p$
- Orders ***deviate*** from profit maximizing quantities
- **Pull-to-center** effect (Schweitzer & Cachon 2000)
  - the *tendency* of the decision makers to set their order decisions between **the mean demand** and the **normative order quantity**

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Behavioural Findings

Behavioral newsvendor studies:

- Explanations for the discrepancy include
  - psychological costs of underage and overage (Ho et al. 2010)
  - demand chasing (Bolton & Katok 2008)
  - random errors (Kremer et al. 2010)

- **Biased perceptions** of the **demand uncertainty** might be another important driver.
  - **Overprecision** (Ren & Croson 2013)
  - Decision makers may be *overprecise* so that they *perceive* the demand variability to be **lower** than its true value

Behavioural Findings

Behavioral newsvendor studies:

- **Overprecision** (Ren & Croson 2013)
  - $D_p = \beta D + (1 - \beta)E(D)$

  - D_p is the perceived demand
  - D is the actual demand
  - $E(D)$ is the mean of the actual demand

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Behavioural Findings

Behavioral newsvendor studies:

- **Overprecision** (Ren & Croson 2013)
  - $D_p = \beta D + (1 - \beta)E(D)$
  - $(1 - \beta)$ is the overprecision parameter
    - If $(1 - \beta) = 0$, decision makers are **perfectly unbiased**
    - If $(1 - \beta) > 0$, decision makers are **overprecise,** they *perceive* demand to be **less variable (more stable)** than it *actually* is.

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Behavioural Findings

If the decision maker's perception of uncertain demand is *different* from its true form

Erroneous judgmental demand forecasts

Skewed order decisions which *deviate* from normative quantities

- Understanding how decision makers *react to* demand uncertainty has important ramifications for
  - demand forecasting
  - resultant order decisions

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Research Questions

- How will decision makers' *order decisions* react to changes in demand variability?
- Will *pull-to-centre* effect persist?
- Will the decision makers demonstrate *overprecision*?

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EXPERIMENTAL DESIGN

- price = 120
- cost = 30 (*high profit margin setting*)
- cost = 90 (*low profit margin setting*)
- demand distribution: D ~ Uniform

(Schweitzer and Cachon 2000)

- pilot round + 40 experimental rounds (4 levels of demand conditions - each treatment lasted 10 rounds)
- Study not time restricted
- Information message displayed on the screen when the cost/demand parameter changed

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EXPERIMENTAL DESIGN

Between-subject

- **High profit margin setting** (p = 120, c = 30)
  number of participants = 26
- **Low profit margin setting** (p = 120, c = 90)
  number of participants = 29

Within-subject

Demand condition	Demand Mean	Demand Variance
Uniform(30,50)	40	33.33
Uniform(20,60)	40	133.33
Uniform(10,70)	40	300.00
Uniform(0,80)	40	533.33

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EXPERIMENTAL DESIGN

Sample screenshot from high-margin condition (**before** order decision)

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EXPERIMENTAL DESIGN

Sample screenshot from high-margin condition (**after** order decision)

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RESULTS

Demand condition	High-margin setting		Low-margin setting	
	Average order decision	Normative decision	Average order decision	Normative decision
Uniform(30,50)	39.40	45	38.11	35
Uniform(20,60)	40.13	50	35.85	30
Uniform(10,70)	40.94	55	35.83	25
Uniform(0,80)	41.41	60	33.42	20

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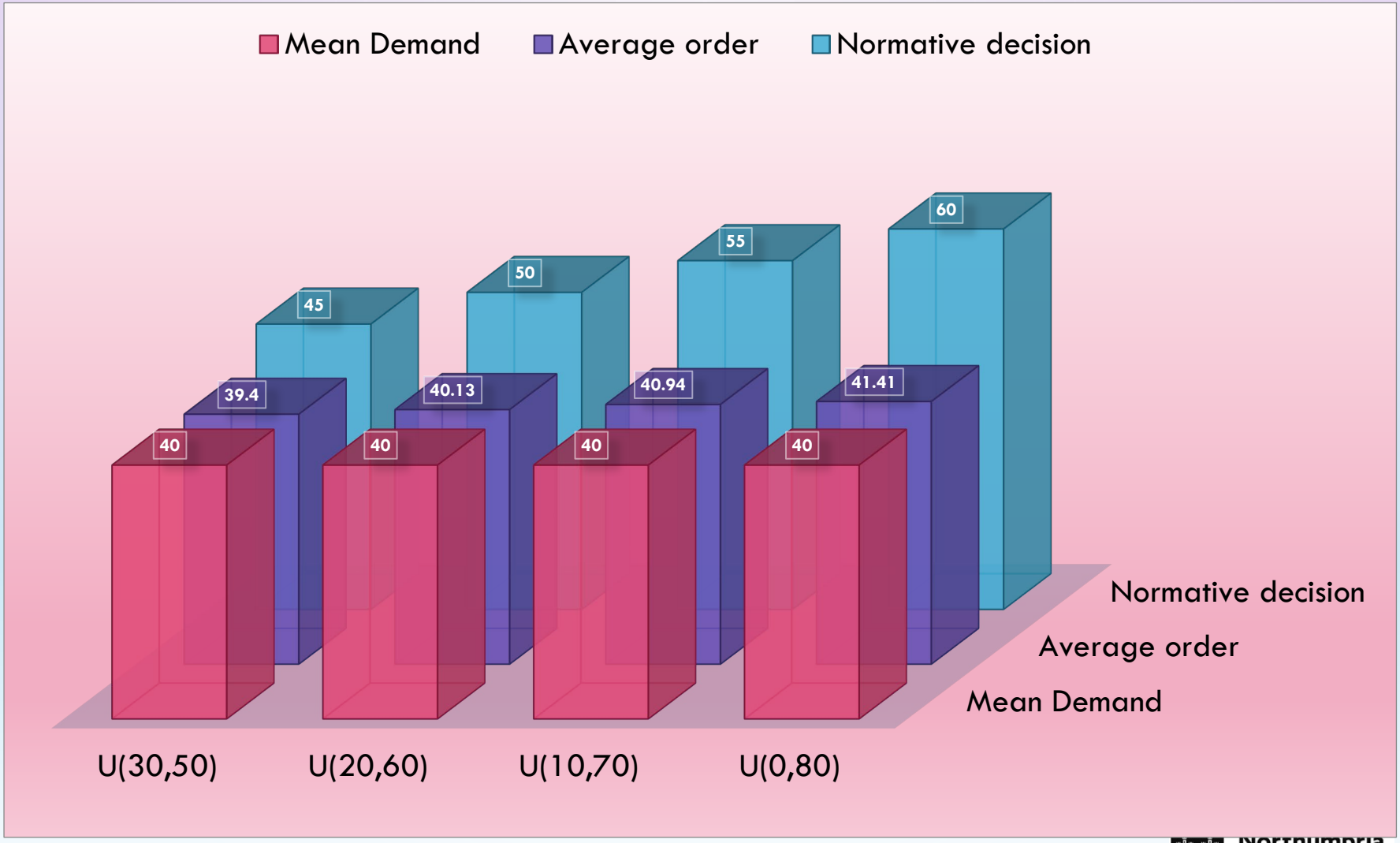
RESULTS : HIGH-MARGIN



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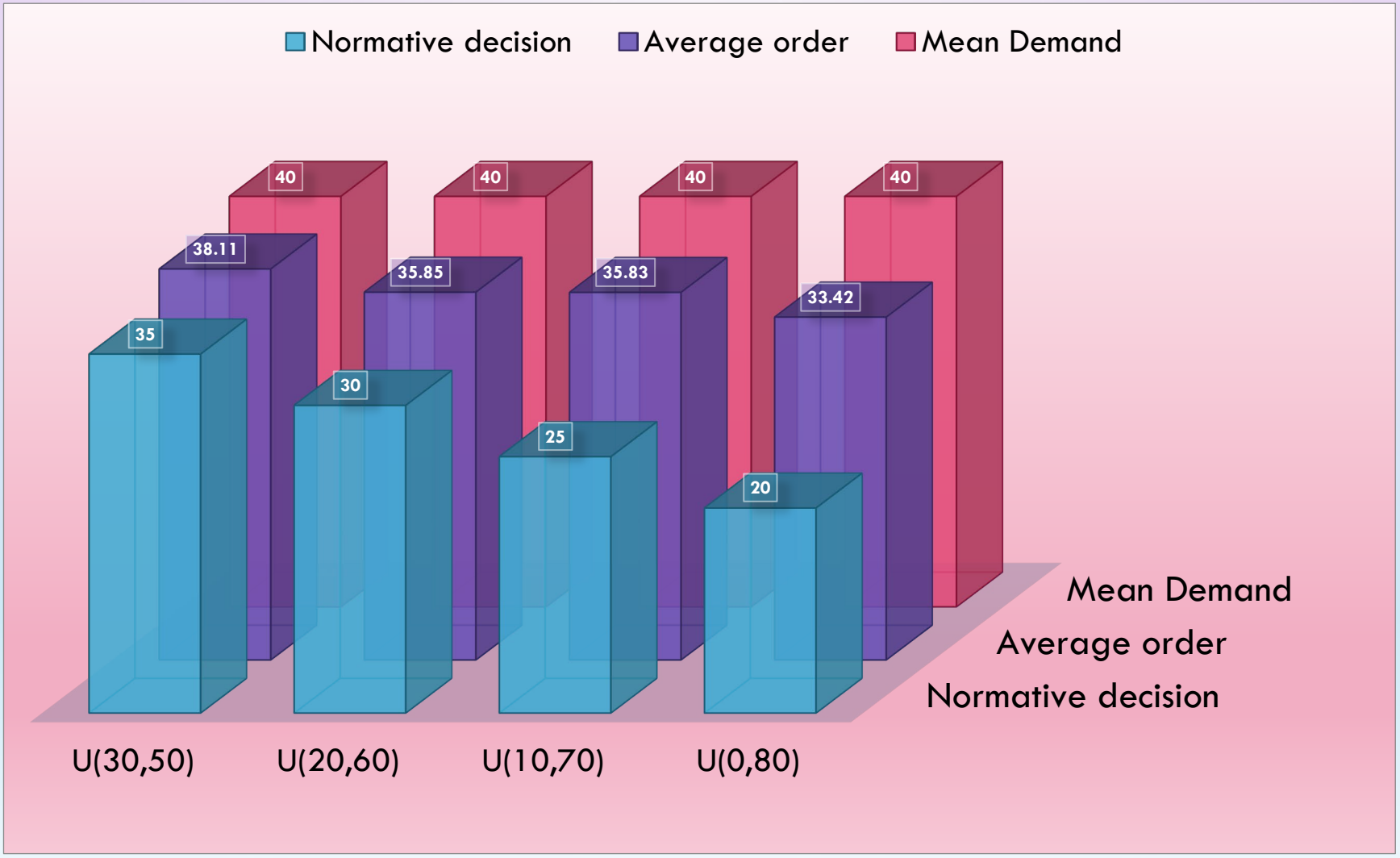
RESULTS : LOW-MARGIN



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RESULTS : OVERPRECISION

- The overprecision parameters $(1 - \beta)$ were uniformly **positive**.
- The participants *perceived* demand to be **less variable (more stable)** than it *actually* is

Demand condition	Overprecision Parameters $(1 - \beta)$	
	High-margin setting	Low-margin setting
Uniform(30,50)	1.12	0.62
Uniform(20,60)	0.99	0.59
Uniform(10,70)	0.94	0.72
Uniform(0,80)	0.93	0.67

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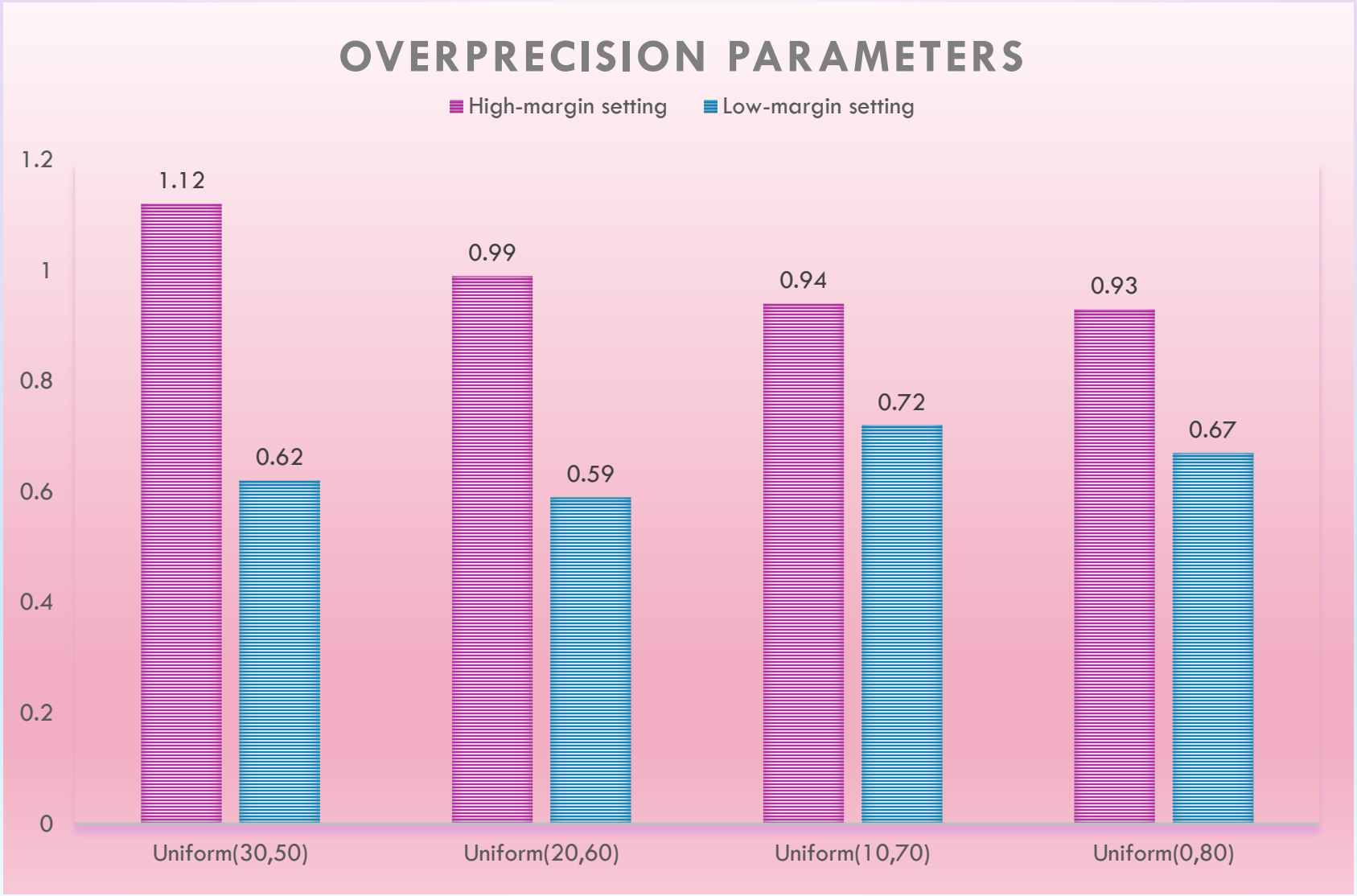
RESULTS : OVERPRECISION



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Discussion & Concluding Remarks

- A **behavioural** study of newsvendor decision making under different demand patterns
- The **actual** *order decisions* **differ** profoundly from *normative* profit maximizing quantities
  - *Pull-to-centre effect* persists almost irrevocably
- Decision makers' *order decisions* react to changes in **demand variability**

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Discussion & Concluding Remarks

- Their average orders are ***further away*** from the *normative order quantities* as variability increases

- Decision makers seem to perceive demand to be ***less variable*** than it actually is for both *high-margin* and *low-margin* settings

- These findings are in line with Ren and Croson (2013) that decision makers are **overprecise** in perceiving demand uncertainty

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Future Research

- We need to better understand the process that starts with *perceiving the demand* and ends up with the order decision. Specifically,
  - How do demand perceptions affect the forecasts?
  - How do demand forecasts influence the order decisions?

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