Project 11: Human decision making in production planning systems: How do superior information and systematic bias impact the performance?

Maryam Azani, Lijia Tan, Rob Basten, Ton de Kok

AI Planner of the Future

EAISI EINDHOVEN AI SYSTEMS INSTITUTE

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LCB

ESCF European Supply Chain Forum

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Introduction – General Idea of Research Project

Information Overload

Manual Work

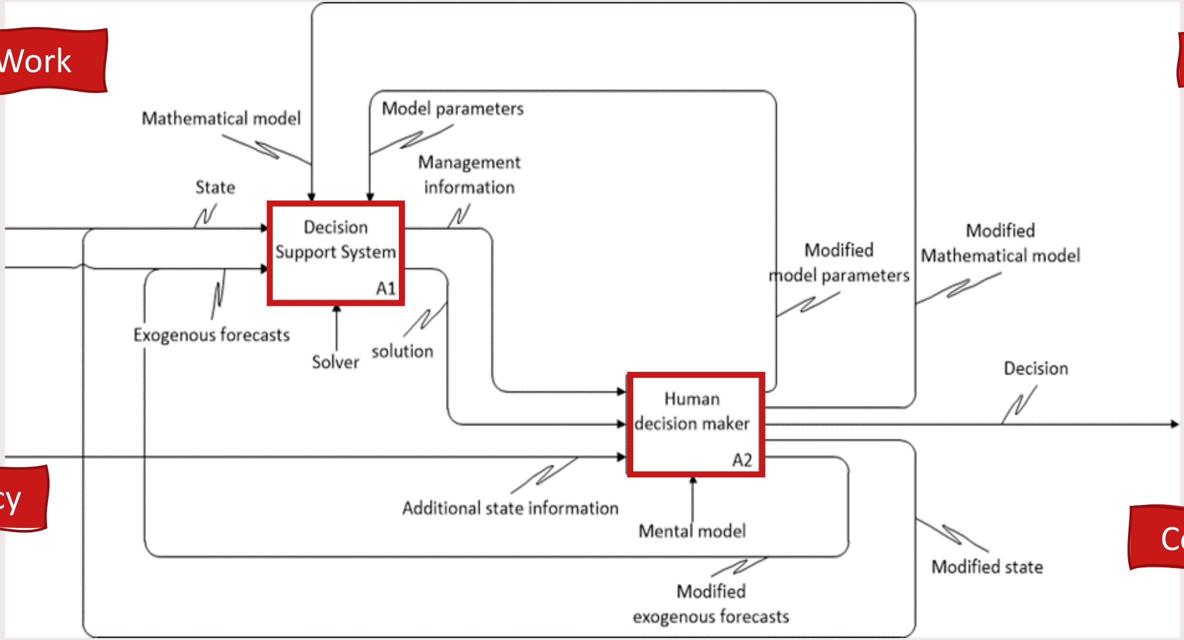
Black Box Algorithms

Uncertainty

Feasibility

System Deficiency

Cognitive Bias



Introduction – Sequence of Studies

Study 1: Human-System Interaction in Uncertain Production Planning Environment (Literature Review)

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Study 2: Behavioural Investigation of Feasibility and Demand Uncertainty in Production Planning Systems (Lab Experiment)

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Study 3: A Behavioural Investigation of Feasibility and Demand Uncertainty in Production Planning Systems (Lab Experiment)

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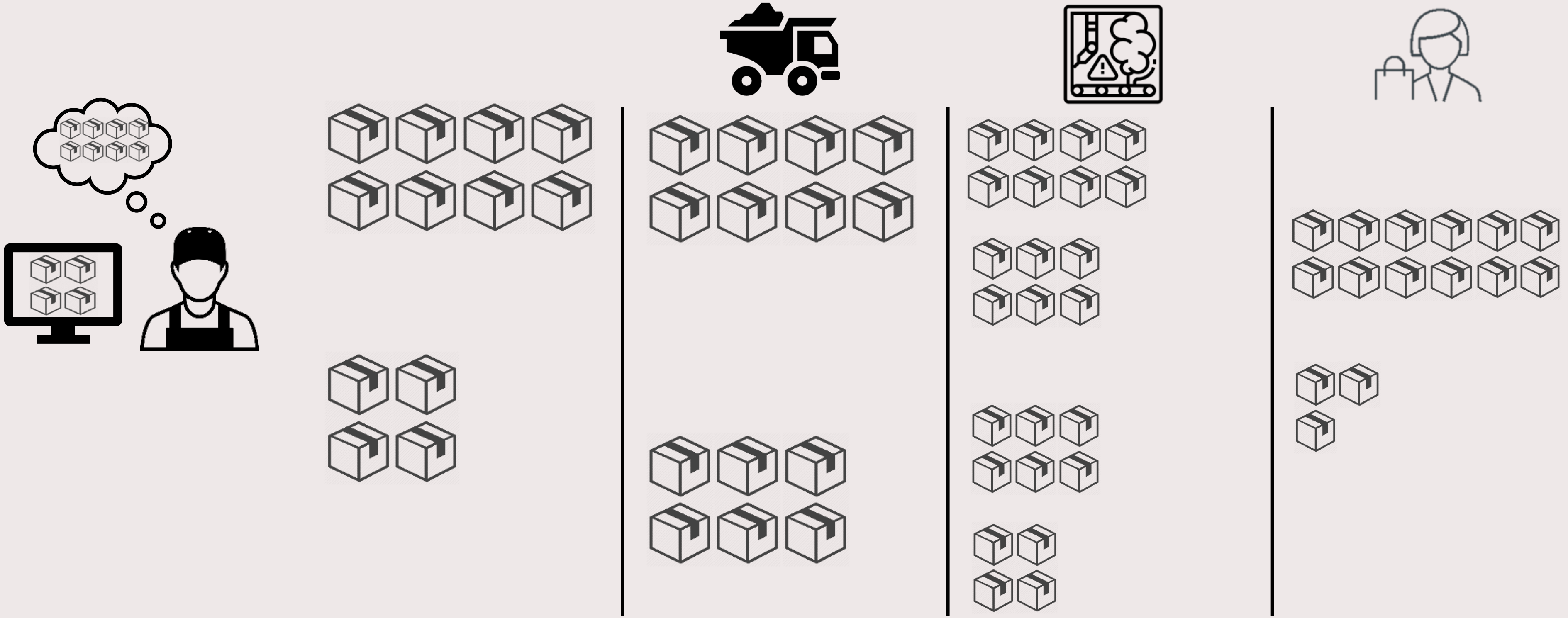
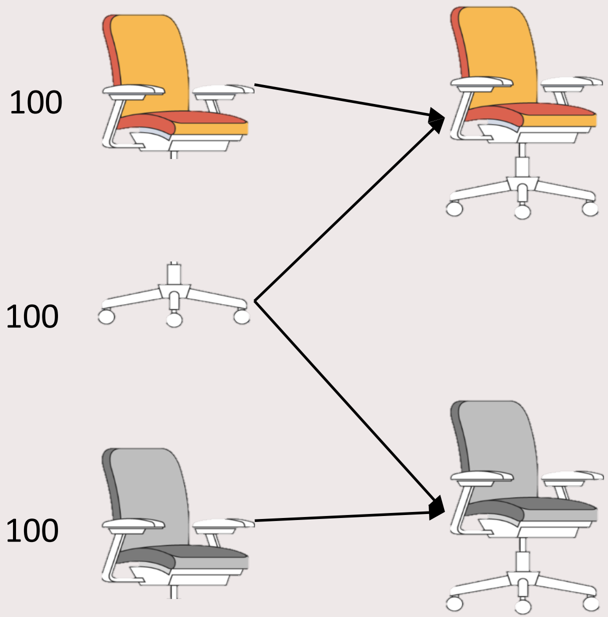
Study 4: Proposing a High Performance Behaviourally Compatible System Model (Agent Based Simulation; Artificial Intelligence)

Motivation – Uncertainty in Production Planning



Motivation - Production Planning Systems (1/2)



Time	*1*	*2*
Demand Forecast	90	100
Scheduled Receipt	0	0
Net Inventory	0	0
Safety Stock	10	10

Time	*1*	*2*
Demand Forecast	101	100
Scheduled Receipt	0	0
Net Inventory	0	0
Safety Stock	10	10

Motivation - Production Planning Systems (2/2)

System (red)

Time	1	2
Demand Forecast	90	100
Scheduled Receipt	0	0
Safety Stock	10	10
Planned Order Release Suggestion	***200***	100

Time	1	2
Demand Forecast	101	100
Scheduled Receipt	0	0
Safety Stock	10	10
Planned Order Release Suggestion	***211***	100

System (orange)

Time	1	2
Demand Forecast	90	100
Scheduled Receipt	0	0
Safety Stock	10	10
Planned Order Release Suggestion	***0***	100

Time	1	2
Demand Forecast	101	100
Scheduled Receipt	0	0
Safety Stock	10	10
Planned Order Release Suggestion	***100***	100

System (green)

Time	1	2
Demand Forecast	90	100
Scheduled Receipt	0	0
Safety Stock	10	10
Planned Order Release Suggestion	***10***	100

Time	1	2
Demand Forecast	101	100
Scheduled Receipt	0	0
Safety Stock	10	10
Planned Order Release Suggestion	***90***	100

Motivation- Prior Knowledge on Production Planning Systems

MPR-

Planners neglect information provided by Material Requirements Planning (MRP) systems, which are widely adopted in practice but often modified over time as users learn more about the system (Fransoo & Wiers, 2008)

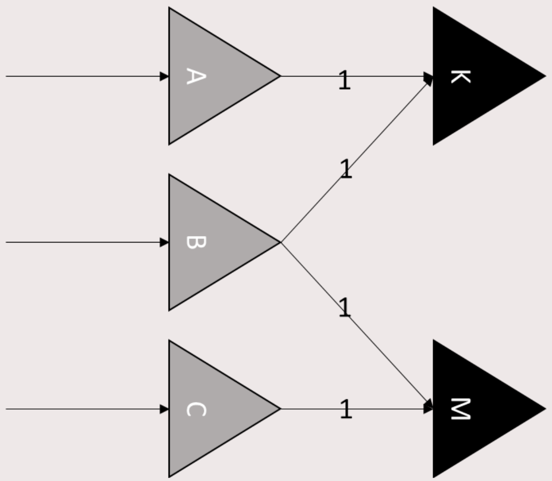
APS -

Advanced planning and scheduling systems are designed to help organizations optimize their operations and improve efficiency; however, they are usually resisted by humans (Wiers & de Kok 2017)

Research Question

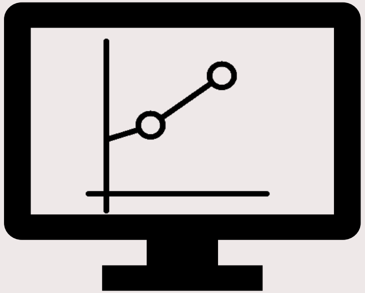
How do the feasibility and uncertainty of production planning systems influence human planners' decisions?

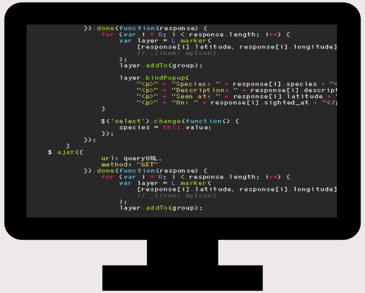
Research Design- General Idea



- ✓ Two stage, multi-period, multi-item decision
- ✓ Rolling schedule
- ✓ W-model structure (2 final products, 3 components)
- ✓ Lead time for material delivery and assembly identical and equal to 1
- ✓ Uniformly distributed demand
- ✓ Performance evaluation based on inventory and penalty costs

Research Design- Treatment Variation





- ✓ Graphical User Interface
- ✓ Information & Content
- ✓ Algorithm & Logic

MRP logic

System

Time	1	2
Demand Forecast	90	100
Scheduled Receipt	0	0
Safety Stock	10	10
Planned Order Release Suggestion	***200***	100

Time	1	2
Demand Forecast	101	100
Scheduled Receipt	0	0
Safety Stock	10	10
Planned Order Release Suggestion	***211***	100

LP logic

System

Time	1	2
Demand Forecast	90	100
Scheduled Receipt	0	0
Safety Stock	10	10
Planned Order Release Suggestion	***0***	100

Time	1	2
Demand Forecast	101	100
Scheduled Receipt	0	0
Safety Stock	10	10
Planned Order Release Suggestion	***100***	100

SBS logic

System

Time	1	2
Demand Forecast	90	100
Scheduled Receipt	0	0
Safety Stock	10	10
Planned Order Release Suggestion	***10***	100

Time	1	2
Demand Forecast	101	100
Scheduled Receipt	0	0
Safety Stock	10	10
Planned Order Release Suggestion	***90***	100

Research Design- Conjecture on Planner's Performance Under Systems

MRP logic system < **LP logic** system

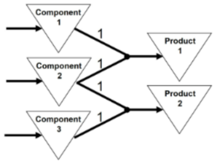
LP logic system < **SBS logic system**

Research Design- Production Planning Game Interface

Instruction

Welcome to the production planning game, an exciting experiment that will take approximately 1 hour of your time. In this game, you will assume the role of a planner and make critical decisions for production planning. Your factory specializes in assembling widgets, and your objective is to fulfill market demands to the best of your ability. You will have 2 opportunities to play this game, and each game consists of 14 rounds. Your goal is to meet customer demand as accurately as possible by efficiently replenishing and assembling components. You will be working with two products and three components, each with specific requirements:

I. Product 1 requires 1 unit of component 1 and 1 unit of component 2.
II. Product 2 requires 1 unit of component 2 and 1 unit of component 3.



To meet customer demand in a given round (e.g., round 3), you must order the necessary components in round 1 and make assembly decisions in round 2.

1. Decisions:

Component Ordering: Each round you can replenish components. The components you replenish in each round, will arrive at your warehouse the next round.
Assembly: Once your components arrive in the warehouse, you can assemble them into the final product. There is a lead time of 1 round for assembly. Your replenishment decision will be based on demand forecasts, and you will receive updated forecasts for your assembly decisions. However, please be aware that actual demand may differ from the updated forecast within the range of $\varepsilon \sim U[-5,5]$. After the game, we kindly request you to complete a brief survey regarding your gender, education level, and other relevant information. Thank you for your participation, and we hope you thoroughly enjoy this engaging game.

2. Decision Support:

During the game, a system will provide you with suggestions on order quantities to assist your decisions. Please feel free to use them in your own way.

3. Payoff:

Each round, you will receive a payoff based on your performance. The payoff is calculated as follows:
Product 1: For each unit of demand you do not fulfill, you will receive a penalty cost of 30 points. For each unit of product 1 you have in stock, you will receive a holding cost of 6 points.
Product 2: For each unit of demand you do not fulfill, you will receive a penalty cost of 40 points. For each unit of product 2 you have in stock, you will receive a holding cost of 8 points.
Components: For each unit of component you have in stock, you will receive a penalty of 2 points.
Your total payoff will be the sum of the payoffs for product 1, product 2, and components in all rounds.

Next

Round 1

You will act as a widget retailer. Your goal over 14 rounds is to minimize costs by strategically ordering the right quantity of widgets. Your final payoff will be calculated based on the cumulative costs associated with both the products and components, as per the following formulae:

- **Excess Order:** If you order more than the demand, the additional cost will be the holding cost multiplied by the surplus quantity (order quantity - demand quantity).
- **Insufficient Order:** If you order less than the demand, the extra cost will be the backlog cost multiplied by the shortage quantity (demand quantity - order quantity).

Please note: Backlog costs are only associated with products, whereas holding costs can apply to both products and components.

Product 1			
Time	1	2	3
Demand Forecast	0	0	100
Scheduled Receipt	0	-	-
Net Stock	0	10	10
Suggested Order Receipt	10	10	100
Suggested Order	10	100	100
Your Order	0		

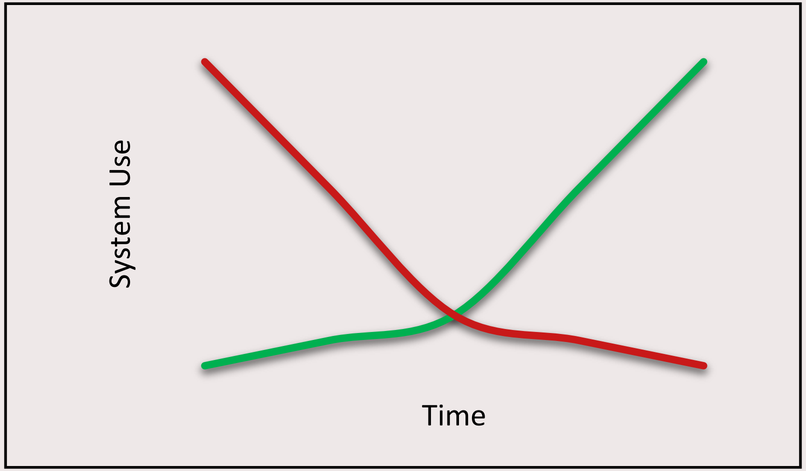
Product 2			
Time	1	2	3
Demand Forecast	0	0	100
Scheduled Receipt	0	-	-
Net Stock	0	10	10
Suggested Order Receipt	10	10	100
Suggested Order	10	100	100
Your Order	0		

Learning from Other Domains- Behavioral Perspective of Human Planners (1/2)

- Technology acceptance model suggests that the two main factors that determine users' acceptance of a technology are **perceived usefulness** and **perceived ease of use**.

- Perceived ease of use can have a stronger influence on users' initial adoption of a technology. The dominance of perceived ease of use in the beginning can help users overcome any initial fears or barriers to adoption.

- Perceived usefulness becomes more important over time when users learn more about system capabilities and deficiencies.

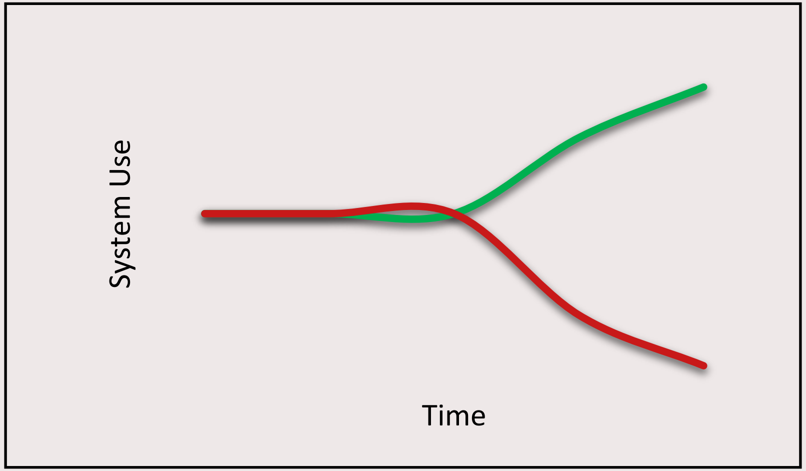


Learning from Other Domains- Behavioral Perspective of Human Planners (2/2)

- **Algorithm aversion** suggests that people have a tendency to avoid using algorithms, even when they are shown to be more accurate than human judgment.

- This aversion arises because people lose trust in algorithms more quickly than in human decision-making when they observe algorithms making mistakes.

- After understanding system deficiencies, **habit** might underlie utilising the technology’s limited functionalities, resulting in extensive manual work.



Thank you for your attention!

Maryam Azani
PhD student at Technical University of Eindhoven
m.azani@tue.nl
Maryam Azani | LinkedIn

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