Prosche Motors*

Prosche Motors is a European company that designs, manufactures and sells electric cars. You have just been appointed as the new COO and are in charge of handling some delicate issues around the production and shipment of a new model nicknamed Tycoon, a highly customizable electric roadster aimed to compete with the company's rivals in the North-American market. In this mini-case, we will focus on the company's operations during the first quarter of next year. **Figure 1** below depicts a brief schematic of the supply chain for the Tycoon.

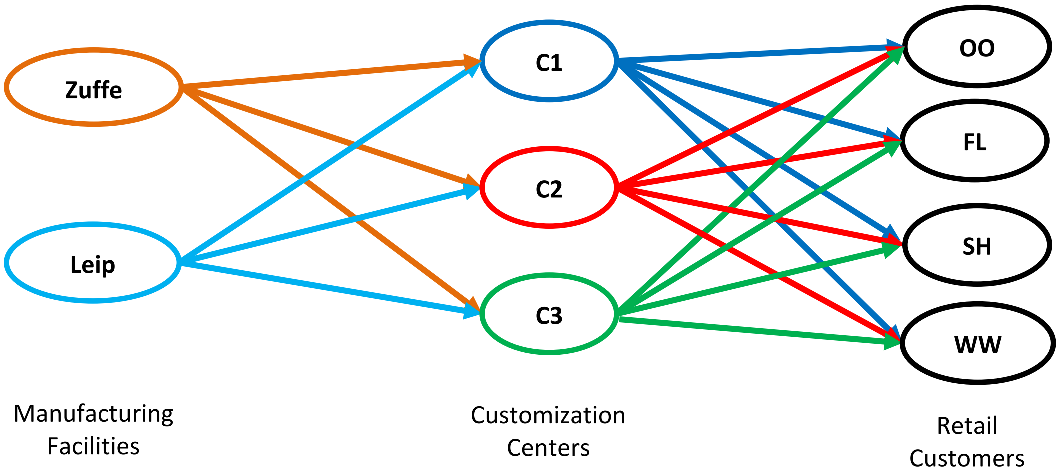

Figure 1. The supply chain for the Tycoon.

Production. Prosche manufactures a bare-bones version of the Tycoon at its facilities in Zuffe and Leip. **Table 1** provides an overview of the production capacities and costs in these facilities. Zuffe is a large, modern facility whereas Leip is a smaller and slightly older facility, with a lower capacity and a higher per-unit cost. The costs are different at the facilities, due to sourcing and transporting the necessary materials and components (such as batteries, rare minerals, etc.) and the different energy and labor market conditions.

	Cost (€ per unit)	Quarterly Capacity (units)
Zuffe	54,000	5,000
Leip	58,500	2,000

Table 1. Per-unit costs and production capacities at the two facilities.

Customization process. From the facilities, the cars are then transported to three special-purpose centers nicknamed **C1**, **C2** and **C3**, where they undergo customization to fit the requirements of the clients. **Table 2** displays the per-unit costs involved in handling and transporting cars from factories to customization centers, which heavily depend on the precise origin and destination. Each customization center has been designed to be as flexible as possible, with processes capable of handling multiple types of configurations. However, due to the highly specialized nature of the designs, the centers must rely heavily on manual labor and can only handle a limited number of units each quarter, at fairly high costs. The costs and capacities are recorded in **Table 3**.

	C1	C2	C3
Zuffe	€ 1,000	€ 2,500	€ 2,000
Leip	€ 2,000	€ 1,500	€ 1,800

Table 2. Transportation cost (per unit) from factories to customization centers.

	Staffing Cost (€ per unit)	Quarterly Capacity (units)
C1	€ 3,000	2,000
C2	€ 6,000	2,200
C3	€ 7,500	3,300

Table 3. Staffing costs and quarterly capacities at customization centers.

*This mini-case was prepared by Professor Dan Iancu (daniancu@stanford.edu) as a basis for class discussion. It is not intended to serve as an endorsement, source of primary data, or illustration of effective or ineffective management.

Retail Clients. Prosche has received pre-orders for the coming quarter from four major retail clients, code-named OO, FL, SH, and WW. Each client has specific requests for customization and is located in a very different region, which means that Prosche will incur very different costs when customizing and transporting the cars to their final destinations. The costs are recorded in Table 4, for every customization center and every retailer. The pre-orders placed by the clients and the per-unit prices paid to Prosche vary substantially and are recorded in Table 5.

	OO	**FL**	**SH**	**WW**
C1	€ 4,000	€ 6,000	€ 3,000	€ 5,000
C2	€ 6,000	€ 6,000	€ 2,000	€ 4,500
C3	€ 4,500	€ 7,000	€ 6,000	€ 3,000

Table 4. Customization and transportation cost (per unit) from centers to clients.

	OO	**FL**	**SH**	**WW**
Pre-orders (units)	5,000	2,500	1,600	550
Price (per unit)	€ 71,000	€ 74,000	€ 69,000	€ 71,000

Table 5. Pre-orders and per-unit prices for the next quarter for four major retail clients.

Rationing Supply. Prosche has been facing severe shortages in the supply of key components, so for the past few quarters it was never able to meet all the pre-orders it received. **Customers only pay for the orders that are filled**, but to avoid angering the clients, the outgoing COO had used **a specific policy to handle rationing: each client would receive enough orders to ensure their fill rate (i.e., the ratio of shipments received to pre-orders placed) exceeds some required threshold**, which management would usually set based on discussions. Historically, the required threshold was 50%, but you are reconsidering that value…

Data Science Team. Your data science team implemented an AI model that recommends how many units to produce at each manufacturing facility and how to customize and ship these to clients. The team was unsure how to handle rationing, so they are leaving some choices up to you!

Your goal is to evaluate the team's model and its usefulness in informing some important decisions…

Part 1: Making sense of the AI model's output

The following output was obtained by running an AI model with the following specs:

- maximize the gross profit for the quarter
- meet all the physical constraints (e.g., capacities at factories and centers)
- for any client, do not ship more than the client pre-orders
- no requirements are imposed on the fill rates achieved at each client.

Based on these outputs, please address the following questions:

Q1. Does the production and shipment plan treat the clients "fairly"? *(please answer in the poll)*

Q2. Does the plan make "practical" sense? *(please answer in the poll)*

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Creating an AI Model to optimize the operations...

Solved the optimization AI Model. Here is the recommendation:

Gross profit: 33,625,000.
==================================================
Number of units produced at the factories:
   Zuffe  : 5,000 (capacity was: 5,000)
   Leip   : 0     (capacity was: 2,000)
==================================================
Number of units shipped from factories to customization centers:
   Zuffe to C1  : 2,000
   Zuffe to C2  : 2,200
   Zuffe to C3  : 800
   Leip  to C1  : 0
   Leip  to C2  : 0
   Leip  to C3  : 0
==================================================
Number of units processed at customization centers:
   C1 : 2,000 (capacity was: 2,000)
   C2 : 2,200 (capacity was: 2,200)
   C3 : 800   (capacity was: 3,300)
==================================================
Number of units shipped from customization centers to clients:
   C1 to OO : 100
   C1 to FL : 1,900
   C1 to SH : 0
   C1 to WW : 0
   C2 to OO : 0
   C2 to FL : 600
   C2 to SH : 1,600
   C2 to WW : 0
   C3 to OO : 250
   C3 to FL : 0
   C3 to SH : 0
   C3 to WW : 550
==================================================
Filled orders and fill rates at clients:
   OO : 350   orders filled out of 5,000, i.e., fill rate of 7.0  %.
   FL : 2,500 orders filled out of 2,500, i.e., fill rate of 100.0 %.
   SH : 1,600 orders filled out of 1,600, i.e., fill rate of 100.0 %.
   WW : 550   orders filled out of 550  , i.e., fill rate of 100.0 %.
```

Part 2: Navigating tradeoffs

Consider the following output, which was obtained by running an AI model with the following specs:

- maximize the gross profit for the quarter
- meet all the physical constraints (e.g., capacities at factories and centers)
- for any client, do not ship more than the client pre-orders
- for any client, ensure that the fill rate achieved exceeds a required level *f*.

The output was generated for the specific value *f=50%*, but there is also a visualization for many values of *f*. Based on these outputs, please address the following questions:

Q3. What is the largest fill rate *f* that could be required? *(please answer in the poll)*

Q4. What fill rate *f* would you require in this case? *(please answer in the poll)*

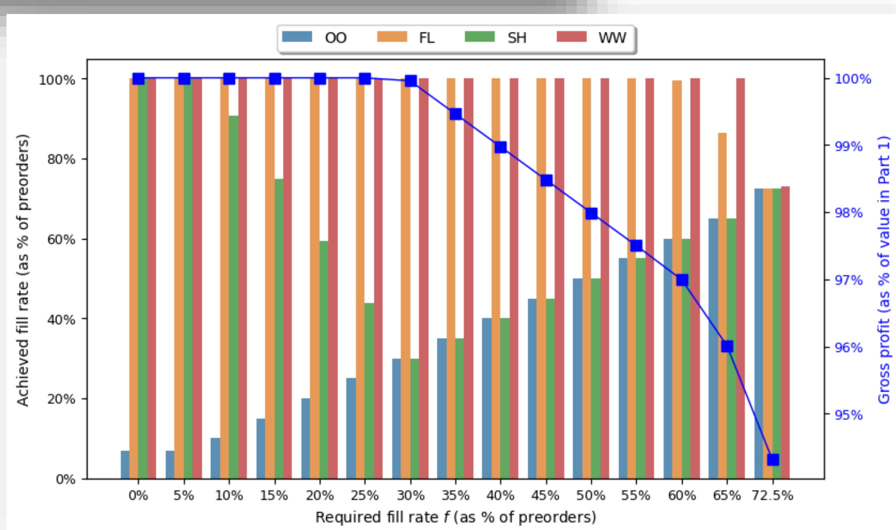
```
Solved the AI model with required fill rate: 50%

Gross profit: 32,950,000.
Profit change compared to Q1: -2.0%.
==================================================
Number of units produced at the factories:
   Zuffe  : 5,000 (capacity was: 5,000)
   Leip   : 1,350 (capacity was: 2,000)
==================================================
Number of units shipped from factories to customization centers:
   Zuffe to C1  : 2,000
   Zuffe to C2  : 850
   Zuffe to C3  : 2,150
   Leip  to C1  : 0
   Leip  to C2  : 1,350
   Leip  to C3  : 0
==================================================
Number of units processed at customization centers:
   C1 : 2,000 (capacity was: 2,000)
   C2 : 2,200 (capacity was: 2,200)
   C3 : 2,150 (capacity was: 3,300)
==================================================
Number of units shipped from customization centers to clients:
   C1 to OO : 900
   C1 to FL : 1,100
   C1 to SH : 0
   C1 to WW : 0
   C2 to OO : 0
   C2 to FL : 1,400
   C2 to SH : 800
   C2 to WW : 0
   C3 to OO : 1,600
   C3 to FL : 0
   C3 to SH : 0
   C3 to WW : 550
==================================================
Filled orders and fill rates at clients:
   OO : 2,500 orders filled out of 5,000, i.e., fill rate of 50.0 %.
   FL : 2,500 orders filled out of 2,500, i.e., fill rate of 100.0 %.
   SH : 800   orders filled out of 1,600, i.e., fill rate of 50.0 %.
   WW : 550   orders filled out of 550  , i.e., fill rate of 100.0 %.
```

Clarification about the figure.

● the **vertical colored bars** correspond to the **left axis and the legend,** and show the fill rate actually achieved at each client;

● the **blue line plot** corresponds to the **right axis** and shows the profit achieved, as a percent of the profit reported in Part 1.



Part 3: Pricing bottlenecks

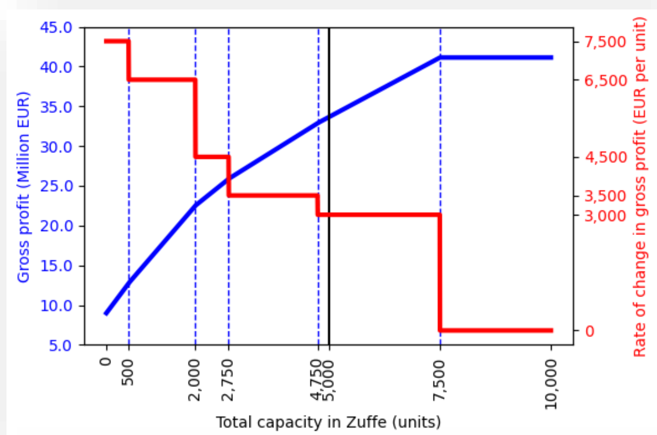
You are considering expanding the capacity of the manufacturing facilities and customization centers but are unsure where to focus your efforts. The output below was obtained by **re-running the AI model from Part 1** with different capacities at the facilities. Based on this information, please address the following questions:

Q5. If you were to increase capacity at *one* facility, which would you choose? *(please answer in the poll)*

Looking back at Parts 1-3, some questions for brainstorming:

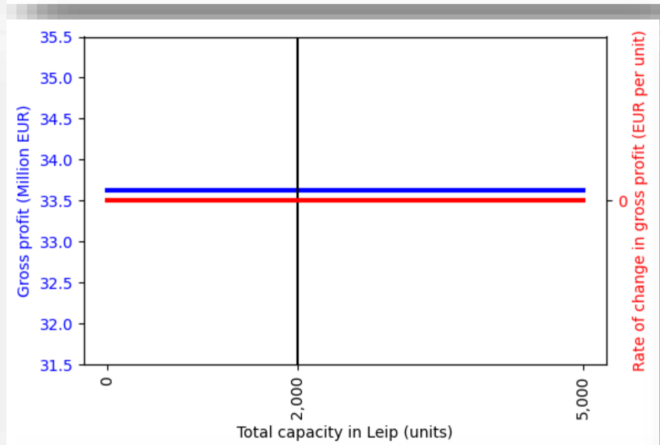
Do you already use such models to inform decisions in your organization?

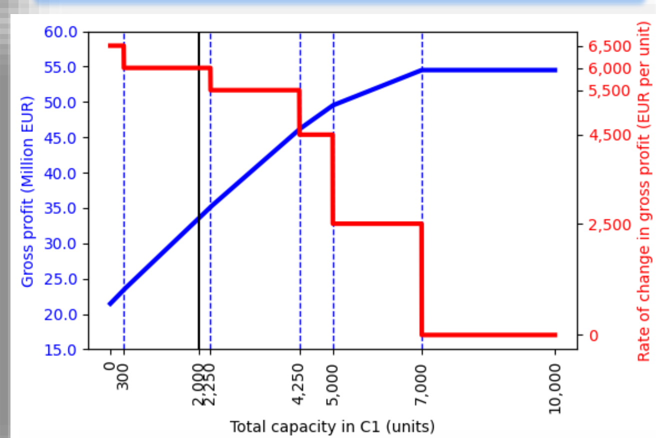
If yes, what kind of decisions? If not, what are some decisions that could benefit from this and what are barriers to implementing such AI models?

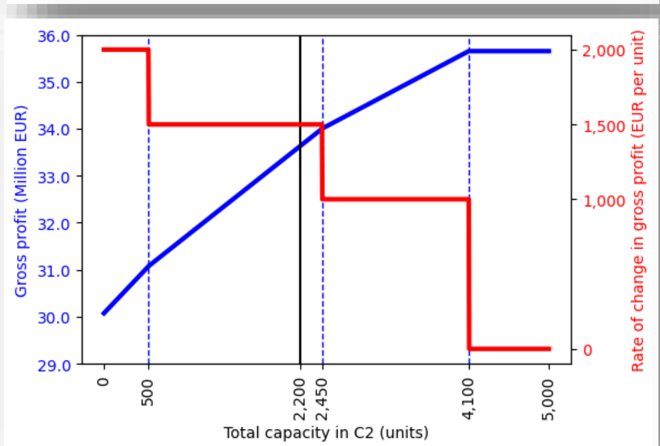


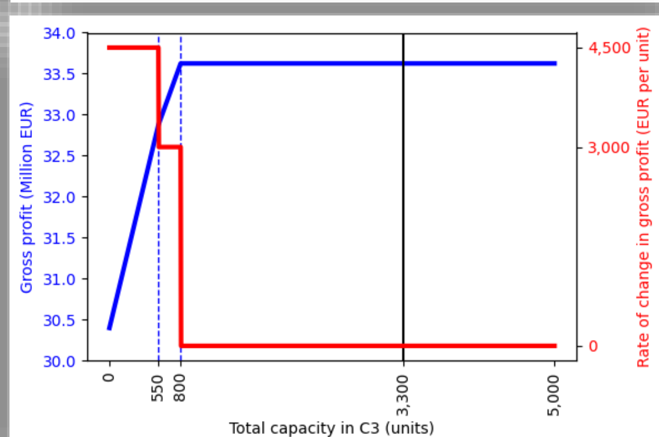
A few clarifications about each figure.

- The **blue plot** corresponds to the **left** axis and shows the **gross profit**.
- The **dashed blue vertical lines** mark the points where the slope of the blue line changes.
- The **red plot** corresponds to the **right** axis and shows the **rate of change in the profit**, i.e., the slope of the blue line.
- The **solid black vertical line** marks the value of the capacity mentioned in the case for that facility.









Part 4. Quantifying the impact of uncertainty

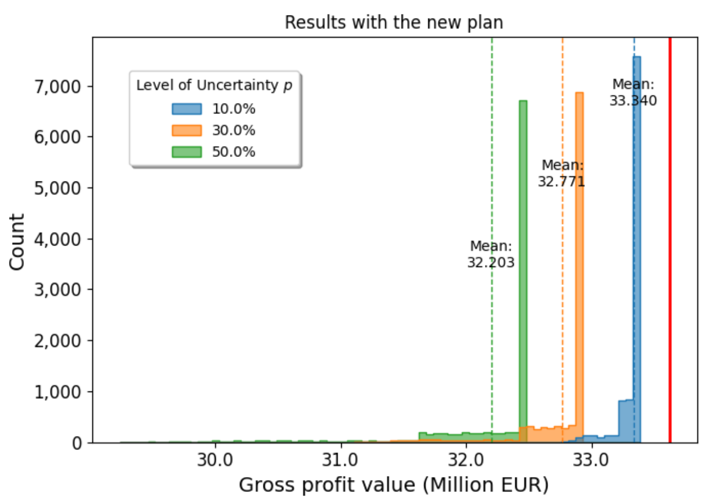
Upon further investigation, you have realized that the pre-orders that clients place are not firm. Rather, clients usually provide these as estimates, but the actual orders placed during the quarter often differ from the pre-orders. **The outgoing COO had enforced the practice that Prosche should always come up with a plan upfront based on the pre-orders, and start producing and shipping the cars to warehouses near the clients before the final orders are confirmed**. If a client's final order were higher than the pre-order, Prosche would decline filling anything extra; and if the final order were lower than the pre-order, Prosche would sell any remaining cars in bulk through a secondary channel, for €65,000 each. Because this uncertainty could have a material impact, you asked the data science team to update its models to capture it. They prepared a **new model** with the following specs:

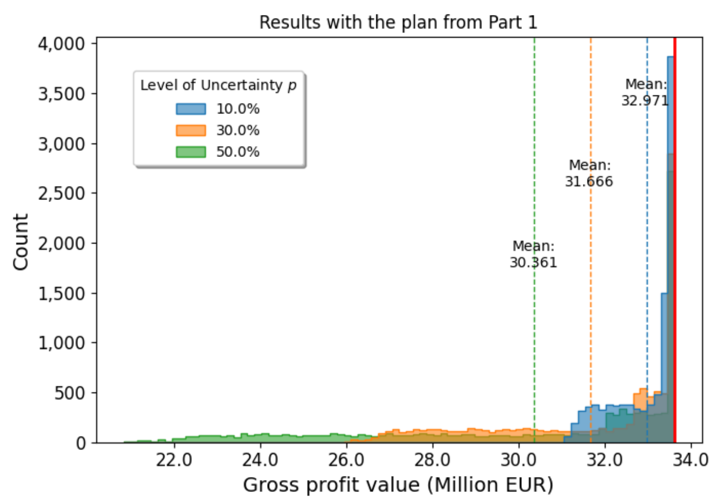
- assume that orders can take any value, equally likely, within a percentage *p* of the pre-orders and use 10,000 scenarios drawn from the corresponding range to simulate the true orders.
  (For instance, with p=10%, true orders at OO could take any value from 4,500 to 5,500, and the model will use 10,000 values drawn randomly from that range to represent the true orders.)
- allow examining different levels of uncertainty, by changing *p* from 0% to 100%.
- respect the outgoing COO's rule of having an upfront production and shipment plan.
- for each level of uncertainty *p*, determine a plan that maximizes the mean gross profit achieved over the 10,000 scenarios.
- allow for the possibility of shipping more than the pre-orders at a client.
- meet all the physical constraints.

In addition, the team also included the option – for benchmarking purposes – of **just using the plan you determined in Part 1**. Based on the information below, please answer the following questions:

Q6. How would you characterize the impact of uncertainty? *(answer in the poll)*

Q7. Would you prefer the new plan or the plan from Part 1? *(answer in the poll)*





A few clarifications about the plots.

● Each figure displays several **histograms** corresponding to different levels of uncertainty *p*.

● Each histogram shows the 10,000 values of gross profits achieved in the 10,000 scenarios corresponding to the level of uncertainty *p*.

● For each histogram, there is a **dotted vertical line** with the same color that shows the **mean** of the gross profit (i.e., the average of the 10,000 values in the histogram).

● The **solid red line** shows the gross profit value from **Part 1**.

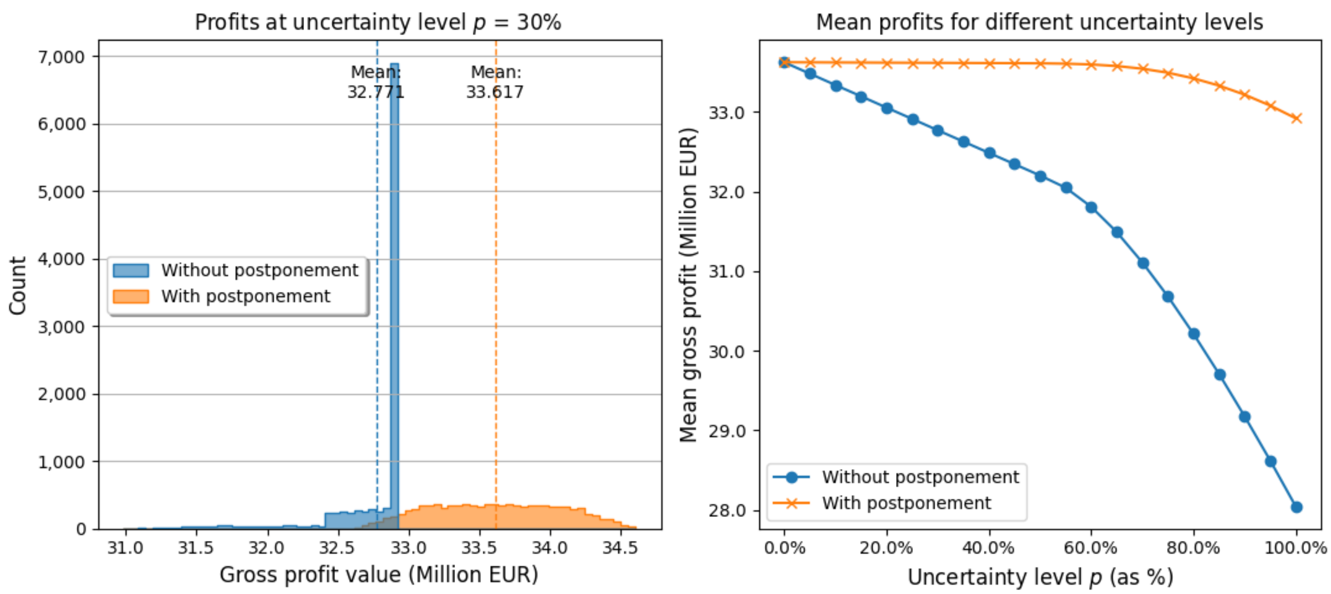
Part 5: Quantifying the benefits of postponement / flexibility / information

Thinking again about the situation in Part 4, you have come to realize that there may be huge benefits in **being able to postpone the production decisions until the time when the actual orders from clients are known**. In that case, even if the orders differ from the pre-orders, you would be able to react and produce more or less depending on what is required. The data science team updated its AI model from Part 4 to capture this possibility.

The outputs below compare **this updated model (with postponement)** with the **new model from Part 4 (without postponement).** Based on this information, please answer the following questions:

Q8. Assuming that the uncertainty level is *p* = 30%, what is the value of being able to postpone the production? *(please answer in the poll)*

Q9. How does the value of postponement depend on the uncertainty level? *(please answer in the poll)*



Looking back at Parts 4-5, some questions for brainstorming:

Do you already use such models to inform decisions in your organization?

If yes, what kind of decisions? If not, what are some decisions that could benefit from this and what are barriers to implementing such AI models?