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SUNIL GUPTA

Miroglio Fashion (B)

After much internal debate, Francesco Cavarero and Davide Garelli decided to partner with Evo Pricing (Evo) and asked them to build an artificial intelligence (AI) system for demand forecasting and inventory replenishment for Miroglio's Elena Mirò brand. Evo CEO Fabrizio Fantini and his team of data scientists worked in close collaboration with Garelli's team and with Marcello Offi, Miroglio's Chief Data Officer, to come up with the following system.

Initial Inventory Allocation

Inventory allocation before the start of a season involved three decisions: (a) what percent of overall inventory to send to stores at the beginning of the season and how much to keep in warehouse for in-season replenishment, (b) how many items to send to each store, and (c) which items and sizes to send.

The first decision depended on the accuracy of and confidence in the new replenishment system. Based on the system described below, Evo decided to allocate 60% of the total inventory to stores at the start of the season, compared to the previous 85%. The second decision followed Miroglio's segmentation of store clusters, ensuring that its larger stores received more inventory of the same assortment. The third decision of allocating specific items to a store was done by first identifying features of each item (e.g., its fabric, category, color, price point etc.). Using a similarity index, this item was then matched to previous items sold in that store that had similar features. Finally, the model computed the initial allocation of the item as the weighted first four weeks' sales volume of those other items. This meant, for example, that an expensive black blouse was more likely to be allocated to stores that sold many black items (not just blouses), had higher sales of blouses (of all colors), and sold more expensive items.

Inventory Replenishment

The 40% of inventory excluded from the initial allocation was reserved for weekly replenishment as follows:

Step 1: Initial forecast

Fantini and his team knew that individual Miroglio stores sold relatively few units in each size of an item (or stock-keeping unit, SKU), implying that data at this disaggregated level were too sparse to

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do accurate prediction. Therefore, for each store, they aggregated past sales of an item in a given category (e.g., women's pants) across all sizes to first build a forecast at an item-store level. Next, using aggregate category sales (across items and stores) they removed the effects of markdowns on past sales and estimated a seasonality coefficient. This seasonality coefficient was then applied to adjust item-store forecasts. Finally, they arrived at the size allocation for each item-store forecast by giving equal weight to two factors: relative frequency of a certain size for an item across all stores; and relative frequency of a size for a store across all items (see **Exhibit 1**).

While this approach was simple and perhaps easy to explain to Miroglio management, Giuseppe Craparotta and Elena Marocco, the lead data scientists at Evo, proposed a more sophisticated and powerful forecasting approach using image analysis. In this approach, a machine would analyze images of fashion items to abstract key attributes (these might include not only attributes typically identified by humans, such as shape and design, but also many other unique aspects that might be hard for people to describe). It would then correlate these image attributes with sales patterns of these items. Once again, the machine could identify patterns in the sales data, beyond the more obvious seasonality or trend patterns, that humans might overlook and find difficult to explain. However, research showed that the richness of these attributes and high-dimensional correlations could lead to significantly better forecasting accuracy than the simple approach that the team initially suggested.

Fantini wondered whether to propose that Miroglio management adopt the simple, explainable, but less accurate approach, or the state-of-the-art AI method which provided far better forecasts but could be perceived as a "black box." Implementing a state-of-the-art approach could establish Evo as the AI and machine learning pioneer in the fashion industry, but would it create resistance from Miroglio's management?

Step 2: Headquarters' replenishment proposal and store managers' input

Regardless of the forecasting approach, the Evo team agreed with Miroglio's Head of Retail Carlo Tibaldi and Miroglio's business analyst Davide Garelli that store managers' knowledge of their customers and local market trends could be useful inputs, as long as this input was controlled in some manner. The team especially liked Garelli's idea of providing each store manager with a non-monetary budget that they could use to accept or replace replenishment items that Miroglio's headquarters proposed. Garelli explained: "Our Head of Buying has a budget that she uses to decide how many blue jeans or black blouses to buy based on a demand forecast. However, she uses her judgment to modify these quantities from the demand forecast. We can offer a similar budget to store managers and effectively make them the buying heads of their own stores." Tibaldi was very excited about this idea: he believed that this approach would empower store managers and encourage them to embrace the analytical model.

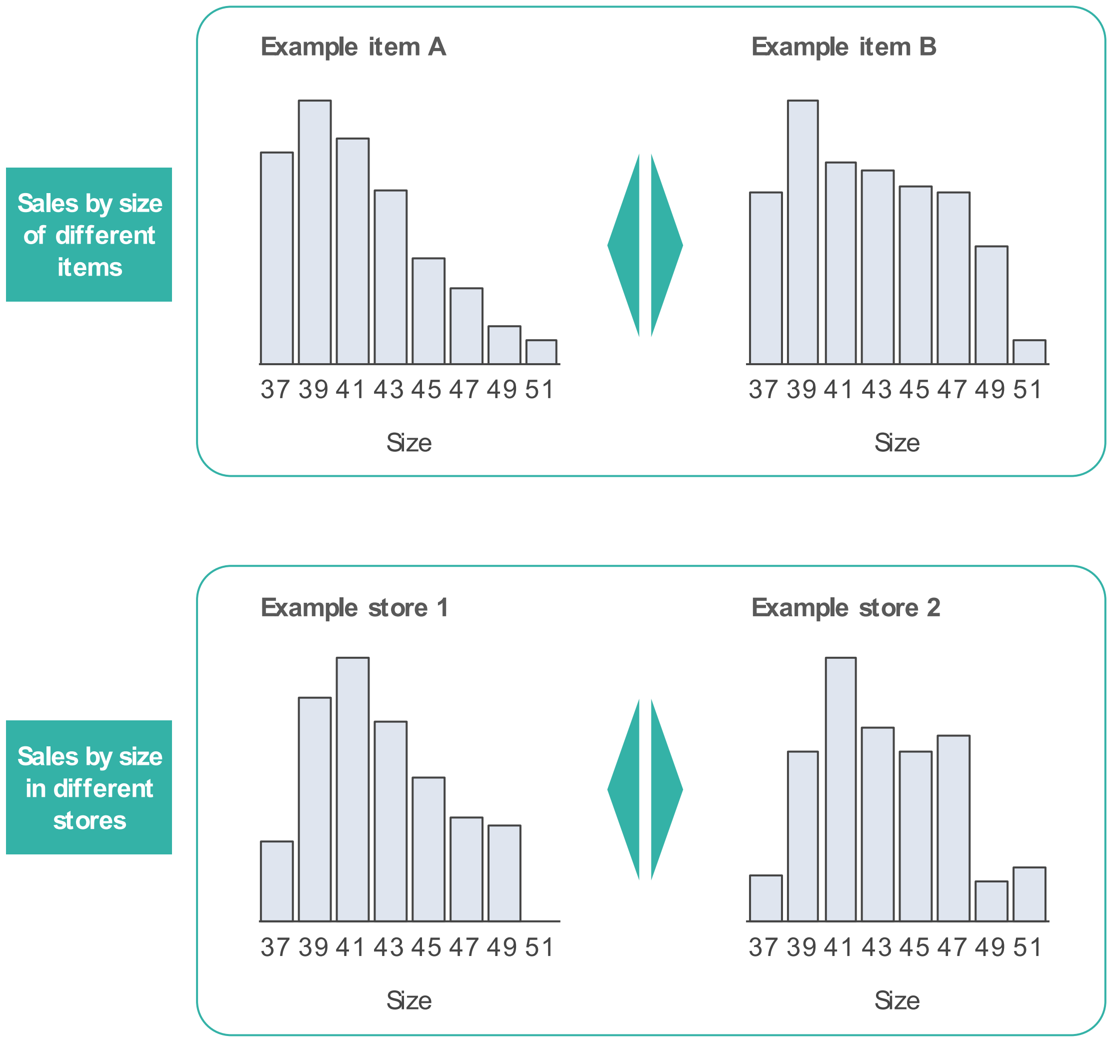
Evo's team agreed with this suggestion and created a budget that was calculated as the difference between a store's potential sales in the next four weeks (as estimated by the model) plus an extra safety stock of 20%, minus the current stock in the store (see **Exhibit 2** for an example). If the budget was positive for a store, that store was relatively understocked compared to its sales potential. If negative, the store was overstocked.

Based on these estimates, Miroglio's headquarters would recommend that particular items in an individual store be either replenished or released for transfer to understocked stores (see **Exhibit 3**). However, store managers would have the option to change these recommendations as long as they did not exceed their non-monetary budget. This meant that if a store manager wanted to order a larger quantity of certain items than proposed by headquarters, she had to release some other items from store inventory in order to remain within her budget.

Step 3: Optimal allocation of stock

Once store requests were received, the model's algorithms would arrive at an optimal allocation of different sizes and items for each store that maximized overall expected profits for the firm, including the cost of between-store transfers. The model would also ensure that each store stayed within its budget and that replenishment orders did not exceed the overall supply of an item in the warehouse.

Exhibit 1 Size Distribution of Pieces Sold for Two Items (All Stores) and for Two Stores (All Items)



Source: Evo Pricing.

Exhibit 2 Example of Store Budget with Three Items

	Item 1	Item 2	Item 3
Selling price (€)	100	200	150
Expected sales (units)	5	3	3
Stock (units)	2	4	2

Expected revenues: €1,550 = (5 x 100) + (3 x 200) + (3 x 150)
Potential revenue from stock: €1,300 = (2 x 100) + (4 x 200) + (2 x 150)
Extra coverage: €310 = 20% x 1,550
Budget: €560 = 1,550 + 310 – 1,300

Source: Evo Pricing.

Exhibit 3 Example of Recommended Actions

Store	Item	Stock (units)	Potential (units)	Difference (units)	Action
Store 1	Item 1	10	-1	9	Mandatory release
	Item 2	1	10	-9	Urgent replenishment
Store 2	Item 1	3	1	2	Recommended release
	Item 2	6	5	1	No action
Store 3	Item 1	7	8	-1	No action
	Item 2	2	5	-3	Replenishment

Source: Evo Pricing.