

# Your next slot is... Explainable customer choice modeling for attended home delivery

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## Abstract

This whitepaper explores how retailers can improve their time slot delivery pricing strategies by balancing predictive accuracy with business transparency. We examine a European online retailer's challenge of predicting which delivery time slots customers will choose when presented with multiple options at varying prices. Comparing traditional machine learning approaches with interpretable symbolic expressions, we find that, while machine learning offers marginally better predictive accuracy (29% vs 24%), symbolic expressions provide significant advantages in computational speed, transparency, and business utility. The research confirms that customers prioritize delivery speed and are price-sensitive, insights relationships that can directly inform pricing decisions. For retailers managing attended home deliveries, the findings suggest that interpretable expressions can be leveraged for stakeholder communication and real-time customer interactions.

**Keywords:** time slot pricing, machine learning, genetic programming, explainability, online retail

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## 1. Problem context

In today's rapidly evolving e-commerce landscape, retailers are constantly seeking innovative ways to enhance customer experience while optimizing operational efficiency. Among the various services offered, attended home deliveries present a unique challenge that requires careful management [2, 3]. This service requires retailers and customers to agree on a delivery time slot for a specific fee, creating a delicate balance between customer satisfaction and operational costs.

When customers shop online, they typically go through several steps: logging in, selecting products, and then choosing a delivery time slot with its associated fee (see Fig. 1). This selection process is critical, as it directly impacts both the customer experience and the retailer's transportation costs. Since customers are price sensitive, their choices will be influenced by the pricing of different time slots. Meanwhile, these choices affect delivery routes, which must be adjusted to meet promised delivery windows.

For retailers, understanding and anticipating customer choices becomes crucial in adjusting price offerings in a way that can reduce operational costs while maintaining customer satisfaction. The challenge lies in finding an approach that not only predicts customer behavior accurately but also provides insights that business stakeholders can understand and trust.

A European online retailer faces this exact challenge daily, offering customers multiple delivery time slots across several days, each with different pricing. When customers arrive at the

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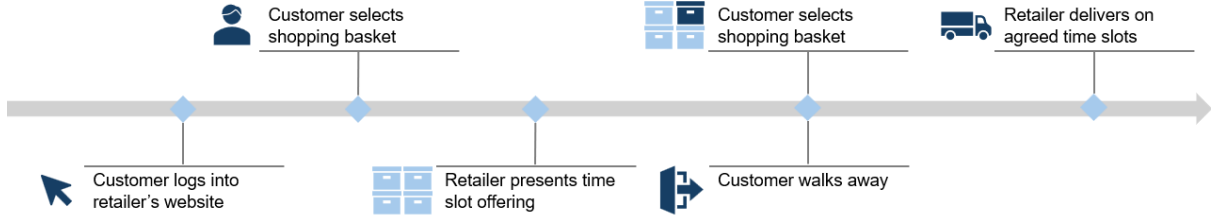


Figure 1: Customer journey in the context of attended home deliveries.

time slot selection screen, they see various options, some of which might be unavailable due to capacity constraints or cutoff times. The retailer needs to understand what drives the customer choices among these options to optimize their pricing and scheduling strategies [4, 5, 6].

## 2. Solution

To address this challenge, we developed and compared two distinct approaches: traditional machine learning models and genetic programming symbolic expressions. Although the former are known for their predictive power, they often function as "black boxes," making it difficult for business stakeholders to understand how predictions are made. In contrast, symbolic expressions derived through genetic programming offer transparency and interpretability, allowing stakeholders to directly understand the mathematical relationships that drive customer choices [1, 7].

Our methodology treated the time slot selection problem as a classification task, where for each customer and time slot pair, we predicted the probability of selection. We analyze various factors that might influence customer choices, including:

- **Pricing features:** The price of the time slot and how it compares to other available options
- **Time slot features:** Delivery day, time of day, and how soon after ordering the slot is scheduled
- **Customer features:** Past purchasing behavior, basket value, and previous delivery preferences
- **Relationship features:** How the current time slot aligns with the customer's historical choices

For traditional machine learning, we tested several algorithms including Gradient Boosting Machine, Random Forest, Logistic Regression, and Neural Networks. For the interpretable approach, we used genetic programming to derive mathematical expressions that predict customer choices while remaining transparent and understandable.

Our findings revealed an interesting trade-off between performance and explainability. Traditional machine learning models, in particular, Gradient Boosting Machines, known for their strong predictive power in a plenitude of real-world problems, demonstrated superior predictive performance, correctly identifying the chosen time slot in 29% of cases. The symbolic expression approach (see Fig. 2) was slightly behind at 24%, but still significantly better than a naive approach that assumes customers always choose the same slot as their previous order (17%). However, symbolic expressions offered significant advantages in other areas:

- **Computational efficiency:** Predictions were generated approximately 17 times faster than with traditional machine learning models — critical in an online retail environment where customers expect immediate responses.
- **Transparency:** The mathematical relationships were directly observable, allowing business stakeholders to understand exactly how features influence predictions.
- **Actionable insights:** The expressions revealed clear patterns about customer preferences, such as price sensitivity and the value placed on delivery speed.

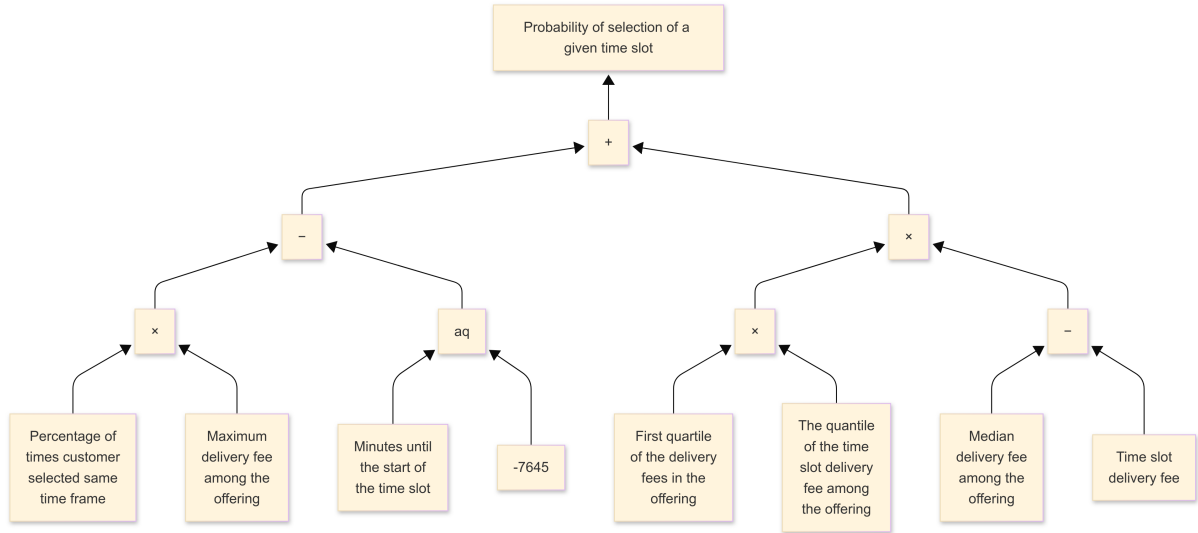


Figure 2: Tree representation of the symbolic expression obtained.

Both approaches confirmed important business insights: customers are indeed price-sensitive (higher prices decrease selection probability), and they value delivery speed (slots starting sooner after ordering have higher selection probabilities). However, while traditional machine learning required additional techniques to extract these insights, the symbolic expressions made them immediately apparent. For example, the symbolic expressions showed exactly how changes in price would need to be balanced against other factors to maintain the same selection probability—information that can directly inform pricing strategies.

### 3. Conclusion

This study demonstrates that while traditional machine learning models offer slightly better predictive performance in customer choice modeling, interpretable approaches using symbolic expressions provide significant benefits in terms of transparency, efficiency, and business utility. The symbolic expressions confirmed that customers value delivery speed and are sensitive to price—insights that align with business intuition but are now quantitatively validated. Furthermore, these expressions provide specific mathematical relationships that can guide pricing decisions, such as how much to discount a time slot based on a customer’s historical preferences.

For business stakeholders in e-commerce and retail, several key implications emerge:

- **Trust and adoption:** The transparency of interpretable models can increase stakeholder trust and facilitate faster adoption of data-driven decision-making.

- **Direct business insights:** The ability to directly observe relationships between variables (such as price, delivery timing, and customer history) can inform more effective pricing and operational strategies.
- **Balanced approach:** Consider using both types of models — black-box for critical predictions where raw performance matters most, white-box models, like symbolic expressions, for when explainability and stakeholder communication are the key factors.
- **Speed advantages:** In time-sensitive customer interactions, the computational efficiency of symbolic expressions could provide a competitive advantage.

As e-commerce continues to evolve, the ability to make quick, data-driven decisions while maintaining transparency will become increasingly important. Interpretable approaches like symbolic expressions offer a promising path forward, especially in sectors where understanding the "why" behind predictions is as important as the predictions themselves. By balancing performance with explainability, retailers can develop more effective pricing strategies, optimize delivery operations, and ultimately enhance both operational efficiency and customer satisfaction in attended home delivery services.

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