MTO vs. MTS: Customer Preferences and Firm Strategies in Competitive vs. Cooperative Markets

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We study a market model of two firms offering substitute products to price-and-time-sensitive customers. One firm produces customized MTO products on a first-come, first-served basis, while the other is a MTS supplier offering standard products on demand. Customers decide which product to purchase based on their valuations of the products, the prices, and the estimated waiting time for the customized products, or they go elsewhere. We analyze the equilibrium strategies of the firms competing on output rates and compare these strategies to the optimal joint strategies under a cooperation scenario. Additionally, we explore the effect of the MTO firm's production capacity and the MTS firm's storage capacity on market outcomes. Through numerical analysis, we investigate how various parameters, including those related to product valuation distribution, influence market dynamics.

Key words: Customized products; Standard products; Competition; Cooperation; Market share; Output rate; Pricing; Strategic customers

1. Introduction and Problem Formulation

Customer perceptions of product value vary significantly, influenced by functional, emotional, life-changing, and social impact needs. To address this diversity, companies increasingly use technology-enabled mass customization to tailor goods to individual needs, though these customized products are more expensive and have longer wait times compared to standard products that benefit from economies of scale and immediate availability. Despite higher prices, customized products offer greater benefits, with many consumers willing to pay more and wait longer for them. However, excessive waiting times or high prices can drive customers to substitutes, as seen during the COVID-19 pandemic in the car market. Companies must strategically price their products to balance attractiveness and profitability, while many mass-production manufacturers are incorporating customization services, and luxury brands are embracing standardization for profitability. Effective customization poses significant challenges for mass producers, often leading to the discontinuation of such services. Leveraging partnerships, acquisitions, and outsourcing can provide solutions for offering effective customization without starting from scratch.

This study develops a model analyzing competitive and cooperative strategies between a make-to-order (MTO) supplier and a make-to-stock (MTS) supplier in a market of price-and-time-sensitive strategic customers. Customers decide which product to buy based on their valuations of the products, the product prices, and the estimated waiting time for customized products. The study investigates the Nash equilibrium strategies of both firms when competing on output rates and compares them to optimal joint strategies if they cooperate, exploring the impact of production and storage capacities on market outcomes and customer behavior through numerical analysis. The analysis draws mainly from the stream of research on rational queueing (Hassin and Haviv 2003, Hassin 2016). A recent work in this area by the authors is Deligiannis et al. (2024), while a related work is Zhou et al. (2023).

The model that we consider features a market with two firms, F1 and F2, offering substitute products to randomly arriving strategic customers who may demand one unit of a product. F1 produces customized MTO products at unit cost c_1, following a FIFO M/M/1 queueing model with an average service time of $1/\mu$. F2 sells standard MTS products at unit cost c_2, with negligible stock replenishment lead times, ensuring prompt service. For most of our analysis, we consider c_2 to be fixed except in our sensitivity analysis where we assume that it is decreasing in F2's storage capacity, u, due to economies of scale. Customers arrive according to a Poisson process with rate Λ and independently choose between F1, F2, or balking based on their individual product valuations, R for F1 and θR for F2, where $\theta \in (0,1)$. In steady-state, the arrival rates to F1 and F2 are λ_1 and λ_2 respectively. The expected waiting cost for F1 customers is $W(\lambda_1) = \frac{w}{\mu - \lambda_1}$, and the expected utilities for joining F1 and F2 are $U_1(\lambda_1) = R - W(\lambda_1) - p_1$ and $U_2 = \theta R - p_2$, respectively. The firms' expected profits are given by $G_i(\lambda_i, p_i) = \lambda_i(p_i - c_i)$ for $i = 1, 2$.

2. Analysis and Numerical Experiments

Customers act independently to maximize their utility, leading to a symmetric aggregate equilibrium strategy. They choose between joining F1, F2, or balking based on comparing $U_1(\lambda_1)$, U_2, and zero (utility of balking). The thresholds $r_{1,0}$, $r_{2,0}$, and $r_{1,2}$ indicate customer indifference points, where $r_{1,0} = W(\lambda_1) + p_1$, $r_{2,0} = \frac{p_2}{\theta}$, and $r_{1,2} = \frac{W(\lambda_1)+p_1-p_2}{1-\theta}$. These thresholds determine the best response: joining F1 if $R \geq r_{1,2}$, joining F2 if $r_{2,0} \leq R \leq r_{1,2}$, or balking if $R \leq r_{2,0}$. Two market cases arise: a duopoly (when $W(\lambda_1) + p_1 > p_2/\theta$) with positive arrival rates for both firms, and a monopoly (when $W(\lambda_1) + p_1 \leq p_2/\theta$) where only F1 has positive arrivals. The equilibrium arrival rates, $\lambda_1^e(p_1, p_2)$ and $\lambda_2^e(p_1, p_2)$, depend on these conditions and are derived from solving specific equations involving the valuation distribution and waiting costs. The equilibrium prices p_1^e and p_2^e are characterized, showing dependence on the arrival rates and illustrating the dynamic pricing strategies under different market conditions.

The firms' strategies depend on market structure. In a competitive market, each firm operates independently with the aim of maximizing its own expected profit. This setting creates a competitive game where each firm's optimal strategy depends on the output rate of the other firm. The best response functions of the firms are characterized by properties such as decreasing behavior and constraints based on the distribution of customer arrivals. These properties ensure the uniqueness of the Nash equilibrium, where both firms' strategies are mutually optimal. The conditions for equilibrium differ depending on factors such as cost structures and customer arrival rates, with the equilibrium shifting between a duopoly and monopoly scenario based on certain thresholds.

On the other hand, in a cooperative market, firms collaborate to optimize joint outcomes, aiming to maximize their combined total payoff. This approach involves jointly setting prices or output rates to leverage each firm's strengths. The optimal strategies in a cooperative setting lead to a unique global maximizer for the firms' joint payoff. However, the conditions for optimality are complex and depend on factors such as cost parameters and the shape of the distribution of customer arrivals. The cooperative model contrasts with the competitive one by emphasizing joint profit maximization over individual firm competition.

Comparing firm competition and cooperation, it is evident that cooperation yields higher total payoffs for the firms, as it leverages synergies between them. In contrast, competition focuses on individual profit maximization, which can lead to suboptimal outcomes in terms of overall industry performance. The analysis underscores the trade-offs between competition and cooperation in different market structures, highlighting how the choice between them can significantly impact firm profitability and industry dynamics.

We explore the impact F1's production capacity (μ) and F2's storage capacity (u) on market outcomes. We establish propositions regarding the conditions under which the equilibrium market is a duopoly or a monopoly based on μ and u. Moreover, we derive monotonicity properties of the Nash equilibrium arrival rates and equilibrium prices with respect to μ and u, illustrating the intricate interplay between production and storage capacities in determining market dynamics. These findings provide insights into the strategic decisions firms must make to enhance their competitiveness and navigate market conditions effectively.

Additionally, we conduct numerical experiments to delve deeper into the implications of various parameters, including μ, u, and customer heterogeneity, on market outcomes, firm profitability, customer benefit, and system efficiency under both competitive and cooperative scenarios. By considering a normal distribution for customers' valuations, we illustrate the impact of their heterogeneity. The experiments reveal subtle insights, such as the initial decrease in total profit under competition due to low storage capacity for F2, and the imbalance between increased firm profitability and decreased customer surplus under cooperation. Sensitivity analyses on storage and production capacities validate analytical findings and highlight the differential impact of these capacities on prices and customer benefits under competition and cooperation. Furthermore, exploring the effect of customer valuation similarity parameter (θ) uncovers scenarios where F2 is effectively excluded from the market under both competitive and cooperative settings, emphasizing the complex dynamics between firms and customers.

3. Conclusions

This study sheds light on the complex dynamics of competition and cooperation between MTO and MTS suppliers in a market of price-and-time-sensitive strategic customers. By analyzing equilibrium strategies, firm behaviors, and market outcomes, valuable insights emerge regarding the impacts of customer heterogeneity, production and storage capacities, and strategic pricing on firm profitability and industry dynamics. The findings highlight the trade-offs between competition and cooperation, with cooperation offering higher total payoffs for firms. Numerical experiments deepen our understanding of these dynamics, revealing the subtle implications of various parameters on market outcomes, firm profitability, customer benefit, and system efficiency.

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