Third-Party Retailers' Logistics Service Level Decision Considering Platform Private Brand Invasion Mode

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Abstract. E-commerce platforms are invading the market by introducing private brand, which has the potential to self-preference behavior. We introduce platform retailers' (PRs') private brand preferences into the Hotelling model and explore the third-party retailers' (TPRs') optimal logistics service level under two scenarios: PRs' fair invasion and PRs' biased invasion. The study shows that as PRs' private brand preference increases, TPRs' logistics service level will decline. When there is a fair invasion of platform private brands and consumers are sensitive to logistics service levels, TPRs may invest in logistics services as an anti-invasion tool to mitigate market share loss due to PRs' invasion. However, in a biased invasion scenario, TPRs may reduce their own logistics service levels. In particular, PRs' self-preference can be anti-competitive. Our findings may provide some theoretical support for TPRs' logistics service level decisions and government departments' regulation of platform firms' self-preferential behavior.

Keywords: private brand; platform self-preference; invasion mode; logistics service level.

1 Introduction

Currently, in order to turn flow into cash, e-commerce platforms operate in dual roles: on the one hand, the platform acts as a market intermediary to provide demand matching services for TPRs and consumers; on the other hand, the platform acts as a retailer to provide first-party products for consumers and create the platform's private brand. For example, in January 2018, JD launched its private brand "J.ZAO". Amazon launched its first private brand "Pinzon" as early as 2005. How platforms can be both good referees and good athletes is a challenge. [1]Sally Hubbard, an American antitrust expert, said in an interview with Marketplace Pulse that Amazon is using its platform privileges to make its own-brand products better than its competitors by distorting algorithm rankings, direct marketing to consumers. Overall, PRs choosing to enter marketplaces for private brand sales are bound to compete with TPRs.

Today, products are becoming increasingly homogeneous, and consumers are starting to pay for "products + services". [2]According to a survey by the National Retail Federation, two-thirds are currently paying for delivery services such as Amazon Prime or Shipt. Previous studies have shown that investment in logistics services plays an important role in the choice of consumer purchase channels and consumer demand[1-2]. We consider two different invasion methods of

[1] https://www.marketplacepulse.com/articles/amazon-is-a-monopoly-an-interview-with-sally-hubbard
[2] https://nrf.com/blog/3-ways-convenience-impacts-shopping-behavior

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PRs' private brands: one is fair invasion, where the platform does not impose any preference on private brands; the other is biased invasion, where the platform distorts search results by giving more traffic to private brand products, making private brand products superior to those of TPRs, which we call "private brand preference". Our study makes the following contributions: (1) Using the Hotelling model, PR's private brand preference is modeled as changing the distance between consumers and PRs so that its private brand products appear in the consumer's search interface first. (2) Using intra-group network externalities to quantify the negative effects of competition between PRs and TPRs. (3) Exploring how TPRs can maintain their market share by developing their own logistics service investment strategies in different invasion scenarios of PRs.

There are three streams of literature relevant to our study, namely dual-role platform, private brand and service level decision of supply chain. Hagiu [3] defined two business models of market intermediaries: the "merchant" model and the "bilateral platform" model. Some studies refer to them as "hybrid platform", "dual-role platform", etc., which are called "dual-role platform" in our paper. Tian et al. [4] studied whether online retailers should operate as distributors, or as online markets, or adopt both operating modes. Existing research shows that the impact of self-preference on consumers depends heavily on the form of self-preference and the market environment [5]. In terms of consumer surplus, platform preferences are always detrimental and consumers are likely to be mismatched when seller-consumer interests conflict [6]. Zennyo [7] thought that the platform's self-preference was not necessarily anti-competitive. On the contrary, they may be beneficial to competition.

Regarding private brands, it can not only improve the bargaining power of retailers when competing with national brands [8-10], but also help to alleviate the double marginal effect caused by national brands. Some scholars have explored the impact of brand differentiation [11], cost information asymmetry [12], and other factors on the introduction of retailers' private brands [13]. Other scholars argued that private brand introduction squeezes the market share and profits of national brand manufacturers [14]. However, another part of the empirical study found that national brand manufacturers do not necessarily suffer from the introduction of private brands, but rather benefit from them [15].

Many scholars have done a lot of research on the service level decision of supply chain. Liu and Xie [16] conducted a study on the service level optimization problem of functional logistics service providers and logistics service integrators under logistics service quality commitment on the service level decision of logistics service supply chain. Zhou et al. [17] studied pre-sales service level decisions in a dual-channel supply chain with free riding and service-cost sharing. Zhang et al. [18] proved that retail service investment is an effective anti-manufacturer encroachment measure for dominant retailers. Ali et al. [19] pointed out that potential market demand disruption has a significant impact on price and service level decisions of competing retailers.

2 Model Construction

2.1 Model description

We consider an e-commerce platform consisting of a PR and a representative TPR, where the PR competes with the TPR on the e-commerce platform by introducing its private brand products. In this paper, we consider how the TPR can resist the PR's invasion by changing its own logistics service level under two scenarios: fair invasion and biased invasion of the PR.

We assumed that the commission paid by the TPR to the platform is exogenous, denoted by c. Combined with the commission rate set by e-commerce platforms in reality, assume $c \le 30\%$. To simplify the model, we assume that the unit purchase cost and unit sales cost of both the PR and the TPR are zero, and the utility brought to the consumer by the product is large enough to ensure that each consumer can only purchase one unit of the product from one of the retailers [20]. All consumers make their purchase decisions independently, i.e., there is no correlation between consumers' decisions [21]. In this paper, we consider that the TPR first decides its logistics service level s_r and retail price p_r. Then the PR decides its invasion mode: fair invasion or biased invasion, and retail price p_o. We assume that the PR has its own logistics system and that its logistics service level s_o is exogenous. Referring to the research results of Tsay et al. [22], the investment cost of logistics services for retailers is $C_{(s_i)} = s_i^2 / 2$. The consumer's perceived value of the logistics service provided by the retailer is λs_i, which λ is the consumer's sensitivity to the logistics service level.

In this paper, we normalize the market size and use the Hotelling model to portray the heterogeneity of the cost of consumer visits to the two types of retailers, with platform retailers and third-party retailers located at the ends of the line and consumers uniformly distributed over the interval [0, 1]. Similar to Adner, Chen [23] study, it is assumed that the consumer's valuation v of the product is large enough to ensure that each consumer purchases one unit of the product. The consumer's preference for the purchase channel depends on his location, and t indicating the consumer's cost per unit of movement. Assume that the platform retailer's fair invasion cost is e_f and the biased invasion cost is e_b. In this paper, the platform retailer's private brand preference is defined as the platform's technical means to change consumers' online search order so that its own products are more likely to appear in consumers' search results, incurring a certain technical cost, so $e_b > e_f$. Using x_b to denote the degree of consumer mismatch caused by the platform retailer's private brand product preference.

Assume that conditions $\lambda^2 < 8t$ and $(3 - 2x_b)t \ge \lambda s_o$ hold to ensure that the retail price, logistics service level, and profit of each retailer are positive under equilibrium.

2.2 Model Analysis

When the platform invades, the utility of buying products from the PR and the TPR is $U_o = v - p_o - t(x - x_b) + \lambda s_o$ and $U_r = v - p_r - t(1 - x + x_b) + \lambda s_r$, respectively. By letting $U_r = U_o$ and solving for x, we can get the indifference point between buying the TPR's

products and the PR's private brand products as $x=\frac{p_r-p_o+t+\lambda\left(s_o-s_r\right)}{2t}+x_b$. When $x<1$, consumers in the range of $[0,x)$ choose to buy platform private brand products, and the demand for the PR's private products is $N_o=\int_0^x dx$, and consumers in the range of $(x,1)$ choose to buy the TPR's products, and the demand for the TPR's products is $N_r=\int_x^1 dx$. When $x\geq 1$, the market is completely covered by the PR, i.e., the PR becomes a monopolist. Similar to Su [24] study, we similarly assume that consumers will buy the product as long as its utility is not negative. That is, when $p_o^*=v-t\left(x-x_b\right)+\lambda s_o$, the PR can extract the maximum surplus of consumers.

Then, we derive the profit functions of the PR and the TPR as follows:

$$\pi_o^k=\begin{cases}p_oN_o+cp_rN_r-\frac{s_o^2}{2}-e_j, & x<1\\ v-t+\lambda s_o-\frac{s_o^2}{2}-e_j, & x\geq 1\end{cases} \tag{1}$$

$$\pi_r^k=\begin{cases}(1-c)\,p_rN_r-\frac{s_r^2}{2}, & x^F<1\\ 0, & x^F\geq 1\end{cases} \tag{2}$$

In addition, we can derive the consumer surplus and social welfare functions as follows:

$$CS^k=\begin{cases}\int_0^x\left(v-p_o-tx+\lambda s_o\right)dx+\int_x^1\left(v-p_r-t\left(1-x\right)+\lambda s_r\right)dx, & x<1\\ 0, & x\geq 1\end{cases} \tag{3}$$

$$\omega^k=\begin{cases}v+t\left(x-x^2-\frac{1}{2}\right)+\lambda s_ox+\lambda s_r\left(1-x\right)-\frac{s_o^2+s_r^2}{2}-e_j, & x<1\\ v-t+\lambda s_o-\frac{s_o^2}{2}-e_j, & x\geq 1\end{cases} \tag{4}$$

From equation (1) and (2), we can deduce that $\frac{\partial^2\pi_o^k}{\partial p_o^2}=-\frac{1}{t}<0$, $\frac{\partial^2\pi_r^k}{\partial p_r^2}=-\frac{1-c}{t}<0$, π_o^k and π_r^k are strictly concave functions with respect to p_o and p_r, respectively. Then, we can derive the TPR's optimal logistics service level $s_r^{k*}=\frac{\lambda\left(\left(3-2x_b\right)t-\lambda s_o\right)}{8t-\lambda^2}$, the TPR's optimal retail price $p_r^{k*}=\frac{4t\left(\left(3-2x_b\right)t-\lambda s_o\right)}{\left(1-c\right)\left(8t-\lambda^2\right)}$, the PR's optimal retail price $p_o^{k*}=\frac{2t\left(\left(5+c\right)t+\left(c-1\right)\lambda^2+\left(1-3c\right)\left(\lambda s_o+2tx_b\right)\right)}{\left(1-c\right)\left(8t-\lambda^2\right)}$, and the indifference point

$x^{k*}=\frac{5t-\lambda^2+\lambda s_o+2tx_b}{8t-\lambda^2}$. Letting $K=2t\left(\left(5+c\right)t+\left(c-1\right)\lambda^2+\left(1-3c\right)\left(\lambda s_o+2tx_b\right)\right)$, we can derive the optimal solutions for the TPR's profit (see equation (5)), the PR's profit (see equation (6)), the consumer surplus (see equation (7)) and the social welfare (see equation (8)).

$$\pi_r^{k*}=\begin{cases}\frac{\left(\lambda s_o-(3-2x_b)t\right)^2}{2\left(8t-\lambda^2\right)}, & x^*<1\\ 0, & x^*\geq 1\end{cases} \tag{5}$$

$$\pi_o^{k*}=\begin{cases}\frac{K\left(5t-\lambda^2+\lambda s_o+2tx_b\right)+4ct\left(\left(3-2x_b\right)t-\lambda s_o\right)^2}{\left(1-c\right)\left(8t-\lambda^2\right)^2}-\frac{s_o^2}{2}-e_j, & x^{k*}<1\\ v-t+\lambda s_o-\frac{s_o^2}{2}-e_j, & x^{k*}\geq 1\end{cases} \tag{6}$$

$$CS^{k*}=\begin{cases}v+\left(\lambda s_o-p_o^{k*}\right)x^{k*}+\left(\lambda s_r^{k*}-p_r^{k*}+tx^{k*}\right)\left(1-x^{k*}\right)-\frac{t}{2}, & x^{k*}<1\\ 0, & x^{k*}\geq 1\end{cases} \tag{7}$$

$$\omega^{k*}=\begin{cases}v+t(x^{k*}-(x^{k*})^2-\frac{1}{2})+\lambda s_o x^{k*}+\lambda s_r^{k*}(1-x^{k*})-\frac{s_o^2+(s_r^{k*})^2}{2}-e_j, & x^{k*}<1\\ v-t+\lambda s_o-\frac{s_o^2}{2}-e_j, & x^{k*}\geq 1\end{cases} \tag{8}$$

When the platform retailer invades fairly, $k=F$, $e_j=e_f$. And when the platform retailer invades biasedly, $k=B$, $e_j=e_b$.

Proposition 1: (1) $s_r^{B*}<s_r^{F*}$. The TPR's optimal logistics service level s_r^{B*} decreases with the degree of bias invasion of the PR's private brand x_b; (2) When there is a fair invasion of the PR's private brand, the TPR's optimal logistics service level s_r^{F*} increases with consumer' sensitivity to logistics service level λ; (3) When there is a biased invasion of the PR's private brand, the TPR's optimal logistics service level s_r^{B*} increases with consumer' sensitivity to logistics service level λ when $s_o<\frac{\left(8t+\lambda^2\right)\left(3-2x_b\right)}{16\lambda}$ and decreases with consumer' sensitivity to logistics service level λ when $s_o>\frac{\left(8t+\lambda^2\right)\left(3-2x_b\right)}{16\lambda}$.

Proposition 1 indicates that when the PR is biased to invade, the TPR will reduce the level of logistics services to make the marginal cost and marginal income of logistics service investment equal. And the relationship between the logistics service level of the TPR and consumers' sensitivity to logistics service level depends on the logistics service level of the PR and the degree of biased invasion. When both of them are large, the TPR's market share is low. At this time, it is not appropriate to invest too much to improve the logistics service level. However, when the PR invades fairly, considering the competitive relationship between the TPR and the

PR, the TPR has a stronger incentive to improve its logistics service level when the consumer's sensitivity to logistics service level increases, so as to gain more market share.

Proposition 2: Regardless of whether the PR is a fair invasion or a biased invasion, the TPR's optimal logistics service level s_r decreases with the PR's logistics service level s_o.

When the PR's logistics service level s_o rises, the indifference point moves to the TPR, and the PR's market share increases (see Proposition 3). At this time, the PR's retail price p_o will increase and the TPR's retail price p_r will decrease (see Proposition 4). In order to ensure an overall profit, the TPR will lower their logistics service level to reduce costs.

Proposition 3: $x^{B*} > x^{F*}$, the undifferentiated point x^{B*} increases with the PR's degree of invasion x_b and increases with the PR's level of logistics service s_o.

Proposition 3 shows that the PR's biased invasion and the improvement of logistics service level can make their own brand products closer to consumers, and increase the market encroachment of the PR, which in turn shrinks the TPR's market share.

Proposition 4: $p_r^{B*} < p_r^{F*}$, $p_o^{B*} > p_o^{F*}$, the PR's retail price p_o increases with the level of the PR's logistics service s_o, the platform commission rate c, and the degree of bias invasion x_b. The TPR's retail price p_r decreases with the level of the PR's logistics service s_o, the degree of bias invasion x_b, and increases with the platform commission rate c.

Proposition 4 shows that when the PR's logistics service level s_o and the degree of biased intrusion x_b increase, the PR has an incentive to increase the retail price to capture more profits. When the platform commission rate c increases, the TPR will transfer the cost to consumers by raising the retail price, while the PR will make the TPR's retail price rise further by raising the retail price of its own-brand products to earn more commission revenue.

Proposition 5: $\pi_r^{B*} < \pi_r^{F*}$, the PR's biased invasion always hurts the profit of the TPR, and the TPR's profit decreases with the degree of the PR's biased invasion x_b.

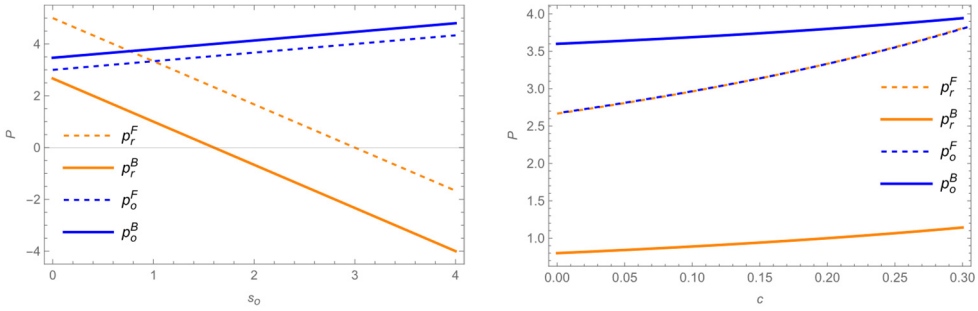
Proposition 5 shows that the PR's biased invasion shrinks the market share of the TPR, reduces the optimal retail price of the TPR, and leads to an overall loss of profit.

Proposition 6: When the PR has full possession of the market, the PR extracts all the surplus from the consumer. and there is always $\omega^{B*} < \omega^{F*}$.

Proposition 6 shows that the PR's biased invasion harms consumer surplus and social welfare. The reason is that the PR makes its own-brand products superior to those of the TPR through technological means, which excludes the TPR from the market, reduces consumers' choices. Therefore, the PR's excessive self-preference may be anti-competitive.

3 Numerical Analysis

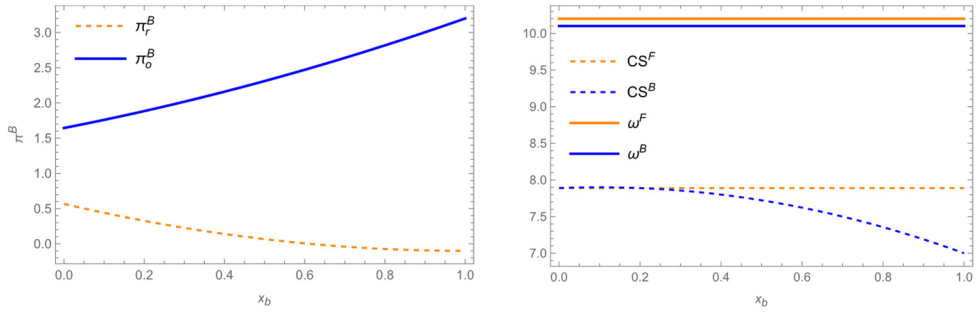
We set the benchmark parameters as follows: $v=10$, $c=0.2$, $\lambda=2$, $s_o=1$, $t=2$, $x_b=0.7$, $e_f=0.1$, $e_b=0.2$. Figure 1 simulates the impact of the PR's logistics service level s_o and commission rate c on the TPR's logistics service level and undifferentiated point, which confirms Proposition 4. Besides, we can see from Figure 1 that no matter what kind of retailer, they will transfer the additional costs, such as logistics service investment costs and commission costs, to consumers by raising the retail price.



(a) (b)

Fig. 1. Impact of s_o and c on retail prices of the TPR and the PR

Figure 2 simulates the impact of the PR's degree of biased invasion on each retailer's profit, consumer surplus, and social welfare, which confirms Proposition 5 and Proposition 7. Besides, we can learn from Figure 2(b) that the overall social welfare when the platform retailer has a biased invasion is lower than when the platform retailer has a fair invasion; consumer surplus is severely impaired when the platform retailer has a biased invasion.



(a) (b)

Fig. 2. Impact of x_b on each retailer's profits, consumer surplus and social welfare

4 Conclusions

In this article, we deeply investigate the TPR's logistics service level decisions under the PR's fair invasion and biased invasion scenarios. The following research findings are drawn: The

degree of biased invasion by the PR and the sensitivity of consumers to logistics service levels have important effects on the TPR's logistics service levels and the market share of each retailer. In particular, the PR's biased invasion leads to the decline of the TPR's logistics service level. When the PR invades fairly, the TPR can use logistics service investment as an anti-invasion tool to mitigate the market share reduction caused by the PR's invasion. However, when the PR invades in a biased manner, the TPR needs to increase or decrease its logistics service level in a targeted manner according to the level of biased invasion and logistics service level of the PR. In particular, when the PR's invasion cost can be ignored, the PR's excessive self-preference always increases the PR's profits and decreases the TPR's profits, consumer surplus, and overall social welfare. It can be argued that the PR's excessive self-preference behavior is anti-competitive, creating a crowding-out effect on the TPR.

Considering the rising consumer demand for logistics service levels, the TPR can adopt a differentiated target market positioning strategy. The target market can be located in consumer groups with higher sensitivity to logistics service level to avoid head-to-head competition with the PR. The manifestations of platform self-preference behavior are increasingly diverse, and the illegal boundaries are vague. Government departments should pay attention to the potential competitive harm caused by e-commerce platforms' cross-business integration and continue to introduce relevant laws and regulations to regulate platforms' anti-competitive behavior and prevent enterprises with market power from unfairly transferring consumers' wealth.

Future research could consider the impact of TPRs' fairness concerns on the PRs' invasion behavior within a framework of consumer and third-party retailer volume endogenization. In addition, future research may consider the retailer's choice of logistics service mode under the above research situation.

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References

[1] Yan, B., Chen, Z., Wang, X. & Jin, Z: Influence of logistic service level on multichannel decision of a two-echelon supply chain. International Journal of Production Research. pp. 3304-3329 (2020)
[2] Shu, L., Qu, S., & Wu, Z.: Supply Chain Coordination with Optimal Pricing and Logistics Service Decision in Online Retailing. Arabian Journal for Science and Engineering. pp. 2247-2261 (2020)
[3] Hagiu, A.: Merchant or Two-Sided Platform? Review of Network Economics. pp. 115-133 (2007)
[4] Tian, L., Vakharia, A. J., Tan, Y. R. & Xu, Y: Marketplace, Reseller, or Hybrid: Strategic Analysis of an Emerging E-Commerce Model. Production and Operations Management. pp. 1595-1610 (2018)
[5] Kittaka, Y., Sato, S. & Zennyo, Y: Self-preferencing by platforms: A literature review. Japan and the World Economy. pp. 101191 (2023)
[6] Cornière, A. & Taylor, G: A model of biased intermediation. The RAND Journal of Economics. pp. 854-882 (2019)
[7] Zennyo, Y: Platform Encroachment and Own-Content Bias*. The Journal of Industrial Economics. pp. 684-710 (2022)

[8] Ailawadi, K. L. & Harlam, B: An Empirical Analysis of the Determinants of Retail Margins: The Role of Store-Brand Share. Journal of Marketing. pp. 147-165 (2004)
[9] Meza, S. & Sudhir, K: Do private labels increase retailer bargaining power? Quantitative Marketing and Economics. pp. 333-363 (2010)
[10] Wei, J. & Xu, Z: How does manufacturer's self-operating channel interact with platform retailer's E-commerce brand introduction? Transportation Research Part E: Logistics and Transportation Review. pp. 102951 (2022)
[11] Choi, S. & Fredj, K: Price competition and store competition: Store brands vs. national brand. European Journal of Operational Research. pp. 166–178 (2013)
[12] Cao, Z., Wang, Y., Zhao, J. & Min, J: Store brand introduction and quantity decision under asymmetric cost information in a retailer-led supply chain. Computers & Industrial Engineering. pp. 106995 (2021)
[13] Cheng, F., Chen, T., Shen, Y. & Jing, X: Impact of green technology improvement and store brand introduction on the sales mode selection. International Journal of Production Economics. pp. 108587 (2022)
[14] Chung, H. & Lee, E: Effect of Store Brand Introduction on Channel Price Leadership: An Empirical Investigation. Journal of Retailing. pp. 21-32 (2018)
[15] Zhou, Y., Liu, T. & Cai, G: Impact of In-Store Promotion and Spillover Effect on Private Label Introduction. Service Science. pp. 96-112 (2019)
[16] Liu, W. H. & Xie, D: Quality decision of the logistics service supply chain with service quality guarantee. International Journal of Production Research. pp. 1618-1634 (2013)
[17] Zhou, Y. W., Guo, J. & Zhou, W: Pricing/service strategies for a dual-channel supply chain with free riding and service-cost sharing. International Journal of Production Economics. pp. 198-210 (2018)
[18] Zhang, S., Zhang, J. & Zhu, G: Retail service investing: An anti-encroachment strategy in a retailer-led supply chain. Omega. pp. 212-231 (2019)
[19] Ali, S. M., Rahman, Md. H., Tumpa, T. J., Moghul Rifat, A. A. & Paul, S. K: Examining price and service competition among retailers in a supply chain under potential demand disruption. Journal of Retailing and Consumer Services. pp. 40-47 (2018)
[20] He, P., Zhang, S. & He, C: Impacts of logistics resource sharing on B2C E-commerce companies and customers. Electronic Commerce Research and Applications. pp. 100820 (2019)
[21] Hotelling H: Stability in Competition. The Economic Journal. pp. 41-57 (1929)
[22] Tsay, A. A. & Agrawal, N: Channel Conflict and Coordination in the E-Commerce Age. Production and Operations Management. pp. 93-110 (2009)
[23] Adner, R., Chen, J. & Zhu, F: Frenemies in Platform Markets: Heterogeneous Profit Foci as Drivers of Compatibility Decisions. Management Science. pp. 2432-2451 (2020)
[24] Su, X: Consumer Returns Policies and Supply Chain Performance. Manufacturing & Service Operations Management. pp. 595-612 (2009)