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Seeking survivals under COVID-19: The WhatsApp platform's shopping service operations

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Abstract

Under COVID-19 outbreak, retail operations are seriously threatened. There are lots of cases in which physical stores basically have to stop operating. This creates problems to the firm, its employees, and consumers. Recently, Timberland in Hong Kong and various other brands such as Joyce Boutiques and The North Face have established the "*WhatsApp Shopping Service Operation*" (WSO) in which consumers can shop by using the well-established communication tool "WhatsApp." Salespeople in stores provide services via WhatsApp to assist the consumers without them having to visit the stores. We collect primary data from real-world cases and theoretically explore WSO. We build a standard consumer utility based model to derive the firm's optimal pricing and employment decisions under different cases. We evaluate the impacts of COVID-19 and values of WSO implementation from the "*Worker-Consumer-Company*" (WCC) welfare perspective. Our results interestingly imply that WSO is superior to the traditional online channel in terms of keeping business under the pandemic; meanwhile, implementing WSO can help stimulate demand in the physical store under COVID-19. However, whether WSO is effective to help increase the firm's profit and WCC welfare depends on both consumer type' distribution and consumers' fear of infection. When consumers' fear of infection is very polarized (i.e., extremely low or high), WSO is not recommended. We further propose that the government's subsidy for WSO implementation could be an effective way to help the firm improve its profit and WCC welfare. We also check the robustness of our study by extending the model to consider endogenous consumer type, endogenous service level, and WCC-welfare-oriented firm.

KEYWORDS

COVID-19, innovative models, retail operations, service operations, WhatsApp, workers welfare

1 | INTRODUCTION

1.1 | A motivational case

During the COVID-19 pandemic, physical store operations suffer a lot. During the times when people are warned to stay at home with government offices and schools all closed, retail businesses are facing an unforeseeable and unimaginable challenge (Pournader et al., 2020; Choi, 2021a; Mitręga & Choi, 2021). In Hong Kong, a recent report shows that retail business dropped by one third for the first half of 2020 (Hong Kong Business, 2020). Owing to the pandemic, lots of fashion brands, like Topshop, Victoria's Secret, Prada, and LV, have closed or planned to close shops in Hong Kong and other cities (Chen, 2020). It is hence important for retail firms to seek survivals under the COVID-19 pandemic.

Timberland is an internationally famous fashion brand, which possesses an image of "English heritage." It sells products ranging from apparel, boots, and shoes to gear. It was born in 1978 when Abington Shoe Company became The Timberland Company. Its headquarters is located in New Hampshire, USA. In Hong Kong, Timberland operates 21 stores and outlets (P.S.: Timberland.com.hk) in major shopping plazas such as Times Square, Ocean Terminal, New Town Plaza, etc. It is important to note that the rental fees in Hong Kong are among the highest in the world. The operating expense of Timberland Hong Kong is hence substantial. Similar to other brands, Timberland definitely faces high pressure under the COVID-19 pandemic period.

Timberland Hong Kong's sales volume mainly relies on bricks-and-mortar stores even though it does have its official sales website. This is quite common in crowded cities like Hong Kong as consumers enjoy window shopping and it is easy and convenient to shop in the "normal days." From social media advertisement such as Facebook, it is interesting to note that Timberland Hong Kong has launched the "WhatsApp Shopping Service Operation" (WSO) recently. Unlike the traditional online selling strategy, WSO relies on physical stores and the staff members there (Choi & Sethi, 2021). Specifically, Timberland Hong Kong offers WSO to "the designated stores," which represent most of the stores in major plazas. Moreover, WSO is available during business hours only. Obviously, it is an innovative strategy to allow consumers to buy via sending WhatsApp messages to the individual stores. Salespeople in the stores will check consumers' requests and orders and then provide recommendations. It is very manual-based, while it fits the "fashion boutique" style in which consumers commonly treasured salesperson's advice and services, especially the ones they know well (Goff et al., 1997). Using WhatsApp as the means of ordering also allows more flexible time for the staff members to check inventory and provide advice, without jamming all the phone lines. Details of products (photos, price, etc.) can also be conveniently shared and discussed. WSO is not the "patent" for Timberland Hong Kong. A multitude of brands including The North Face, Terre Bleue, and FILA, etc., have launched WSO for consumers all over the world.[1]

WSO can be supported by the new service, namely WhatsApp Business, which enables all sizes of firms to connect with their consumers. Firms, which join the WhatsApp Business service, can report catalogs of products in their accounts for consumers to browse as well as talk to consumers through individual stores' business accounts.[2] For instance, Timberland (Hong Kong and Malaysia) and The North Face (Hong Kong) are featuring WSO supported by the WhatsApp Business service. Besides, WSO can be run simply by chatting with consumers through ordinary WhatsApp accounts. In this way, product information is usually provided on firms' official websites in the form of catalogs, such as FILA (Singapore), or introduced by physical stores' salespeople, such as Terre Bleue (Belgium). Even though different formats of WSO are adopted by firms, the features related to order fulfillment, delivery, engagement of physical stores, and sales service are basically the same. Consumers commonly experience similar shopping services provided by physical stores' salespeople under these two operating formats.

Note that WSO is strikingly different from traditional online channels from the perspectives of engagement of physical stores and salespeople. WSO is an approach, which offers a chance for physical stores to combat the impacts brought by COVID-19. Comparing with traditional online channels (e.g., the official website and third-party platforms), WSO highly depends on the service provided by salespeople in physical stores. This feature is attractive. From the consumers' side, by chatting with salespeople through WhatsApp, they can experience almost the same service from physical stores without fears of infection. As a result, WSO would provide a service level higher than the one provided by the traditional online channel. From the firm's side, the implementation of WSO enables physical stores to (i) keep businesses in physical stores and (ii) let salespeople continue to work, even when there is no consumer visiting the physical store. In addition, based on real-world observations, we notice that consumers can always enjoy the free delivery through WSO while they may need to pay for the delivery cost by themselves through traditional online channels. We summarize the features of WSO compared with traditional online sales channels from the aspects of engagement of physical stores, sales service, and delivery in Table A1 (in Online Appendix A) based on the observed real-world industrial practices.

Unemployment is a serious social problem, which is getting increasingly worse during COVID-19. It is reported that the US unemployment rate has risen sharply from 3.8% in February 2020 to around 15% in May 2020 (Kochhar, 2020). Under this circumstance, the whole society and government are desperate for firms to take more social responsibilities and focus on the issue of workers' welfare. Consequently, seeking a way to maintain the employment level and offset consumer's concerns about COVID-19 is the biggest challenge faced by firms with social welfare in mind (Choi, 2021b). Specifically, firms should pay attention to general welfare of the people (e.g., consumer and workers' welfare) so as to achieve sustainability and bear the needed social responsibility under the COVID-19 pandemic (Lee, 2020). It requires firms to have a deep understanding of the impacts of COVID-19 on the firm's operations strategies (e.g., pricing, employment level), profit, consumer welfare, as well as workers' welfare (Feng et al., 2021). In this paper, we examine the impacts of COVID-19 and explore the values of WSO on firm's operations, aiming at providing useful managerial insights for the firm to combat the challenges that we mentioned above.

1.2 | Research questions and major findings

Motivated by the real case on WSO in Timberland Hong Kong and various other retailers as a way to cope with COVID-19, we theoretically explore the respective real-world operations. We analytically consider three models, namely the model without COVID-19 and the firm operates a pure physical store (Model PPS), the model with COVID-19 and the firm operates a pure physical store (Model PPS-C), and the model with COVID-19 and the firm operates WSO (Model WSO). We attempt to answer the following research questions.

[1] Firms who adopt WSO provide similar services as Timberland Hong Kong and details of their WSO are provided in the Appendix.

[2] https://blog.whatsapp.com/shopping-payments-and-customer-service-on-whatsapp/?lang=en, accessed on 19 April 2021.

1. What are the impacts of COVID-19 on the firm's physical store operations? What are the values of WSO for the multiple-channel firm amid COVID-19?
2. How to improve the performance of WSO adoption in terms of the firm's profit and social welfare?
3. Extending the model analyses to the cases when (i) consumer types are endogenous, (ii) the firm endogenously decides service level, and (iii) the firm is WCC-welfare-oriented, will the main findings remain valid?

Based on a standard consumer utility based model, we derive the firm's optimal pricing and employment level decisions by maximizing the firm's profit under three cases, namely Models PPS, PPS-C, and WSO. We first verify the inevitable damages caused by COVID-19 to the firm's physical store operations. Then, we interestingly uncover that, when the firm makes a centralized decision for both "WSO/online" and "offline" operations, WSO is superior to traditional online channels (e.g., the official website) in terms of keeping business under COVID-19, which shows the significance of this new business mode. Besides, we find that the implementation of WSO can stimulate demand in the physical store channel when consumers have a higher fear of infection. This finding is counter-intuitive as the conventional wisdom may suggest that WSO will snatch the demand of physical stores as a portion of consumers will switch to purchase through WSO. While in fact, the high consumers' fear of infection prompts the firm to improve its total service level when implementing WSO, which eventually stimulates the demand for the whole firm (which includes the physical store). This result highlights the significance of implementing WSO as it can help eliminate the demand reduction in physical stores caused by COVID-19.

However, WSO implementation is not always recommended for the firm in terms of increasing profits and social welfare; whether it is valuable to adopt WSO depends on both consumers' fear of infection and consumer type' distribution. We define the profit-welfare-improvement (PWI) outcome for the case in which both the firm's profit and Worker-Consumer-Company (WCC) welfare can be improved simultaneously. Our results show that the PWI outcome can be achieved only when the consumers' fear of infection is moderate and there are more WSO type consumers in the market. Particularly, when the consumers' fear of infection is moderate while there are fewer WSO type consumers in the market, we suggest the government adopts an incentive mechanism (e.g., providing a subsidy) to support the firm's WSO implementation, which can be an effective way to help the firm survive COVID-19 as well as improve WCC welfare. However, when the consumers' fear of infection is polarized (i.e., extremely low or high), WSO is never recommendable.

Moreover, our results imply that WSO is more valuable for the firm with a lower service improvement cost coefficient than the higher one, as the lower service improvement cost coefficient encourages the firm to hire more salespeople, which is beneficial to the consumer and workers' welfare. We also suggest the firm enlarges the number of WSO type consumers, for example, by advertising more about WSO mode, so as to boost its total profit. Finally, by extending the model to consider endogenous consumer type, endogenous service level, and WCC-welfare-oriented firm, we successfully prove the robustness of our study. Surprisingly, we find that the WCC-welfare-oriented firm is superior to the profit-oriented firm in terms of keeping business (i.e., having positive demand); whereas the implementation of WSO is not helpful to improve WCC welfare when the production cost of the WCC-welfare-oriented firm is relatively high.

1.3 | Primary data and research method

This operations management (OM) study is motivated by the real practices from Timberland Hong Kong. In constructing the theoretical model and discussion of findings, close attention is paid to the corresponding operations details. We have also talked to the salespeople of Timberland Hong Kong to learn more of the details and hence this paper is not solely theoretical, but also very practical. The analysis also follows the mainstream OM literature with robustness testing. Of course, similar to other analytical OM studies, we do make various common assumptions in constructing the models (e.g., the consumer utility function) and hence we also admit the respective limitations.

Specifically, we conducted two open-ended interviews with salespeople, who are responsible for the WhatsApp shopping service, in two different stores in Hong Kong through WhatsApp. One of the interviews was conducted by indicating our research intention (V City Tuen Mun store), while the other was conducted when we were consumers (Tuen Mun Plaza store). Through the open-ended interviews and discussions, we aim to investigate the (i) changes that COVID-19 brings to Timberland retail stores, (ii) changes that the WhatsApp shopping service brings to Timberland retail stores, and (iii) details of the operations for the WhatsApp shopping service including the launching time and approach. In the following, we summarize the interview content with salespeople in two different stores in Table 1.[3] The interview results basically validate our observations of industrial practice and model settings. In particular, we note that WSO is a reactive action to cope with COVID-19.

1.4 | Contribution statements and paper arrangement

WSO is an innovative operations model, which is also a measure to deal with COVID-19. To our best knowledge, this study is the first one in the operations management (OM) and decision sciences literature which examines WSO under COVID-19. We analytically verify the significance of adopting WSO to dampen the negative impacts brought by

[3] The interview guide, descriptions of interview and original data of the interview were provided in Review-Only Materials.

TABLE 1 Interview results

Objectives	V City Tuen Mun store	Tuen Mun Plaza store
1. Changes that COVID-19 brings to salespeople, consumers, and physical stores.	- Salespeople started to sell products through WhatsApp. - Fewer consumers visit the physical store due to the fear of infection. - The physical store is seriously affected.	- Salespeople started to sell products through WhatsApp. - Consumers can purchase products without going to the physical store. - One of the reasons for physical stores to adopt the WhatsApp shopping service is COVID-19.
2. Changes that WhatsApp shopping brings to salespeople, consumers, and physical stores.	- Salespeople provide service to consumers through WhatsApp. - Physical stores have the other approach to sell products.	- Salespeople make recommendations to consumers by taking pictures and sending official website links. - Consumers have the other choice for purchasing from the Internet. - The physical stores pay for the delivery cost.
3. When to implement WhatsApp shopping?	After COVID-19 pandemic.	After COVID-19 pandemic.
4. Where do the salespeople provide service to WhatsApp consumers?	In the physical store.	In the physical store.

COVID-19 on retail operations (e.g., eliminating the demand reduction in physical stores, increasing total profits, etc.) as well as provide scientific guidance for firms and policy makers on the implementation of this new model. In addition, we take the special consideration of workers' welfare when evaluating the welfare performance in our research, which is crucial under COVID-19 while it is still underexplored in the OM literature. We believe that the derived insights not only contribute to the literature, but also provide important reference to operations managers for the potential applications and values of WSO under the COVID-19 pandemic.

This paper is organized as follows. Section 2 includes the related literature. Section 3 shows the basic analytical models. Section 4 presents the analyses and findings. Section 5 extends this study in various critical directions, including the case when (i) the consumer type is endogenous according to consumers' choices (EC), (ii) the firm endogenously decides its optimal service level (ES), and (iii) the firm is WCC-welfare-oriented (WO). Section 6 concludes the whole piece of the research study with a discussion on "generalization," managerial insights, and future research directions. The proofs of all formal analytical results and supplementary materials are placed in Online Appendix A.

2 | LITERATURE REVIEW

This research is closely related to three streams of OM studies: (i) multichannel operations, (ii) workers' welfare in OM, and (iii) operations strategy under COVID-19.

Our work exactly is close to multichannel operations,[4] which have been well adopted in the industry with the development of e-commerce and m-commerce in recent years (Schoenbachler & Gordon, 2002 Tsay & Agrawal, 2004;). Especially, multichannel operations is important to discuss under the pandemic, as it can improve the firm's efficiency when facing demand uncertainty (Chopra et al., 2021). Under the multichannel operations, channel selection, competition, and cooperation are important for sellers (Coughlan, 1985). For example, Shen et al. (2019) explore the channel selection in a supply chain where a manufacturer can choose to cooperate with an online platform and a traditional physical store retailer to sell products. The optimal wholesale price and retail price are explored under two bargaining models between the manufacturer and the online platform. Moreover, single retailers' channel selection when faced with multichannel operations has been explored widely (Zhang et al., 2017; Wang et al., 2020). For example, Zhang et al. (2017) analytically study the retailer's channel choice with the consideration of consumers' acceptance level of the online channel by defining it to three levels. On the other hand, service and pricing are crucial strategies for multichannel sellers to improve profits (Yan & Pei, 2009). For example, Chen et al. (2017) explore the delay time as the core service factor, which affects the supply chain's channel choice. The information provision service and pricing decisions are considered in Zhang et al. (2020) for an omnichannel seller that sells products through both online and physical showrooms. Several studies pay attention to studying the effect of service on the coordination of multichannel operations. For instance, Li et al. (2016) examine the optimal channel structure design, from the perspective of service value, for a supply chain consisting of the manufacturer, retailer, and a third party. The authors verify that the optimal channel structure is affected by the service cost. Hsiao and Chen (2014) analytically study the channel coordination challenge when the manufacturer establishes an online channel with a service cost. The authors argue that the manufacturer's implementation of the online channel might induce consumers to transfer from online to offline. Lin et al. (2021) study the effect of service level for competitive retailers in a supply chain with unethical collusion.

[4] To be noticed that, the cross-channel phenomenon exists in the WSO case, which is represented by consumers online (e.g., WhatsApp) are served by salespeople from the physical store. While the consumer, firm, and salesperson themselves have not cross-channel behaviors and which is different from the definition of omnichannel operations (Beck & Rygl, 2015).

They find that incorporating a platform is effective to leverage the service competition of two retailers. Different from the pertinent research mentioned above, our paper explores the workers' effects on service improvements for the multichannel seller who sells its products through the physical store and the online channel (WhatsApp). Our study verifies the significance of implementing WSO to combat COVID-19, with a goal to avoid the physical stores from closing, for example, keeping demand, improving workers' welfare. Moreover, during the COVID-19 pandemic, consumers are caring more about salespeople's service, and firms are paying more attention to employee management. Therefore, how the service provided by workers as well as how to manage employment level can influence the firm's multichannel operations strategy is important to explore.

Workers' welfare is unattended when the social environment is stable; however, in turbulent environments (e.g., during COVID-19 pandemic), firms face immediate intense pressure to take social responsibilities and pay more attention to workers' welfare (Freeman & McVea, 2001; Huq et al., 2016; Choi & Sethi, 2021). It is hence urgently needed to explore workers' welfare in OM. Jiang et al. (2009) investigate suppliers' labor problems in developing countries, which may incur three kinds of risks: cost risk, operational risk, and reputational risk. Based on empirical analysis, the authors provide several implications for labor evolution in developing countries. Gao and Su (2018) establish a theoretical model to study the impact of self-order technologies on omnichannel's service operations management, especially on workers' employment issues. Despite public opinion suggesting that self-order technologies facilitate job cuts, the results indicate that firms with high capacity costs should have a greater incentive to improve their employment levels with the implementation of self-order technologies. In addition, Jiang et al. (2020) and Benjaafar et al. (2021) focus on workers' related issues in on-demand platforms. By developing analytical models, Jiang et al. (2020) examine how behavioral biases such as regret aversion influence workers' relocation decisions in on-demand platforms, while Benjaafar et al. (2021) provide guidance to regulators under the consideration of labor welfare in on-demand platforms. Similar to Benjaafar et al. (2021), we pay attention to workers' welfare related to their wages, while differently, we explore under a totally different context of COVID-19 pandemic and WSO. Besides, we try to figure out the optimal employment level for the firm, which is similar to Gao and Su (2018).

Operations strategy under COVID-19 is a relatively new topic, which is still underexplored; only a few papers have worked on it. As reported by a recent Harvard Business Review article, COVID-19 pandemic has dropped consumer confidence and reshaped their behavior (Carlsson-Szlezak et al., 2020). Considering the impacts of COVID-19, Choi (2020) establishes an analytical model that captures consumer's purchasing decisions with regard to hygiene level and average distance to the firm. His research shows the values of "bring-service-near-your-home" operations for small service providers to survive COVID-19. Singh et al. (2020) integrate the consumers' flexibility of purchasing in a public distribution system network, aiming at evaluating the influence of COVID-19 on food supply chain. Moreover, how the supply chain should prepare for and respond to the crisis of pandemic is crucial (Craighead et al., 2020). In order to provide a scientific basis to support local operations decisions, Kaplan (2020) builds scratch models to assess the impacts of COVID-19 on different applications including hospital surge planning, event crowd-size restrictions, timing decisions, etc. Ivanov and Das (2020) analytically examine the ripple effect of COVID-19 in supply chain; they propose risk mitigation measures and potential recovery paths for supply chain operations under the COVID-19 pandemic. Govindan et al. (2020) and Bag et al. (2021) pay attention to the healthcare supply chain (HSC) operations. The former develops a practical decision support system for a HSC, aiming at eliminating the negative effects (e.g., disruption risks) caused by COVID-19, and the latter empirically shows the important role of innovative leadership for HSC resilience under COVID-19. Similar to Choi (2020) and Singh et al. (2020), we highlight the impact of COVID-19 on consumer behavior in our research, that is, the consumers' fear of infection will negatively influence their purchasing decisions. However, distinct from all existing literature, we innovatively explore the impacts of COVID-19 on multichannel service operations. We figure out the inevitable damages caused by COVID-19 on the firm's physical store operations as well as the potential benefits brought by the implementation of WSO. Particularly, we pay attention to the welfare in firms' operations including consumer and workers' welfare, which is critically important under COVID-19 but has never been examined before.

3 | BASIC MODEL

We consider a firm that employs y salespeople to provide services and sells the product with a unit retail price p. The unit service level of each salesperson is exogenously given by s. (We provide the meaning of notation, subscript, and superscript used in this paper in Table A2 in Online Appendix A.) This setting captures the fact that many retail brands tend to set a fixed standard for sales service based on their operations principles. For example, Uniqlo has its standard-format for consumer services (e.g., standard service skills) (Fast Retailing Annual Report, 2007). In our own discussions with the industry, the same situation is commonly noted in many department stores and retailers. We will relax this assumption and consider the case in which the firm decides unit service level endogenously in the extended model analysis (Section 5). The firm's total service level that can be realized is given by $T = ys$, which means that the total service level is measured by the employment level and service level of each salesperson. This setting is reasonable because when more salespeople are present, quicker service responses in both the physical store and WhatsApp can be achieved. To improve the total service level, the firm needs to bear a cost $IC(T)$. This service improvement cost follows an

increasing convex function, and hence we have $IC'(T) > 0$ and $IC''(T) > 0$. The increasing convex property reflects that the cost increases when the marginal service level is improved, and it is costly for the firm to seek higher and higher improvement of service level. For tractability, we follow the literature (such as Li & Wan, 2017) to consider $IC(T) = \lambda T^2 = \lambda(ys)^2$ in the following analysis, where $\lambda > 0$ is the coefficient of service improvement cost. The salespeople's wage is comprised of two parts: (i) a fixed wage f for each person, and (ii) a piece-rate wage β depending on the demand.[5] As we mentioned in the introduction, it is the firm's responsibility to achieve social sustainability (including both the consumer and workers' welfare) under the COVID-19 pandemic. Here, pricing affects consumer welfare and staffing influences workers' welfare. So, it requires the firm to make careful decisions on both pricing and employment level, which are two factors directly influencing the consumer and workers' welfare in operations. Hence, in our model, we suppose that the firm initially sells its product through physical stores purely, while having the choice to conduct WSO (or not) under the COVID-19 pandemic; then, the firm decides the retail price p and employment level (i.e., no. of salespeople) y simultaneously to maximize its profit with the consideration of unit production cost c.

The market size is normalized to be 1. Consumers are heterogeneous in their valuation v for the product, which is drawn from a uniform distribution: $v \sim U[0, 1]$. They make purchasing decisions based on their utilities, which depends on the price p, total service level sy, and other considerations under different scenarios. For instance, consumers will receive a fear of infection ξ when going to physical stores under COVID-19, while having a trust discount t when shopping through WSO because of unfamiliarity and concerns (e.g., information privacy concerns, authenticity concerns, etc.) during shopping under WSO. We hence classify two types of consumers called "store type" and "WSO type" corresponding to features of consumer's concerns accordingly. Similar to Nageswaran et al. (2020), our basic model assumes that a consumer is of the WSO type with an exogenously given proportion θ, which captures consumers' inherent preference for one mode of shopping (over the other) with a particular firm, and $\theta \in [0, 1]$. We will further explore the case in which θ is endogenously determined in the extended model in Section 5. If a consumer does not purchase the product, the utility is zero. In our paper, we consider that the firm first decides the selling price and the employment level simultaneously, and then consumers make their purchasing decisions according to their utilities. (We provide Figure A1 in Online Appendix A that depicts the sequence of events.)

Before proceeding with deeper analysis, we propose the novel concept of Worker-Consumer-Company (WCC) welfare, which is defined as the summation of the firm's profit π, consumer surplus CS, and workers' welfare WW. We regard WCC welfare as an important indicator that can be used to reflect the firm's social welfare performance with the special consideration of workers' welfare (Benjaafar et al., 2021). This concept is especially crucial under the outbreak of COVID-19, as in such a turbulent environment, the firm faces intense pressure to take corporate social responsibilities and should focus more on workers' welfare (Freeman & McVea, 2001; Huq et al., 2016). Then, in order to reveal how COVID-19 pandemic and the new WSO mode would affect the firm's operations performance, we explore the following three cases in our basic model: (i) without COVID-19 and the firm operates a pure physical store (Model PPS), (ii) with COVID-19 and the firm operates a pure physical store (Model PPS-C), and (iii) with COVID-19 and the firm operates WSO (Model WSO). We also compare WSO with the traditional online channel to evaluate the significance of this new operational mode under COVID-19.

[5] This setting is consistent with the real-world practice based on our interview results (refer to Review-Only Materials).

3.1 | Model PPS

Without COVID-19 (denoted as $\overline{COV}$), the firm usually sells its product through the pure physical store. The consumers make their purchasing decisions based on utility function: $U_{PPS}^{\overline{COV}} = v - p + ksy$, where k represents consumer's sensitivity to the sales service for store shopping. Note that this linear utility function which is decreasing in selling price and increasing in total service level is commonly used in the service operations literature, for example, Tsay and Agrawal (2000), Hua et al. (2016), etc. The consumers will make the purchase when they receive a positive utility, that is, $U_{PPS}^{\overline{COV}} > 0$, otherwise, they will buy nothing. Hence the demand under Model PPS can be realized as $D_{PPS}^{\overline{COV}} = \int_{p-ksy}^{1} f(v)dv = 1 - p + ksy$. Thus, the firm's total profit is:

$$\pi_{PPS}^{\overline{COV}}(p, y) = \left(p - c - \beta\right)(1 - p + ksy) - \lambda s^2 y^2 - fy,$$

which is equal to the total income of physical stores minus the total operations costs (i.e., service improvement cost and salespeople's wage).

Under Model PPS, the consumer surplus ($CS_{PPS}^{\overline{COV}}$), workers' welfare ($WW_{PPS}^{\overline{COV}}$), and WCC welfare ($WCC_{PPS}^{\overline{COV}}$) are, respectively, given as follows:

$$CS_{PPS}^{\overline{COV}} = \int_{p-ksy}^{1} (v - p + ksy) f(v)\, dv = \frac{1}{2}(1 - p + ksy)^2;$$

$$WW_{PPS}^{\overline{COV}} = fy + \beta D_{PPS}^{\overline{COV}} = fy + \beta(1 - p + ksy);$$

$$WCC_{PPS}^{\overline{COV}} = \pi_{PPS}^{\overline{COV}} + CS_{PPS}^{\overline{COV}} + WW_{PPS}^{\overline{COV}}.$$

Note that, in all the following analyses, we consider the case when $\lambda > \frac{k^2}{4}$, which means that service improvement is costly, and it is infeasible to increase the service level indefinitely. This assumption is reasonable as in practice, improving service level usually incurs a non-trivial and sufficiently high cost, for example, investment in resources (Xia et al., 2017). Having this assumption also ensures the concavity of the firm's profit function. By maximizing the firm's total profit, we derive Lemma 1.

Lemma 1. *(i) The firm's optimal retail price and employment level are* $p_{PPS}^{\overline{COV}*} = \frac{s[(2\lambda-k^2)(c+\beta)+2\lambda]-fk}{s(4\lambda-k^2)}$ *and* $y_{PPS}^{\overline{COV}*} = \frac{ks(1-c-\beta)-2f}{s^2(4\lambda-k^2)}$, *respectively. (ii)* $D_{PPS}^{\overline{COV}*} \geq 0$ *if and only if* $\beta \leq \beta_{PPS}^{\overline{COV}}$, *where* $\beta_{PPS}^{\overline{COV}} = 1 - c - \frac{fk}{2s\lambda}$.

Lemma 1(i) presents the optimal decisions for the case without COVID-19, by setting which the firm can earn its maximum profit. From Lemma 1(ii), we find that the demand is positive if and only if the salesperson's piece-rate wage is not too high; in other words, the firm will lose all the business if it pays a sufficiently high piece-rate wage to salespeople. This is because the firm tends to reduce the employment level of the salesperson if the payment is high, which will drive away consumers because of the low total service level.

3.2 | Model PPS-C

We consider the case in which the firm still operates a pure physical store under the COVID-19 pandemic (denoted as *COV*). In this scenario, the consumers who go to the physical store and make the purchase will get a fear ξ due to the pandemic.[6] Here, ξ refers to the fear of infection, which makes the consumers avoid accessing the public places under the pandemic (Lazzerini et al., 2020). This setting is also consistent with our interview results that show that fewer consumers visit the physical store after COVID-19 (see Table 1). Thus, consumer utility can be realized as $U_{PPS}^{COV} = v - p + ksy - \xi$, and the corresponding demand is $D_{PPS}^{COV} = \int_{p-ksy+\xi}^{1} f(v)dv = 1 - p + ksy - \xi$. Consequently, the firm's total profit is:

$$\pi_{PPS}^{COV}(p, y) = \left(p - c - \beta\right)\left(1 - p + ksy - \xi\right) - \lambda s^2 y^2 - fy,$$

consumer surplus is:

$$\begin{aligned} CS_{PPS}^{COV}(p, y) &= \int_{p-ksy+\xi}^{1} \left(v - p + ksy - \xi\right) f(v)\, dv \\ &= \frac{1}{2}\left(1 - p + ksy - \xi\right)^2, \end{aligned}$$

and workers' welfare is:

$$WW_{PPS}^{COV} = fy + \beta D_{PPS}^{COV} = fy + \beta\left(1 - p + ksy - \xi\right).$$

The corresponding WCC welfare is hence given as follows:

$$WCC_{PPS}^{COV} = \pi_{PPS}^{COV} + CS_{PPS}^{COV} + WW_{PPS}^{COV}.$$

We derive the optimal decisions and summarize them in Lemma 2.

Lemma 2. *(i) The firm's optimal retail price and employment level are* $p_{PPS}^{COV*} = \frac{s[(2\lambda-k^2)(c+\beta)+2\lambda(1-\xi)]-fk}{s(4\lambda-k^2)}$ *and* $y_{PPS}^{COV*} = \frac{ks(1-c-\beta-\xi)-2f}{s^2(4\lambda-k^2)}$, *respectively. (ii)* $D_{PPS}^{COV*} \geq 0$ *if and only if* $\beta \leq \beta_{PPS}^{COV}$, *where* $\beta_{PPS}^{COV} = 1 - c - \xi - \frac{fk}{2s\lambda}$, *which is smaller than* $\beta_{PPS}^{\overline{COV}}$ *and decreasing in* ξ.

Same as the results derived in Lemma 1, we find that if the piece-rate wage for salespeople is sufficiently high, the firm will lose all its business. Particularly, note that the maximum piece-rate wage under pandemic is lower than the one in the case without pandemic (i.e., $\beta_{PPS}^{COV} < \beta_{PPS}^{\overline{COV}}$). It means that the firm is more likely to lose all the business under the COVID-19 pandemic. We hence infer that COVID-19 pandemic is detrimental and even fatal to the firm's physical store operations. That is the reason why so many brands have decided to close up their physical stores during the outbreak of COVID-19. Hong Kong expects 1/4 of retail stores to close by the end of 2020 (Staff, 2020). The fashion retailer Inditex claimed to close as many as 1200 stores over the next two years (Chaudhuri, 2020); H&M planned to cut 250 of its stores globally (BBC News, 2020). Our results provide a theoretical basis for these practical observations.

3.3 | Model WSO

When facing COVID-19 pandemic, the firm has a choice to conduct WSO, by using which the consumers can enjoy the sales services by chatting with salespeople through WhatsApp and make purchases without fear of infection. Nevertheless, because WSO is a relatively new sales mode, the consumers who make the purchase through WSO will have a trust discount t for using it. Besides, this trust discount captures consumer's concern of purchasing without physically touching the products (Zhang et al., 2017), which will directly reduce consumer utility. Hence, the utility function for those consumers buying through WSO is $U_{WSO} = v - p + lsy - t$, where l represents consumer's sensitivity to the sales service for WhatsApp shopping. For simplicity, we let $l = k$, which implies that the store type and WSO type consumers are homogeneous in the sensitivity of service level. This assumption is reasonable in the context of WSO, as the services are provided by the same group of salespeople in both the physical store and WSO; hence, the consumers are likely to possess the same expectation for the service levels. Recall

[6] Note that the salespeople may also have fear of infection, while no matter whether they possess high or low fear of infection, they have no choice but to work in stores, or they will face unemployment, which should not be a preferable choice for workers (in a place like Hong Kong or Japan). Hence, in the context of this research, we do not consider it as a driving factor.

that a proportion θ of consumers is of WSO type, and the remaining $(1-\theta)$ are store type. Hence the total demand can be realized as $D_{WSO} = (1-\theta)D_{PPS} + \theta\int_{p-ksy+t}^{1} f(v)dv = (1-\theta)(1-p+ksy-\xi) + \theta(1-p+ksy-t)$, where the first item represents the demand from physical stores, and the second item denotes the demand from WSO. Note that when adopting WSO, the firm usually pays for the unit delivery cost g for each WSO demand. This consideration is based on real-world practices such as what we have observed from Timberland, which provides free shipping for purchasing via WSO.[7] Hence the firm's overall profit is:

$$\begin{aligned}\pi_{WSO}(p,y) = {} & \left(p-c-\beta\right)(1-\theta)\left(1-p+ksy-\xi\right) \\ & + \left(p-c-\beta-g\right)\theta(1-p+ksy-t) \\ & - \lambda s^2 y^2 - fy.\end{aligned}$$

Consumer surplus is:

$$\begin{aligned}CS_{WSO} = {} & (1-\theta)\int_{p-ksy+\xi}^{1}\left(v-p+ksy-\xi\right)f(v)\,dv \\ & + \theta\int_{p-ksy+t}^{1}(v-p+ksy-t)f(v)\,dv \\ = {} & \frac{(1-\theta)\left(1-p+ksy-\xi\right)^2}{2} + \frac{\theta(1-p+ksy-t)^2}{2}.\end{aligned}$$

Workers' welfare is:

$$WW_{WSO} = fy + \beta D_{WSO}^{COV}.$$

WCC welfare is:

$$WCC_{WSO} = \pi_{WSO} + CS_{WSO} + WW_{WSO}.$$

We let $\emptyset = (1-\theta)\xi + \theta t$ and obtain Lemma 3.

Lemma 3. *(i) The firm's optimal retail price and employment level are* $p_{WSO}^* = \frac{s[(2\lambda-k^2)(c+\beta+g\theta)+2\lambda(1-\emptyset)]-fk}{s(4\lambda-k^2)}$ *and* $y_{WSO}^* = \frac{ks(1-\emptyset-c-\beta+g\theta)-2gks\theta-2f}{s^2(4\lambda-k^2)}$, *respectively. (ii)* $D_{WSO}^* \geq 0$ *if and only if* $\beta \leq \beta_{WSO}$, *where* $\beta_{WSO} = 1-c-\emptyset-g\theta-\frac{kf}{2s\lambda}$. *(iii)* $\beta_{WSO}(\gtreqless)\beta_{PPS}^{COV}$ *if and only if* $\xi(\gtreqless)t+g$.

Lemma 3(i) presents the optimal decisions for WSO model, and Lemma 3(ii) gives the threshold for a maximum piece-rate wage, exceed which there will be no business for the firm. Although the results are similar to the ones obtained in pure physical store cases (i.e., Lemma 1 and Lemma 2), we still obtain some interesting findings in Lemma 3(iii). Specifically, we notice that WSO cannot always help the firm to survive COVID-19 pandemic; only when the consumers' fear of infection is relatively large, WSO is effective to help the firm keep business as the firm can afford a higher payment to salespeople and is less likely to lose all the business. This result is understandable as fewer consumers are willing to buy from physical stores with high fear of infection, and which embodies the value of WSO.

Then, we proceed to conduct the sensitivity analysis for optimal decisions, trying to find out how the consumer type distribution will influence the firm's WSO implementation in Proposition 1.

Proposition 1. *(i)* p_{WSO}^* *and* y_{WSO}^* *are increasing in* θ *if and only if* ξ *is relatively large. (ii)* π_{WSO}^* *is convex in* θ. *(iii) When* $(t-\xi) < 0$, WCC_{WSO}^* *is convex in* θ; *when* $X(t-\xi) > 0$ WCC_{WSO}^* *is concave in* θ *if and only if* $\xi \in (t-X_1, t-X_2)$, *where* X_1 *and* X_2 *are two unique roots of equation* $X(t-\xi)=0$, *and where* $X(t-\xi) = (k^4-6k^2\lambda+4\lambda^2)(t-\xi)^2 + 2g(k^4-6k^2\lambda+4\lambda^2)(t-\xi) + 2g^2(k^2-6\lambda)\lambda$. *The characteristic of* $X(t-\xi)$ *is shown below*.

(a) If $\lambda \leq \frac{(3+\sqrt{5})k^2}{4}$, $X(t-\xi) < 0$ *always holds*.

(b) If $\lambda > \frac{(3+\sqrt{5})k^2}{4}$, $X(t-\xi) < 0$ *holds for* $\xi \in (t-X_1, t-X_2)$; *otherwise*, $X(t-\xi) > 0$.

Proposition 1 captures the impacts of consumer type distribution on firms' WSO decisions and performance. We notice that the consumers' fear of infection is a critically important factor that will influence the firm's decisions. Specifically, if consumers hold a high fear of infection, the high proportion of WSO type consumers will induce the firm to sell high-price products with more salespeople, while if consumers' fear of infection is relatively low, the firm should set a lower price and employ fewer salespeople when there are more WSO type consumers. Thus, the firm needs to make WSO decisions carefully based on both consumer types and their fear of infection.

Then, before we proceed to conduct the analysis of firm's performance, we want to define two different consumer type distributions: (i) *Concentrated distribution*, under which the consumers are concentrated in the same type (i.e., either store type or WSO type); that is, the proportion of WSO type consumers θ is relatively large or small. (ii) *Equal distribution*, under which the segments of two types of consumers are approximately the same, that is, the proportion of WSO type consumers θ is around 0.5 (i.e., moderate). According to Proposition 1(ii), we find that the firm's optimal profit is always convex in the proportion of WSO type consumers. It implies that WSO is more profitable for the firm when the proportion of consumers of the same type is higher (i.e., under the centralized distribution), rather than equally distributed. We hence suggest the firm takes measures to enlarge the number of WSO type consumers, for example, advertising more about WSO mode, so as to boost its total profit. Note that, increasing the number of store type consumers is also doable but it is not recommended, as under the COVID-19 pandemic,

[7] Details can be checked in Appendix. Note that although Timberland claims to provide free shipping if the order is net HK$500 or above, it can be regarded as providing free shipping for each purchase as the price for its products are always higher than HK$500.

encouraging more consumers to shop in store should be dangerous and unacceptable. Next, as to the WCC welfare performance, Proposition 1(iii) shows that for the firm with a low service improvement cost coefficient, concentrated distribution of two types of consumers is more welcomed, whereas for the firm with high service improve cost coefficient, equal distribution of consumer type could be more advantageous as long as consumers' fear of infection is moderate. The potential reasons are: (i) when the firm's service improvement cost coefficient is relatively low, the firm will improve its total service level by employing more salespeople (i.e., $\frac{\partial y^*_{WSO}}{\partial \lambda} > 0$), which is beneficial to both consumer and workers' welfare; thus, the higher WCC welfare can be achieved as long as the firm can gain a higher profit (refer to Proposition 1(iii)). (ii) When the firm's service improvement cost coefficient is relatively high, fewer salespeople will be hired, which is detrimental to consumer and workers' welfare. So, only two ways for the firm to acquire higher WCC welfare are improving consumer surplus by lowering the retail price under extremely low fear of infection, or by enhancing the employment level under extremely high fear of infection (refer to Proposition 1(i)). To summarize, we find it is possible for the firm to gain higher profit and WCC welfare simultaneously under WSO case as long as its service improvement cost coefficient is relatively low or the consumers are under concentrated distribution with extremely high or low fear of infection. Our results can also well explain why not all stores of a brand provide WSO (e.g., see Figure A in Appendix for Timberland case). This is because only those stores with a lower cost coefficient have high incentives to implement WSO, otherwise, the brand is less likely to support them to adopt WSO.

Note that, apart from WSO, the online channel[8] is a traditional and well-developed channel that can also help retailers provide a no-touch and convenient shopping experience to consumers. Selling products through the online channel along with physical stores under the COVID-19 pandemic can be another possible choice for the firm. Therefore, we analytically explore the online channel (denoted as "online") that captures the features listed in Table A1 (in Online Appendix A). Furthermore, we evaluate the significance of implementing WSO by comparing it with the online channel model. Note that we focus on managing existing customers, and the retailer makes a centralized decision for both "WSO/online" and "offline" operations. We summarize the results in Corollary 1 (Details of the model settings and analytical results can be found in Online Appendix B).

Corollary 1. *WSO is more helpful than the online channel to help the retail firm survive COVID-19*.

With the goal of keeping the business operations under the COVID-19 pandemic, Corollary 1 shows the superiority of WSO compared with the traditional online channel. Some more remarks are given below: (i) First, we interestingly notice that the adoption of the online channel is always inferior to WSO in terms of keeping business (i.e., making $D^* > 0$). This is because when using the online channel, the firm will provide a lower service level in the physical store (as fewer salespeople are employed for services). Consequently, adopting the online channel along with physical stores is less attractive to the consumers compared to WSO. (ii) Second, we conduct performance (e.g., firm's profit, consumer surplus, worker welfare, WCC welfare) comparisons between the online channel and WSO. The results indicate that when the consumers' fear of infection is relatively large, the adoption of WSO can help the firm to achieve an all-win situation compared with the online channel. Finally, note that the main purpose of this study is to explore measures which can help firms survive under the pandemic. With this goal in mind, we hence conclude that in this research, it is more valuable to evaluate the contributions of WSO instead of the online channel.

In short, compared with WSO, the use of online channel (i) does not consider the engagement of salespeople, which is one of the focal points in this research (see Table A1), and (ii) is proved to be less effective to help firm survive COVID-19 (see Corollary 1). Thus, we will focus on exploring the values of WSO and no longer considering the performance of the online channel in the following analyses.

4 | COMPARISONS AND ANALYSIS

In Section 3, we have derived optimal outcomes for the three cases, that is, PPS, PPS-C, and WSO; in this section, we will proceed to do the comparisons among these cases, aiming at evaluating the impacts brought by COVID-19 pandemic on firm's operations, as well as identifying the values of WSO implementation and providing useful implications and guidance for the firm to survive COVID-19.

4.1 | Impacts of COVID-19

In this subsection, we do comparisons between cases PPS and PPS-C, by doing which we can identify the impacts of COVID-19 on firm's physical store operations.

Proposition 2. *(i)* $p^{COV*}_{PPS} < p^{\overline{COV}*}_{PPS}$ *and* $y^{COV*}_{PPS} < y^{\overline{COV}*}_{PPS}$. *(ii)* $\pi^{COV*}_{PPS} < \pi^{\overline{COV}*}_{PPS}$ *and* $WCC^{COV*}_{PPS} < WCC^{\overline{COV}*}_{PPS}$.

First, Proposition 2(i) shows that the COVID-19 pandemic always leads to the price reduction and unemployment. This result is completely in conformity with real-world practices: numerous firms have offered product pricing discounts and laid off their workers in the physical stores during the COVID-19 pandemic. Then, Proposition 2(ii) reveals that both firm's profit and WCC welfare will be decreased under the COVID-19 pandemic. This result is intuitive, as the pandemic will curtail consumers' willingness to purchase in the physical store because they are afraid of being infected. Thus, we can easily infer that the COVID-19 pandemic will definitely harm the firm's physical store operations, which desperately requires the firm to take measures to combat these

[8] We sincerely thank an anonymous reviewer who advised us to examine the online channel and compare it with WSO. This helps generate important insights.

negative effects. So, in the next subsection, we will examine how WSO can help the firm to improve its performance in perspective of profit and WCC welfare under the COVID-19 pandemic.

4.2 | Values of WSO implementation

According to our general knowledge, WSO should be helpful to the firm's operations as consumers can alternatively make purchases from WSO without fear of infection; meanwhile, the firm does not need to employ additional salespeople for WSO. However, every coin has two sides. The unfamiliarity of this new mode of shopping may bring concerns to consumers (e.g., information security concern, authenticity concern, etc.). Besides, the firm usually has to pay the additional delivery cost for each delivery, which increases the cost for each demand. Hence, it is challenging for the firm to balance the trade-offs between the advantages and drawbacks of WSO. In this subsection, in order to identify the values of WSO implementation on firm's performance under COVID-19, we compare the results obtained under WSO case with the ones in PPS-C, and derive Propositions 3 and 4.

Proposition 3. $D^*_{PPS}(p^*_{WSO}, y^*_{WSO})(\overset{>}{=}\underset{<}{})D^*_{PPS}(p^{COV*}_{PPS} y^{COV*}_{PPS})$ *if and only if* $\xi(\overset{>}{=}\underset{<}{})\xi_{PPS}$ *where* $\xi_{PPS} = \frac{2s(1-c-t-\beta+g(1-\theta)+t\theta)\lambda-k(f-kst(1-\theta))}{k^2s(1-\theta)+2s\theta\lambda}$.

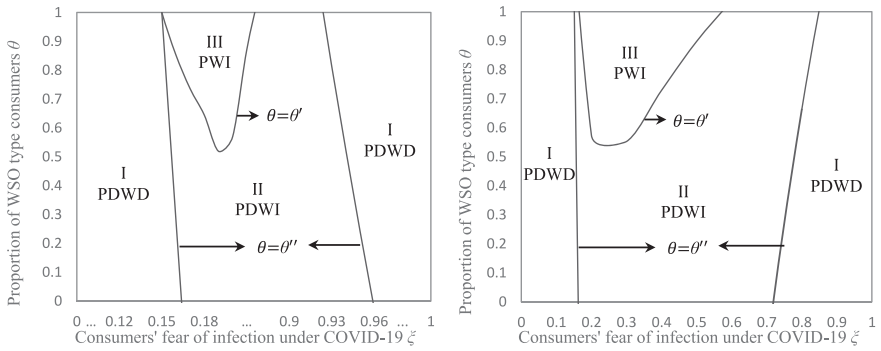
Proposition 3 provides an interesting finding, that is, the demand in the physical store can be higher under the WSO case than under the PPS-C case as long as the consumers' fear of infection is relatively large. This result is counter-intuitive as in our common sense, WSO will snatch the demand of physical stores because a portion of consumers will transfer to purchase through WSO instead of going to physical stores. However, our result implies that the implementation of WSO is able to stimulate the demand in the physical store, especially when consumers have a higher fear of infection. This is because the consumer's high fear of infection prompts the firm to improve its total service level, which eventually stimulates the total demand. This finding is consistent with the real-world observations. Specifically, a recent survey from Latin American Business Stories (LABS) has uncovered that the implementation of WSO has been driving sales and increasing profitability for 53% of brands and companies in Brazil (Fenelon & Torresan, 2021), which shows the great value of WSO implementation for the firm's physical store operations under the COVID-19 pandemic.

Proposition 4. *(i)* $p^*_{WSO} > p^{COV*}_{PPS}$ *and* $y^*_{WSO} > y^{COV*}_{PPS}$ *if and only if* ξ *is relatively large. (ii) When* $0 \le \xi < \underline{\xi}^B$ *or* $\xi > \bar{\xi}^B$, $\pi^*_{WSO} < \pi^{COV*}_{PPS}$; *when* $\underline{\xi}^B \le \xi \le \bar{\xi}^B$, $\pi^*_{WSO}(\overset{>}{=}\underset{<}{})\pi^{COV*}_{PPS}$ *if and only if* $\theta(\overset{>}{=}\underset{<}{})\theta'$, *where* $\underline{\xi}^B$ *and* $\bar{\xi}^B$*are the two positive roots of equation* $s\lambda\xi^2 + [fk - 2s(1-c-\beta)\lambda]\xi - (g+t)(fk - s(2-2c-g-t-2\beta)\lambda) = 0$. *(iii) When* $X(t-\xi) > 0$, $WCC^*_{WSO} > WCC^{COV*}_{PPS}$ *if and only if* $\theta < \theta''$; *when* $X(t-\xi) < 0$, $WCC^*_{WSO} > WCC^{COV*}_{PPS}$ *if and only if* $\theta > \theta''$.[9]

Proposition 4(i) demonstrates the implications of WSO implementation on the firm's decisions. Similar to the findings shown in Proposition 1, the consumers' fear of infection is a critical influence factor with respect to the firm's decisions. If the consumers' fear of infection is relatively large, the firm will raise the price and employ more salespeople to increase the total service level for WSO, while if the consumers are less fear ful of infection, the firm tends to cut down the price and employ fewer salespeople when implementing WSO. Then, by comparing the firm's optimal profits, we find that only when the consumers' fear of infection is moderate and the proportion of WSO consumers is larger than a threshold, the firm can earn more from implementing WSO; otherwise, it is better not to adopt WSO as the total profit will be hurt. Moreover, when it comes to the firm's WCC welfare, we notice that the value of WSO implementation is also jointly influenced by consumer type distribution and their fear of infection. To show a clear picture of this joint impact on the firm's profit and WCC welfare, we depict Figure 1 to present the values of WSO implementation.

Figure 1 exhibits all the possible relationships for the firm's profit and WCC welfare between case WCC and case PPS-C. Consistent with the results derived in Proposition 4(ii) and (iii), we can observe that both the consumer type distribution and their fear of infection will influence the value of WSO implementation significantly. Specifically, when the consumers' fear of infection is moderate, WSO is always valuable to improve WCC welfare, and it is effective to increase profit if the proportion of WSO consumers is relatively large, which is understandable, while when the consumers' fear of infection is extremely large or small, WSO is always disadvantageous for both firm's profit and WCC welfare. This result is counter-intuitive as it is commonly believed that the extremely high fear of infection will prompt more consumers to purchase through WSO, hence the higher value of WSO should be expected. However, in fact, as we have discussed in Proposition 4(i), the high fear of infection will result in a price hike for WSO, which eventually cuts the demand as well as harms the firm's WCC welfare. When the consumers' fear of infection is extremely low, it is understandable that both the firm and consumers will prefer the pure physical store operations to WSO. Besides, we notice that when the cost coefficient of service improvement is relatively small (i.e., Figure 1b) or consumers' fear of infection is relatively low (i.e., left side of Figure 1a), the firm tends to create a higher WCC welfare under WSO if there are more WSO type consumers; however, when the service improvement cost coefficient is relatively large and the consumers' fear of infection is relatively high (i.e., right side of Figure 1a), WSO implementation is more likely to lower the firm's WCC

[9] Please refer to Proposition 1 for the characteristic of function $X(t-\xi)$.



(a) When $\lambda > \frac{(3+\sqrt{5})k^2}{4}$, (b) When $\lambda \le \frac{(3+\sqrt{5})k^2}{4}$,

Remarks: Region I (PDWD) implies $\pi_{WSO}^{COV*} < \pi_{PPS}^{COV*}$ and $WCC_{WSO}^{COV*} < WCC_{PPS}^{COV*}$; Region II (PDWI) implies $\pi_{WSO}^{COV*} < \pi_{PPS}^{COV*}$ and $WCC_{WSO}^{COV*} > WCC_{PPS}^{COV*}$; Region III (PWI) implies $\pi_{WSO}^{COV*} > \pi_{PPS}^{COV*}$ and $WCC_{WSO}^{COV*} > WCC_{PPS}^{COV*}$.

FIGURE 1 The value of WSO implementation with respect to the profit and WCC welfare (let $c = 0.4$, $\beta = 0.1$, $k = 0.25$, $s = 0.9$, $f = 0.05$, $t = 0.05$, $g = 0.1$, and $\lambda = 0.1$ in (a), $\lambda = 0.05$ in (b))

welfare if most of the consumers are WSO type. This is because when both these two influence factors are relatively large, the price of product will be sharply raised under WSO implementation (refer to Proposition 1(i)), which damages consumer surplus and consequently results in decreases in WCC welfare.

To summarize, we define three regions, namely PWI, PDWI (profit-decreasing welfare-increasing), and PDWD (profit-decreasing welfare-decreasing), to identify the values of WSO implementation in terms of firm's profit and WCC welfare. In PWI region (i.e., high proportion of WSO type consumers with a moderate fear of infection), it is strongly recommended for the firm to implement WSO as it is beneficial to both profit and WCC welfare. In PDWD region (consumers' fear of infection is extremely low or high), there is completely no incentive for the firm to adopt WSO as the entire performance will be deteriorated. In PDWI region (i.e., low proportion of WSO type consumers with a moderate fear of infection), implementing WSO is effective for the firm to improve WCC welfare while at the cost of losing profit. This should be a tricky case, as the higher WCC welfare is welcomed by the whole society especially under COVID-19, whereas the loss of profit is unexpected for the firm. So, when this case occurs, that is, $\theta'' < \theta < \theta'$, we propose the government considers adopting an incentive mechanism (e.g., providing a subsidy) to help the firm overcome profit difficulties induced by the implementation of WSO. We have Proposition 5.

Proposition 5. *Under the COVID-19 pandemic, when* $\theta'' < \theta < \theta'$, *the government can provide a subsidy of* $N > \underline{N}$ *to help the firm achieve the PWI outcome in terms of total profit and WCC welfare, where* $\underline{N} = \frac{\theta[A_1(t-\xi)^2+A_2(t-\xi)+A_3]}{2s(4\lambda-k^2)^2} > 0$ *and* A_1, A_2, A_3 *can be checked in the Online Appendix A*.

Proposition 5 indicates a case in which the government has an obligation to conduct an incentive mechanism to support the firm's WSO implementation. This case appears when the implementation of WSO consumer type is equally distributed and their fear of infection is moderate. In this case, the value of WSO implementation is positive for WCC welfare while negative for the firm's profit. For implications, in order to help those firms with higher WCC welfare performance to overcome the financial difficulties under COVID-19, the amount of needed subsidy by the government to support the firm's WSO implementation is presented in Proposition 5. The government can hence make reference to it for setting the right amount of subsidy. Such an incentive mechanism, for example, providing subsidies to help firms survive the pandemic, has been widely considered by governments worldwide during COVID-19. For instance, Japan and Hong Kong have launched subsidy projects to support manufacturers and individual business operators affected by COVID-19; the European Union (EU) and the United States have provided a great amount of funding for a broad range of projects to help their citizens and firms survive COVID-19 (Xu et al., 2021).

We summarize all the important managerial findings derived from the basic model in Table 2 as an overview. To sum up, the outbreak of COVID-19 will deteriorate the firm's physical store operations; the well implementation of WSO can be an effective way for the firm to combat the negative effects brought by COVID-19; however, it may also be a "death-blow" if the firm does not make correct decisions. Our implications proposed in this research can help the firm to survive the COVID-19 crisis.

5 | EXTENSIONS

5.1 | Endogenous consumer types (EC)

In the basic model, we consider that the proportion of each consumer type is exogenously given. In this subsection, we will relax this setting and let consumers decide their type: store or WSO, by incorporating heterogeneity in consumer's value discount for WSO. We suppose the discount t is uniformly distributed from 0 to $\hat{t}$, that is, $t \sim U(0, \hat{t})$. Recall that,

TABLE 2 Summary of managerial findings in the basic model

	Impacts of COVID-19	Values of WSO
Threshold of having "no business"	Lower	Higher if ξ is relatively large
Retail price	Reduced	Increased if ξ is relatively large
Employment level		
Demand in the physical store		
Firm's profit	Harmed	Benefitted if ξ is moderate and θ is relatively large.
WCC welfare		Benefitted under certain conditions (refer to Proposition 2(iii) and Figure 2)

for simplicity, we let $l = k$; the consumer utilities for purchasing in the physical store and through WSO are $U_{PPS}^{COV} = v - p + ksy - \xi$ and $U_{WSO}^{COV} = v - p + ksy - t$, respectively. The consumers will only make the purchase when their utilities are nonnegative. The consumers are store type when $U_{PPS}^{COV} \geq U_{WSO}^{COV}$, and they are WSO type otherwise. We hence get those consumers with $t \leq \xi$ are WSO type, that is, $\theta^{EC} \equiv \min\{\frac{\xi}{\hat{t}}, 1\}$, while the remaining $(1 - \theta^{EC})$ are store type. Note that when $\xi \geq \hat{t}$, all consumers will be WSO type; when $\xi < \hat{t}$, we summarize consumer decisions as below:

$$\begin{cases} \text{buy from physical store} & \text{if } v > p - ksy + \xi \text{ and } t > \xi; \\ \text{buy from WSO} & \text{if } v > p - ksy + t \text{ and } t \leq \xi; \\ \text{buy nothing} & \text{otherwise.} \end{cases}$$

We use superscript "EC" to demonstrate the scenario of endogenous consumer types, and have the following two cases:

(a) **Case I**: If $\xi \geq \hat{t}$, then $\theta^{EC} = 1$. We have $D_{WSO-I}^{EC} = 1 - p + lsy - \varphi$, where $\varphi = E(t) = \frac{\hat{t}}{2}$. The firm's profit is $\pi_{WSO-I}^{EC}(p, y) = (p - c - \beta - g)(1 - p + ksy - \varphi) - \lambda s^2 y^2 - fy$. Consumer surplus is $CS_{WSO-I}^{EC} = \int_{p-ksy+\varphi}^{1}(v - p + ksy - \varphi)f(v)dv = \frac{(1-p+ksy-\frac{\hat{t}}{2})^2}{2}$. Workers' welfare is $WW_{WSO-I}^{EC} = fy + \beta D_{WSO-I}^{EC}$. WCC welfare is $WCC_{WSO-I}^{EC} = \pi_{WSO-I}^{EC} + CS_{WSO-I}^{EC} + WW_{WSO-I}^{EC}$.

(b) **Case II**: If $\xi < \hat{t}$, we have $D_{WSO-II}^{EC} = (1 - \frac{\xi}{\hat{t}})(1 - p + ksy - \xi) + \frac{\xi}{\hat{t}}(1 - p + ksy - \varphi)$. The firm's profit is $\pi_{WSO-II}^{EC}(p, y) = (p - c - \beta)(1 - \frac{\xi}{\hat{t}})(1 - p + ksy - \xi) + (p - c - \beta - g)\frac{\xi}{\hat{t}}(1 - p + ksy - \varphi) - \lambda s^2 y^2 - fy$. Consumer surplus is $CS_{WSO-II}^{EC} = (1 - \frac{\xi}{\hat{t}})\int_{p-ksy+\xi}^{1}(v - p + ksy - \xi)f(v)dv + \frac{\xi}{\hat{t}}\int_{p-ksy+t}^{1}(v - p + ksy - \varphi)f(v)dv = \frac{(1-\frac{\xi}{\hat{t}})(1-p+ksy-\xi)^2}{2} + \frac{\frac{\xi}{\hat{t}}(1-p+ksy-\frac{\hat{t}}{2})^2}{2}$. Workers' welfare is $WW_{WSO-II}^{EC} = fy + \beta D_{WSO-II}^{EC}$. WCC welfare is $WCC_{WSO-II}^{EC} = \pi_{WSO-II}^{EC} + CS_{WSO-II}^{EC} + WW_{WSO-II}^{EC}$.

Recall that we suppose $\lambda > \frac{k^2}{4}$. By finding the optimal decisions for each case, we yield Lemma 4.

Lemma 4. *(i) The firm's optimal retail price and employment level are*:

$$p_{WSO}^{EC*} = \begin{cases} \frac{s\lambda[2(1+c+g+\beta)-\hat{t}]-k[f+ks(c+g+\beta)]}{s(4\lambda-k^2)} & \text{if } \xi \geq \hat{t} \\ \frac{s\lambda[2\hat{t}(1+c+\beta)-3\hat{t}\xi+2\xi(g+\xi)]-k[f\hat{t}+k(s\hat{t}(c+\beta)+gs\xi)]}{s\hat{t}(4\lambda-k^2)} & \text{if } \xi < \hat{t} \end{cases}$$

and

$$y_{WSO}^{EC*} = \begin{cases} \frac{ks[2(1-c-g-\beta)-\hat{t}]-4f}{2s^2(4\lambda-k^2)} & \text{if } \xi \geq \hat{t} \\ \frac{ks[2\hat{t}(1-c-\beta)-3\hat{t}\xi-2\xi(g-\xi)]-4f\hat{t}}{2s^2\hat{t}(4\lambda-k^2)} & \text{if } \xi < \hat{t} \end{cases}, \text{ respectively.}$$

(ii) $D_{WSO}^{EC*} \geq 0$ *if and only if* $\beta \leq \beta_{WSO}^{EC}$, *where*

$$\beta_{WSO}^{EC} = \begin{cases} 1 - c - g - \frac{fk}{2s\lambda} - \frac{\hat{t}}{2} & \text{if } \xi \geq \hat{t} \\ 1 - c - \frac{fk}{2s\lambda} - \frac{(2g+3\hat{t}-2\xi)\xi}{2\hat{t}} & \text{if } \xi < \hat{t} \end{cases}.$$

(iii) $\beta_{WSO}^{EC} (\gtreqless) \beta_{PPS}^{COV}$ *if and only if* $\xi (\gtreqless) g + \frac{\hat{t}}{2}$.

The results derived in Lemma 4 are similar to the ones in the basic model (i.e., Lemma 3): (i) There exists a threshold for the maximum piece-rate wage, exceed which there will be no business for the firm. (ii) Implementing WSO cannot always help the firm to survive COVID-19 pandemic, especially when the consumers' fear of infection is relatively low. Next, we proceed to investigate the value of WSO implementation under the case of endogenous consumer types.

Proposition 6.

(i) $p_{WSO}^{EC*} > p_{PPS}^{COV*}$ *and* $y_{WSO}^{EC*} > y_{PPS}^{COV*}$ *if and only if* ξ *is relatively large. (ii)* $\pi_{WSO}^{EC*} > \pi_{PPS}^{COV*}$ *if and only if* $\begin{cases} \max\{1 - c - \beta - \frac{fk}{2s\lambda}, \hat{t}\} < \xi < \frac{1}{2}(2g + \hat{t}) & \text{if } \xi \geq \hat{t} \\ 0 < \xi < \min\{\underline{\xi}, \hat{t}\} \text{ or } \bar{\xi} < \xi < \hat{t} & \text{if } \xi < \hat{t} \end{cases}$, *otherwise,* $\pi_{WSO}^{EC*} \leq \pi_{PPS}^{COV*}$, *where* $\underline{\xi}$ *and* $\bar{\xi}$ *are the two positive roots of* $Y^{EC}(\xi) = 0$. *(iii)* $WCC_{WSO}^{EC*} > WCC_{PPS}^{COV*}$ *if and only if*

$$\begin{cases} \max\{\underline{\xi}^I, \hat{t}\} < \xi < \bar{\xi}^I & \text{if } \xi \geq \hat{t} \\ \max\{\underline{\xi}^{II}, 0\} < \xi < \min\{\bar{\xi}^{II}, \hat{t}\} & \text{if } \xi < \hat{t} \text{ and } \lambda > \frac{(3+\sqrt{5})k^2}{4}, \\ 0 < \xi < \min\{\underline{\xi}^{II}, \hat{t}\} \text{ or } \bar{\xi}^{II} < \xi < \hat{t} & \text{if } \xi < \hat{t} \text{ and } \lambda \leq \frac{(3+\sqrt{5})k^2}{4} \end{cases}$$

otherwise, $WCC_{WSO}^{EC-COV*} \leq WCC_{PPS}^{COV*}$, *where* $Y^{EC}(\xi)$, $\underline{\xi}^{I}$, $\bar{\xi}^{I}$, $\underline{\xi}^{II}$ *and* $\bar{\xi}^{II}$ *can be checked in Online Appendix A.*

Proposition 6 obtains similar findings shown in the basic model, which proves the robustness of our research. First, the firm should employ more salespeople to sell higher-price products for WSO if the consumers' fear of infection under COVID-19 is relatively large; otherwise, the firm should cut down the price and dismiss salespeople. Second, when the consumers' fear of infection is moderate, WSO is likely to help improve the firm's profit and WCC welfare simultaneously. While particularly, we notice that when consumers can endogenously decide their types by themselves, it can be more recommended for the firm to adopt WSO. Concretely speaking, even when the consumers' fear of infection is extremely low (i.e., $0 < \xi < \min\{\underline{\xi}, \underline{\xi}^{II}, \hat{\imath}\}$), the firm still has an opportunity to achieve the PWI outcome as long as the service improvement cost coefficient is relatively low. This is because the extremely low fear of infection results in higher demand in the physical store, which helps the firm to save a huge amount of delivery cost; consequently, the firm can have opportunities to achieve the PWI outcome in this scenario.

5.2 | Endogenous Service Level (ES)

In this subsection, we further consider the case when the service level (s) is endogenously determined. Because sales service plays a key role that affects the firm's optimal operations strategy, especially for WSO, making a wise service level decision is meaningful for this paper. We use superscript "ES" to denote this case. In this case, we consider that the service level improvement cost should not be over a value H, that is $IC(T) \leq H$. It represents that the firm total investment in service is limited with a fixed value and this setting fits the real-world industrial observations and is supported by prior studies in the literature. For example, there always exists a budget constraint on improving sales force (Murthy & Mantrala, 2005). A Harvard Business Review article also highlights this consideration through investigating industrial practices (Chung, 2015). Therefore, it is important to take the constraint of service level into consideration when the firm makes manpower decisions. In other words, the firm should first decide the unit service level s endogenously under the budget constraint, and then set the price p and employment level y accordingly, aiming at optimizing its total profit. By using the same methods as the ones in the basic model, we derive Lemma 5. All the optimal decisions are shown in Table A3 in Online Appendix.

Lemma 5. *(i) In all three models (i.e., PPS, PPS-C, and WSO), the firm will set its unit service level s at the maximum value*, that is, $\frac{\partial \pi_i^{ES}(p(s),y(s))}{\partial s} \geq 0$. *(ii)* $D_{PPS}^{ES-COV*} \geq 0$ *if and only if* $\beta \leq \beta_{PPS}^{ES-\overline{COV}} \leq \beta_{PPS}^{ES-COV}$, *where* $\beta_{PPS}^{ES-\overline{COV}} = 1 - c + \frac{\sqrt{2}Hk}{\sqrt{H\lambda}}$ *and* $\beta_{PPS}^{ES-COV} = 1 - c + \frac{\sqrt{2}Hk}{\sqrt{H\lambda}} - \xi$. *(iii)* $\beta_{WSO}^{ES} (\overset{>}{=}) \beta_{PPS}^{ES-COV}$ *if and only if* $\xi (\overset{>}{=}) g + t$ *where* $\beta_{WSO}^{ES} = \frac{\sqrt{2k\sqrt{H\lambda}} - \lambda(-1+c+\theta(g+t-\xi)+\xi)}{\lambda}$.

Observing the results in Lemma 5, it is straightforward to notice that there is a maximum piece-rate wage to make sure that the firm has businesses. Thresholds of piece-rate wage have the same relations as the basic model. Besides, to be noticed that it is always beneficial for the firm to set the unit service level as the maximum value because the improvement of service level induces the increase of marginal benefit that the firm can obtain. Next, we show that the impacts of COVID-19 and the values of WSO mode keep the same when the firm endogenously decides the optimal unit service level.

Proposition 7. *(i)* $p_{PPS}^{ES-COV*} < p_{PPS}^{ES-\overline{COV}*}$, $y_{PPS}^{ES-COV*} < y_{PPS}^{ES-\overline{COV}*}$, *and* $s_{PPS}^{ES-COV*} > s_{PPS}^{ES-\overline{COV}*}$; *(ii)* $\pi_{PPS}^{ES-COV*} < \pi_{PPS}^{ES-\overline{COV}*}$; $WCC_{PPS}^{ES-COV*} < WCC_{PPS}^{ES-\overline{COV}*}$.

Proposition 7(i) verifies that the existence of COVID-19 leads to a price reduction and lowers the employment level. What one needs to pay attention to is that COVID-19 enhances the requirement of unit service level provided by each salesperson. In other words, the optimal unit service level under COVID-19 is higher than that without the pandemic. It is because the lower employment level puts stress on salespeople and requires a higher unit service level to ensure the demand. Proposition 7(ii) highlights that COVID-19 pandemic seriously hit the operations of physical stores, not only decreasing the profit but also the WCC welfare, even though the firm endogenously decides the optimal unit service level. Proposition 7 demonstrates that our findings on the impacts of COVID-19 are still valid when unit service levels are endogenously given. We then seek the values of WSO implementation.

Proposition 8 *(i)* $p_{WSO}^{ES*} > p_{PPS}^{ES-COV*}$, $y_{WSO}^{ES*} > y_{PPS}^{ES-COV*}$, *and* $s_{SO}^{ES*} < s_{PPS}^{ES-COV*}$ *if and only if* ξ *is relatively large; (ii)* $\pi_{WSO}^{ES*} > \pi_{PPS}^{ES-COV*}$ *if and only if* $\theta > \theta'^{ES}$, *otherwise* $\pi_{WSO}^{ES*} \leq \pi_{PPS}^{ES-COV*}$ *where* $\theta'^{ES} = -\frac{2(g(-1+c+2t+\beta-\xi)+(t-\xi)(-1+c+\beta+\xi))}{(g-t+\xi)^2}$; *(iii)* $WCC_{WSO}^{ES*} > WCC_{PPS}^{ES-COV*}$ *if and only if* $\xi \in (\underline{\xi^{ES}}, \overline{\xi^{ES}})$ *where* $\underline{\xi^{ES}} = \max\{0, \min\{root_1, root_2\}\}$ *and* $\overline{\xi^{ES}} = \max\{root_1, root_2\}$ *are two positive roots of* $X^{ES}(\xi)$; *otherwise*, $WCC_{SO}^{ES*} \leq WCC_{PPS}^{ES-COV*}$.

We can observe from Proposition 8(i) that the consumers' fear of infection plays the same role in affecting the firm's optimal pricing and employment level as the basic model. That is, relatively large fear of infection induces higher retail price and stimulates the firm to hire more salespeople after implementing WSO. While the unit service level of salesperson may not be strictly required because more salespeople will be hired when WSO is implemented, and the total service level can be satisfied by the high level of employment. Second, Proposition 8(ii) demonstrates the value of WSO implementation depends on the consumer type distribution. Similar to the basic model, only when the proportion of WSO

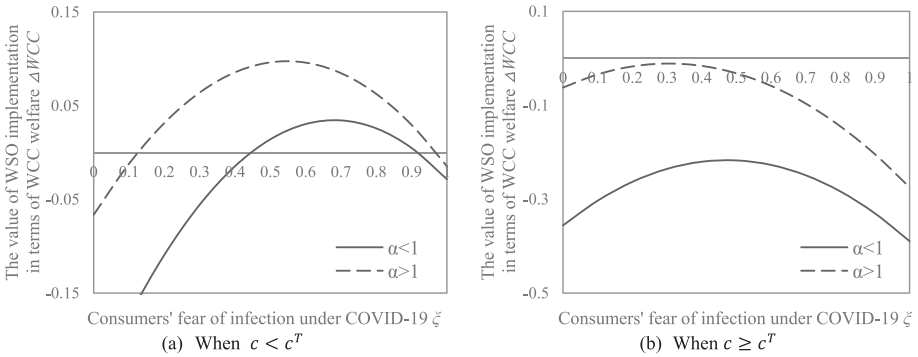


FIGURE 2 The value of WSO implementation in terms of WCC welfare in general cases (let $\beta = 0.3$, $\lambda = 0.2$, $k = 0.25$, $s = 0.6$, $f = 0.05$, $t = 0.05$, $g = 0.1$, $\alpha = 0.8$ or 1.2, and $c = 0.3$ in (a), $c = 0.5$ in (b))

consumers is relatively large, the firm can earn profits and achieve a higher WCC welfare from the implementation of WSO.

5.3 | WCC-welfare-oriented firm (WO)

Under COVID-19, unemployment is a critical issue worthy of attention. Our analytical results in Proposition 2(i) also has shown that the employment level of salesperson will be reduced by COVID-19. This unemployment will definitely harm workers' welfare, which is unexpected. Hence, during this special period of pandemic, economic objectives of the firm may have to change to optimize WCC welfare. We call this kind of firm as WCC-welfare-oriented firm (denoted by superscript "WO"). For the WCC-welfare-oriented firm, the retail price and the employment level are determined to maximize the firm's WCC welfare $WCC = \alpha\pi + \omega(CS + WW)$, where $\alpha(> 0)$ and $\omega(> 0)$ denote the weight of profit and social responsibilities in WCC welfare, respectively (Benjaafar et al., 2019). For simplicity, we normalize ω to 1; hence, $\alpha > 1$ implies that the firm focuses more on its own profit than consumer and workers' welfare, and vice versa. The optimal decisions for the WWC-welfare-oriented firm can be checked in Table A4 in Online Appendix A.

Proposition 9. *WCC-welfare-oriented firm is less likely to lose all the business (i.e., $D^* < 0$) than profit-oriented firm.*

Proposition 9 provides an interesting finding that the WCC-welfare-oriented firm could be superior to the profit-oriented firm in terms of keeping business (i.e., having positive demand). According to our common knowledge, the WCC-welfare-oriented firm seems much easier to lose its business as it put more emphasis on consumer and workers' welfare rather than its own profit; however, its efforts on maximizing total WCC welfare exactly gives itself an opportunity to attract more consumers, which eventually gains a higher market demand. We hence strongly suggest the firm to concentrate more attention on total WCC welfare when making decisions, which can not only benefit its own business but also be conducive to the whole society.

Next, we proceed to explore the impacts of COVID-19 and values of WSO implementation for the WCC-welfare-oriented firm. Due to the complexity, we will first derive analytical results for the special case in which $\alpha = 1$ in Proposition 10, and then conduct numerical studies to examine general cases where $\alpha < 1$ and $\alpha > 1$ in Figure 2.

Proposition 10 (special case in which $\alpha = 1$). *(i)* $\pi_{PPS}^{WO-COV*} > \pi_{PPS}^{WO-\overline{COV}*}$ *and* $WCC_{PPS}^{WO-COV*} < WCC_{PPS}^{WO-\overline{COV}*}$. *(ii)* $\pi_{WSO}^{WO*} > \pi_{PPS}^{WO-COV*}$ *if and only if* $0 < \xi\langle\bar{\xi}^X$ *or* $\xi\rangle\bar{\xi}^X$, *otherwise,* $\pi_{WSO}^{WO*} \le \pi_{PPS}^{WO-COV*}$, *where* $\underline{\xi}^X$ *and* $\bar{\xi}^X$ *are the two positive roots of equation* $Y(\xi)^{WO} = -k^2s(2-\theta)\lambda\xi^2 + (f(2k\lambda - k^3) + s(2k^2(1-c-\beta+t(1-\theta))\lambda + 4\beta\lambda^2 + g(1-\theta)(k^4 - 2k^2\lambda + 4\lambda^2)))\xi + fk(g+t)(k^2-2\lambda) - s(gk^4t(1-\theta) + k^2(2(t+g)(1-c-\beta) - 4gt - (g-t)^2\theta)(k^4 - 2k^2\lambda + 4\lambda^2)))\xi + fk(g+t)(k^2-2\lambda) - s(gk^4t(1-\theta) + k^2(2(t+g)(1-c-\beta) - 4gt - (g-t)^2\theta)\lambda + 4(t\beta + g(t+\beta-t\theta))\lambda^2)$.

(iii) There exists a threshold c^T. *When* $c \ge c^T$, *we have* $WCC_{WSO}^{WO*} \le SW_{PPS}^{WO-COV*}$; *while when* $c < c^T$, $WCC_{WSO}^{WO*} > WCC_{PPS}^{WO-COV*}$ *if and only if* $\max\{0, \underline{\xi}^Y\} < \xi < \bar{\xi}^Y$, *otherwise,* $WCC_{WSO}^{WO*} \le WCC_{PPS}^{WO-COV*}$, *where* $\underline{\xi}^Y$ *and* $\bar{\xi}^Y$ *are the two positive roots of equation* $X(\xi)^{WO} = -(k^2(1-\theta) + 2\lambda)\xi^2 + (2k^2(g+t)(1-\theta) + 4(1-c)\lambda)\xi - k^2t(2g+t)(1-\theta) + 2(-2g(1-c-t) - t(2-2c-t) + g^2\theta)\lambda$.

Proposition 10(i) shows the impacts of COVID-19 on the WCC-welfare-oriented firm's performance. The same with the basic model, we find that COVID-19 is always detrimental to the firm in terms of WCC welfare, while we surprisingly notice that the WCC-welfare-oriented firm can earn more profit with COVID-19 pandemic than without. The reason behind this is that the outbreak of COVID-19 damages consumer surplus due to the fear of infection, hence the WCC-welfare-oriented firm has to make great efforts on earning more profit so as to make up for the loss in consumer surplus and achieve its optimal WCC welfare. Proposition 10(ii) and (iii) present the values of implementing WSO under COVID-19. The results reveal that the production cost should be an

important factor for the WCC-welfare-oriented firm. Specifically, when the production cost is relatively large, implementing WSO can never benefit the firm's WCC welfare; and when the production cost is relatively small, the firm can achieve a higher WCC welfare when the consumers' fear of infection is moderate. Thus, we kindly remind those WCC-welfare-oriented firms with a high production cost to avoid implementing WSO under COVID-19, as it will harm the WCC welfare.

Next, we focus on investigating general cases where $\alpha \neq 1$. We define $\Delta WCC = WCC_{WSO}^{WO*} - SW_{PPS}^{WO-COV*}$ as the value of WSO implementation in terms of WCC welfare. The positive ΔWCC means that the firm can gain a higher WCC welfare when implementing WSO, and vice versa. Figure 2 is depicted for both cases where $\alpha > 1$ and $\alpha < 1$.

Figure 2 demonstrates the value of WSO implementation with respect to WCC welfare. As we can observe, in general cases where $\alpha \neq 1$, the findings obtained in Proposition 10 still hold: (i) the WCC-welfare-oriented firm with high production cost (i.e., Figure 2b) always achieves a lower WCC welfare under the implementation of WSO; (ii) the WCC-welfare-oriented firm with high production cost (i.e., Figure 2a) can benefit from WSO implementation if the consumers' fear of infection is moderate, irrespective to the firm's attitude toward WCC welfare, that is, $\alpha > 1$ and $\alpha < 1$. Besides, we notice that WSO implementation tends to be more valuable for the firm that pays more attention to its profit in WCC welfare (i.e., $\alpha > 1$) than the firm that treasures consumer and workers' welfare more in WCC welfare (i.e., $\alpha < 1$). This is because the main value of WSO is to stimulate additional demand for the firm, which makes great contributions to increasing total profit rather than consumer and workers' welfare. Hence, we can easily understand why the firm focusing more on profit is more likely to benefit from WSO implementation.

6 | CONCLUSION, MANAGERIAL INSIGHTS, FUTURE RESEARCH

The outbreak of COVID-19 has brought severe threats to the retail operations. Numerous brands have already closed or plan to close their physical stores. This creates problems not only for the firm but also for employees and consumers. Recently, Timberland in Hong Kong and various other brands such as Joyce Boutiques and The North Face have established an innovative sales mode, that is, "WhatsApp Shopping Service" operation (WSO), in which consumers can shop and enjoy services by using the well-established and commonly used communication tool "WhatsApp." Salespeople in stores will serve as if the consumers have visited the stores. Motivated by this interesting real-world observation, we conduct an interview with the salespeople of Timberland in Hong Kong, and then based on the primary data collected through the interview, we establish an innovative theoretical model to explore WSO. By proposing a standard consumer utility based model, we capture the consumer's purchasing behavior with regard to the retail price, total service level, their fear of infection under COVID-19, and their potential concerns for WSO. We evaluate the firm's optimal pricing and employment decisions under three possible cases: (i) without COVID-19 and the firm operates a pure physical store (Model PPS), (ii) with COVID-19 and the firm operates a pure physical store (Model PPS-C), and (iii) with COVID-19 and the firm operates WSO (Model WSO). In each case, we explore the firm's optimal profit, consumer surplus, and workers' welfare and integrated them into a novel concept of Worker-Consumer-Company (WCC) welfare, which is used to reflect the welfare performance with the special consideration of workers' welfare. We regard WCC welfare as a critically important indicator that should be considered, as it reflects the influence of COVID-19 on the whole society, rather than on the firm solely. By comparing the three cases, we successfully identify the impacts of COVID-19 pandemic on physical store operations as well as the values of WSO implementation under pandemic in terms of both firm's profit and WCC welfare. Moreover, we further extend our model by considering scenarios with the endogenous consumer type, endogenous service level, and the WCC-welfare-oriented firm to check the robustness of our study.

To our best knowledge, this is the first paper examining WSO under COVID-19. The obtained insights not only contribute to the literature, but also provide practical guidance to operations managers for the potential applications and values of WSO. We summarize the major findings and provide managerial insights to the firm from the following three aspects: (i) impacts of COVID-19, (ii) values of WSO, and (iii) guidance on the improvement of WSO performance.

6.1 | Impacts of COVID-19

Our analytical results verify that COVID-19 will inevitably damage the firm's physical store operations. It is hence important for retail firms to change their operations pattern (e.g., implementing WSO) to seek survivals under the COVID-19 pandemic.

6.2 | Values of WSO

(i) When the firm makes a centralized decision for both "WSO/online" and "offline" operations, WSO is proven to be more effective than the traditional online channel to help the firm survive COVID-19 in terms of keeping the business. We hence suggest firms currently selling via physical stores to implement WSO rather than developing online channels during the pandemic. (ii) The implementation of WSO is able to stimulate demand in the physical store under COVID-19 when consumers have a higher fear of infection. This finding shows the significance of implementing WSO as it can help eliminate the demand reduction in the physical store channel caused by COVID-19. (iii) Nevertheless, the implementation of WSO is not always recommended for the firm under

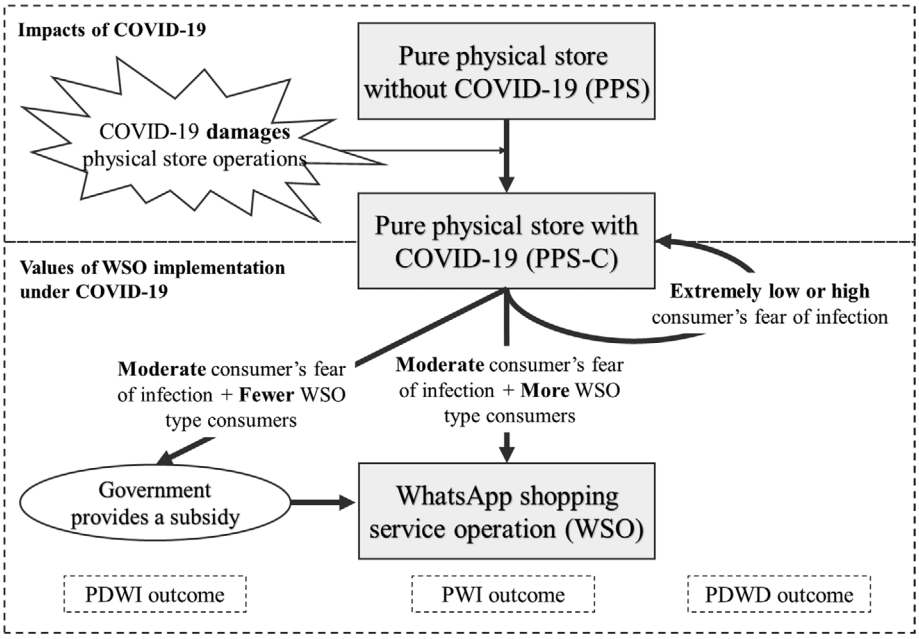


FIGURE 3 Shifts in the firm's optimal operations strategy under different conditions in the market. PWI means "profit-welfare-improvement," PDWI means "profit-decreasing welfare-increasing," and PDWD means "profit-decreasing welfare-decreasing"

TABLE 3 Summary of the firm's optimal operations strategy under COVID-19

		Consumers' fear of infection		
		High	**Moderate**	**Low**
Proportion of WSO type consumers	High	**Pure physical store**	**WhatsApp shopping service operation (WSO)**	**Pure physical store**
	Low		**WSO with government's subsidy**	

COVID-19; whether it is valuable to adopt WSO depends on both consumers' fear of infection and consumer type distribution. We summarize the managerial insights of WSO implementation in Figure 3 and Table 3, which provide an overview of the firm's optimal operation strategy under different conditions.

As shown in Figure 3 and Table 3, we suggest that when the consumers' fear of infection is very polarized, (i.e., extremely low or high), WSO should not be recommended as it is harmful to both the firm's profit and WCC welfare (i.e., the PDWD outcome); in this case, the firm should still operate a pure physical store (Model PPS-C) under the COVID-19 pandemic. This counter-intuitive finding is due to the price hike of WSO under the high fear of infection case (see Proposition 4(i)), which eventually cuts the demand as well as harms the firm's WCC welfare. When the consumers' fear of infection is moderate, the firm can shift to Model WSO without hesitation if there are more WSO type consumers in the market, as the profit-welfare-improvement (PWI) outcome can be achieved, while if there are fewer WSO type consumers in the market, the PDWI (profit-decreasing welfare-increasing) outcome can be achieved; we hence suggest the government conduct an incentive mechanism (e.g., providing a subsidy) for the firm's WSO implementation, which is an effective way to help firm survive COVID-19 as well as improve WCC welfare.

6.3 | Guidance on the improvement of WSO performance

(i) We find that the firm with a lower service improvement cost coefficient could have a higher incentive to implement WSO. It is the reason why not all stores of a brand would like to provide WSO in practice. (ii) The firm should take measures to enlarge the number of WSO type consumers, for example, by advertising more about WSO mode, so as to boost its total profit. This is the case in Timberland (HK) as the brand advertised hard on social media platforms such as Facebook during the time when COIVD-19 pandemic was very serious. (iii) We find that the WCC-welfare-oriented firm is superior to the profit-oriented firm in terms of keeping business (i.e., having positive demand). It is important to note that the implementation of WSO is not helpful to improve WCC welfare when the production cost of the WCC-welfare-oriented firm is relatively high. We hence

recommend the WCC-welfare-oriented firm with a high production cost to adopt the pure physical store operational mode under COVID-19.

For future research direction, we first suggest that the market uncertainty can be considered. When facing the uncertain market demand under COVID-19, we suppose that evaluating the impacts of firm's risk attitude on its WSO strategy could be meaningful; meanwhile, it will also be interesting to evaluate the firm's inventory problem under demand uncertainty by using stochastic models. Second, we think it should be interesting to consider the return policy for WSO. Because consumers cannot assess the fitness of the product by purchasing through WSO, product return is likely to happen; however, return policy may have the potentially damaging impact on the retailer (Xu et al., 2018). Hence, in future research, scholars can explore how the return policy could influence the firm's WSO strategy. Third, the workers' fear of infection is not regarded as a driving factor in our research based on the real-world observations in places like Hong Kong and Japan, while it could be the case in some other places. We hence suggest that in future research, the impacts of workers' fear of infection can be considered. Finally, our research is closely related to omnichannel operations. We believe that it must be interesting to explore the interactions among different channels in the future, for example, information compensation and corresponding impacts on consumer's purchasing behavior (Zhang et al., 2020). It will be interesting to explore whether the presence of WSO will affect the omnichannel operations performance.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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