Subscription programs in omnichannel grocery retailing: implications for revenue and fulfillment operations

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Abstract

This paper investigates the implications for revenue and fulfillment operations of the introduction of online subscription programs to pay for home delivery in omnichannel grocery retailing. Based on data on consumer-level transactions in a retailer before and after the introduction of a subscription program, we find that subscribers increase their online product spending after joining the program. However, the online product sales contribution is offset by changes in consumers' behaviors intended to extract economic benefits from joining the program, with negative impacts on fulfillment operations. We discuss the implications of these findings for the design of subscription programs and fulfillment operations.

Keywords: retail operations, omnichannel, fulfillment

Introduction

Most major grocery retailers currently give consumers the option of buying products offline at brick-and-mortar stores or of purchasing online and have items delivered to their homes (home delivery or H fulfillment) or collected at the retailers' stores (click and collect or CC fulfillment). To that end, retailers must determine how best to charge shoppers for the online fulfillment service provided. One option is to have consumers pay a fee each time they use the service. Another option is for consumers to become members of a subscription program and pay a fee for the fulfillment of all online orders purchased during an extended period of time.

These subscription programs have grown in popularity, but there have also been several failures (McCarthy and Fader, 2017). Thus, it is of interest to investigate their success in generating consumer spending vis-à-vis per-order programs as well as in relation to offline purchasing. Although anecdotal evidence suggests that consumers

significantly increase their spending after they join subscription programs, this may over-estimate these programs' benefits (Iyengar et al., 2021). For one, consumers who expect to buy more in the future are more inclined to become subscribers. Moreover, along with this additional spending, subscribers may impose on retailers added operational burdens as they change their behavior to extract economic benefits from joining the subscription programs (e.g., more frequent online orders which are costly to fulfill, at the expense of offline orders). Only after accounting for these effects will it be possible to accurately contextualize the actual contribution of subscription programs to consumer spending in relation to per-order programs as well as offline shopping. Prior empirical studies (e.g. Iyengar et al., 2021; Wagner et al., 2021) have made only partial progress in accounting for these effects and have stopped short of addressing the impacts of subscription programs in offline shopping.

Our goal is to address this deficiency in the literature. Accordingly, we first estimate the effect of a subscription program for online fulfillment services based on home deliveries offered by an omnichannel grocery retailer on consumers' spending that is solely due to consumers' actually becoming subscribers. In addition, we identify added operational burdens imposed on the retailer by changes in consumers' behaviors intended to extract economic benefits from joining the retailer's subscription program. These behaviors may include: more spending via H fulfillment at the expense of spending offline or via CC fulfillment; more frequent H orders at the expense of offline or CC orders; and a greater frequency of H orders in costlier fulfillment slots. Finally, we examine these phenomena longitudinally to understand their evolution during consumers' subscription periods.

Based on these results, we expand on implications for the design of subscription programs and associated fulfillment operations. Furthermore, we discuss opportunities for future research.

Conceptual background and hypotheses

We draw from *transaction cost theory* to develop testable hypotheses regarding the impact of consumers' joining the subscription program on their spending (products and fulfilment fees) and purchasing behavior (ordering frequency and choice of delivery slots) via H fulfillment, CC fulfillment and Offline fulfillment. Transaction cost theory specifies that consumers choose to conduct economic exchanges with grocers in a way that minimizes their costs of carrying out those exchanges (Chintagunta et al., 2012). In our context, grocers' basic function is to provide not only the products but also the services (e.g., accessibility, product availability) consumers use to convert products into consumption goods at home (Betancourt, 2005). The lower the transaction costs of using these services, the greater the value consumers derive from using the services to buy the products offered by the retailers.

Consumers' use of these services carries costs in the form of monetary fees as well as other transaction costs. When consumers shop offline, they are not likely to encounter significant monetary fees charged by retailers to visit the stores. On the other hand, they will incur transaction costs that include *in-store* and *goods-transference* costs. Chintagunta et al. (2012) expand on these costs' components. *In-store costs* include the search and shopping-time costs consumers incur assembling their baskets and queueing to pay inside the stores, as well as the physical costs they incur navigating the store aisles and transferring products from store shelves, to shopping carts, and to checkout counters. *Goods-transference costs* include the transportation and opportunity costs consumers incur traveling to and from the stores as well as the physical costs consumers incur carrying the products purchased at the stores back home.

When consumers purchase via H or CC fulfillment, they will face significant monetary fees charged by retailers for these services. However, in the case of H fulfillment, they will incur no in-store or goods-transference costs while in the case of CC fulfillment they will incur goods-transference costs.

To join a subscription program, consumers pay an upfront fee for an unlimited use of H fulfillment during the subscription period. As a result, after consumers join a subscription program the attractiveness of the H fulfillment option increases relative to CC and offline fulfillment. In addition, consumers will seek to maximize the economic benefits from joining the subscription program.

Thus, we put forward the following hypotheses:

H1. Subscribers increase their product spending at the retailer via H fulfillment after joining the program, at the expense of product spending via offline and CC.

H2. Subscribers increase the frequency of H orders placed after joining the program, at the expense of store visits (offline and CC).

H3. Subscribers increase the proportion of H orders delivered during premium time slots.

Methodology

We partnered with an omnichannel grocery retailer in a country in the European Union to study the effect of the introduction of a subscription program on revenue and fulfillment operations. The decision to consider a single firm ensures uniformity across exogenous dimensions that might bias customers' decisions to use different channels and allows for valid operational comparisons. This is also consistent with prior research that has relied on single firms to perform empirical analyses (e.g., Bell et al., 2017; Gallino and Moreno, 2014; Lim et al., 2021; Wang et al., 2021).

Empirical setting

The retailer operates a 220-store network across the country and also sells online through a website. The retailer employs the 15 largest stores in its network to fulfill online orders. These stores are located in different regions and have an average area of about 75,000 ft^2. On average, each store carries an assortment of 43,000 SKUs. The stores' assortments are available for sale online at prices matching those offline.

Orders placed online are picked at one of the 15 fulfillment stores to be delivered to customer homes (H fulfillment) or collected by the customer at one of these stores (CC fulfillment). The retailer offers H delivery to a large area, but not all customers are covered. The 15 stores serve seven regions. Five of these regions are semi-rural municipalities and are covered by one store each. The other two are metropolitan regions made up of adjacent urban municipalities linked by public transport. One of these regions is served by eight stores and the other by two stores. All customers are assigned based on their home addresses to a primary store for fulfillment via CC or H (typically, the closest store to the home address). Deliveries via H are always fulfilled from the customer's primary store. In the CC option, orders may be fulfilled from any store the customer chooses to pick the orders from. Customers assigned to a fulfillment store within a metropolitan region can use the other fulfillment stores in the region as alternatives for CC, because the stores are not far from each other and belong to the customer's natural shopping area. However, fulfillment stores located in different regions are too far away from each other to be considered as alternatives for CC in the context of regular shopping behavior.

To buy online, each customer must first create an account and provide her home address and other personal details. To place an order, the customer logs in, browses the product catalogue, and selects the SKUs for purchase by adding them to a virtual shopping cart. During this process, the customer sees the product assortment and prices of her primary store (via H or CC). To ensure consistency in service across channels, the prices and assortment the retailer uses at a primary store are consistent with those across all other stores within the primary store's region. Thus, consumers' choice of a particular store to shop offline or online, via H or CC, does not depend on prices and assortments endogenous to the store.

Once all SKUs are in the cart, the customer must complete the order placement by selecting a date and time window for the delivery of the order to her home or for the collection of the order at a store and then provide a payment method. Fulfillment windows are of two types: short and long. Short (premium) windows are 2 to 3 hours long and are identically available for H and CC every day of the week in six alternative slots: morning, lunch, afternoon, late afternoon, evening, and night. Long windows are 6 to 8 hours long and are available for H fulfillment only, with a slot starting at the beginning of the working day. The fulfillment fee is 4 euro for H deliveries scheduled for delivery during long time windows or 6 euro for H deliveries scheduled for delivery during short time windows. CC fulfillment is free of charge.

Consumers can pay for H delivery every time they order or subscribe to a fulfillment service by paying a fee upfront for unlimited use during a four-month period. The subscription fee to the four-month fulfillment service is 18€. The subscription service became available on February 1, 2015.

Data analysis

We collected data on consumer-level transactions for a period of eight months - starting one month before the subscription program was introduced by the retailer – and track each subscriber's 4-month subscription period. We also collected information on stores and consumer attributes, thereby producing a rich context to address our research goal.

There are four major challenges that we must address in order to fulfill this goal. First, estimating the impacts of the subscription program may be biased because, as we alluded to previously, consumers do not choose randomly to subscribe to the retailer's program. To account for this self-selection bias and accurately estimate the subscription program's causal effects, we use a quasi-experimental design and a difference-in-differences (DID) specification based on a matched sample. We use the propensity score matching technique to identify control customers that match each treatment customer in the treatment group that share the same observed characteristics. Our set of matching covariates captures both ZIP-code level and individual level attributes that may influence a customer's decision to subscribe to the delivery program. These ZIP-code level attributes include population density, male population amount, a purchasing power index, an ageing index, proportion of population with a university degree qualification, average household size, and a categorical variable (0, 1, 2) indicating whether the ZIP code is in one of the two metropolitan regions served by the retailer. The individual level attributes include a customer's average weekly spending per visit at the focal retailer's online channel, distance between the customer's ZIP code to the nearest physical store, customer type based on channel use (H-delivery-only, CC and H, H-and-offline, H-CC-and-offline), and total spending at the focal retailer's online store. Note that individual level attributes are computed using data prior to February 1, 2015 (i.e., launch of delivery subscription date). Second, the subscription program's effects are also difficult to estimate because they involve consumers' spending on products as well as fulfillment fees. In addition, these

effects straddle spending across the offline and online channels operated by the retailer. Therefore, our analysis incorporates data collected across these channels to identify these effects. Finally, measuring the program's effects is complicated by the heterogeneity that exists among consumers (e.g., distance to the stores and density where consumers live) as well as the differences in the timing for the delivery of the orders consumers place for online fulfillment (e.g., orders delivered during prime times vs non-prime times). These variations will influence the observed changes in consumer behaviors intended to extract economic benefits from joining the subscription program as well as the operational burdens these changes may impose on the retailer.

We use the following DID specifications to evaluate the average effect of the treatment application (enrolment in the subscription program) on customer *i*'s shopping activity in week *t*:

$$DV_{it} = \alpha_i + \beta \times TREAT_i \times AFTER_{it} + \theta_t + \varepsilon_{it}, \quad (1)$$

where DV∈ {*ONLINES_H*, *OFFLINES*, *ONLINES_CC*, *ONLINEF*, *ONLINEV_H*, *OFFLINEV*, *ONLINEV_CC*, *ONLINEPT*} represents the dependent variable of interest to include the weekly amount spent in products via H fulfillment (*ONLINES_H*), weekly amount spent in products via the offline channel (*OFFLINES*), weekly amount spent in products via CC fulfillment (*ONLINES_CC*), weekly amount spent on fulfillment fees (*ONLINEF*), weekly count of visits in H fulfillment (*ONLINEV_H*), weekly count of visits in the offline channel (*OFFLINEV*), weekly count of visits in CC fulfillment (*ONLINEV_CC*), and weekly share of premium slots in H fulfillment (*ONLINEPT*), that is, customers' selecting of short windows. Due to the count nature of *ONLINEV* and *OFFLINEV*, we estimate Equation (1) based on a zero-inflated Poisson process to model weekly visits. The indicator $TREAT_i$ equals 1 if customer $\underline{i}$ belongs to the treatment group and 0 otherwise. The indicator $AFTER_{it}$ equals 1 if week *t* corresponds to the posttreatment period (i.e., after customer *i* subscribed to the delivery subscription program) and 0 otherwise. The term α_i denotes customer fixed effects to account for customer heterogeneity, and θ_t accounts for weekly time fixed effects due to temporal shocks or seasonality. The coefficient of interest is β. The term ε_{it} represents independent and identically distributed Gaussian random shocks. We use White's heteroscedasticity-robust standard errors for robust inferences.

To examine the time trend of the treatment effect of interest, we specify the following regression model:

$$DV_{it} = \alpha_i + \sum_{q=1}^{5} BT_{q,it} \times \delta_q + \sum_{r=1}^{16} AT_{r,it} \times \gamma_r + \theta_t + \varepsilon_{it}. \quad (2)$$

The terms BT_{it} and AT_{it} are treatment customer-specific 5-week and 16-week time dummies that capture treatment customer-specific time trends before and after subscription to the delivery program. For example, $AT_{1,it}$ equals 1 if customer *i* is a treatment customer and *t* belongs to the first 16-week period after the subscription and 0 otherwise. All other notations follow that of Equation (1).

The main results are included in Table 1 and Table 2. Table 1 shows the effect of the treatment (enrolment in the subscription program) on weekly spent on products (H, Offline, CC) and fulfilment fees, weekly visits (H, Offline and CC) and share of premium slots via H. It shows that the subscription of the program had a significant impact on all dependent variables except weekly spent on products via CC and weekly visits via CC. H1, H2 and H3 were supported except in what concerns the use of the CC option. Table 2 shows the time trend of the treatment effect for the dependent variables that were significantly impacted.

Table 1. Effect of treatment (affiliation to subscription program) on weekly spent on products and fulfilment fees, visits and share of premium slots.

Variable	(1) Spent - H	(2) Spent - Offline	(3) Spent - CC	(4) Spent - Fees	(5) Visits - H	(6) Visits - Offline	(7) Visits - CC	(8) Share Prem. Slots - H
Treat × After	17.661*** (0.883)	–6.133*** (0.992)	–0.103 (0.098)	–0.071* (0.035)	0.815*** (0.034)	–0.132*** (0.028)	–0.061 (0.311)	0.205*** (0.007)
Cust. Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Week Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. Obs.	10,3916	59,132	7,805	10,3916	10,3916	59,132	7,805	104,502

Notes. Std. Errors in parentheses. * p < 0.05, ** p < 0.01, *** p < 0.001.

Table 2. Time trend of treatment effect for dependent variables that were significantly impacted.

Variable	(1) Spent - H	(2) Spent - Offline	(3) Spent - Fees	(4) Visits - H	(5) Visits – Offline	(6) Share Prem. Slots - H
Treat × 5 Weeks lagged	3.674 (3.038)	0.211 (3.143)	0.074 (0.084)	0.034 (0.115)	0.012 (0.086)	0.038 (0021)
Treat × 4 Weeks lagged	6.839* (3.185)	–2.633 (2.691)	0.163* (0.081)	0.079 (0.097)	0.032 (0.077)	0.041* (0.018)
Treat × 3 Weeks lagged	7.431** (2.658)	–4.203 (2.354)	0.093 (0.075)	0.190* (0.088)	–0.134 (0.071)	0.057** (0.018)
Treat × 2 Weeks lagged	5.579* (2.434)	–4.031* (1.972)	0.012 (0.061)	0.157* (0.073)	0.011 (0.061)	0.056*** (0.016)
Treat × 1 Week lagged	3.065 (2.463)	–0.443 (2.260)	0.095 (0.065)	0.008 (0.077)	–0.021 (0.055)	0.012 (0.016)
Treat × Week 1	1.070 (2.164)	1.109 (2.205)	0.022 (0.056)	0.028 (0.065)	–0.061 (0.048)	0.005 (0.014)
Treat × Week 2	4.660* (2.122)	–4.574* (1.952)	0.017 (0.053)	0.086 (0.057)	–0.115* (0.052)	0.034* (0.014)
Treat × Week 3	3.990 (2.127)	–2.856 (1.954)	–0.048 (0.051)	0.132* (0.060)	–0.128* (0.050)	0.035* (0.014)
Treat × Week 4	6.096** (1.934)	–3.112 (2.011)	–0.044 (0.049)	0.216*** (0.059)	–0.125* (0.052)	0.050*** (0.014)
Treat × Week 5	6.243** (1.990)	–3.717 (2.166)	–0.128** (0.042)	0.331*** (0.060)	–0.143** (0.055)	0.067*** (0.014)
Treat × Week 6	10.393*** (2.301)	–4.439* (2.072)	–0.085 (0.044)	0.424*** (0.060)	–0.157** (0.053)	0.100*** (0.015)
Treat × Week 7	10.688*** (2.239)	–6.812*** (2.027)	–0.061 (0.044)	0.529*** (0.061)	–0.217*** (0.055)	0.127*** (0.015)
Treat × Week 8	13.552*** (2.282)	–6.398*** (1.930)	–0.043 (0.044)	0.531*** (0.061)	–0.213*** (0.054)	0.144*** (0.015)
Treat × Week 9	14.153*** (2.189)	–8.669*** (1.870)	–0.030 (0.045)	0.626*** (0.061)	–0.184** (0.057)	0.138*** (0.016)
Treat × Week 10	17.141*** (2.248)	–10.442*** (1.972)	0.017 (0.045)	0.633*** (0.062)	–0.279*** (0.059)	0.187*** (0.016)
Treat × Week 11	13.259*** (2.080)	–10.658*** (2.081)	0.002 (0.046)	0.630*** (0.061)	–0.372*** (0.055)	0.177*** (0.016)
Treat × Week 12	13.164*** (2.120)	–9.119*** (2.056)	0.006 (0.046)	0.694*** (0.061)	–0.308*** (0.059)	0.185*** (0.016)
Treat × Week 13	15.154*** (2.180)	–9.374*** (1.977)	0.025 (0.047)	0.694*** (0.061)	–0.284*** (0.059)	0.202*** (0.016)
Treat × Week 14	17.957*** (2.165)	–11.839*** (1.899)	0.043 (0.047)	0.746*** (0.061)	–0.356*** (0.059)	0.224*** (0.016)
Treat × Week 15	15.616*** (2.162)	–12.034*** (1.955)	0.035 (0.047)	0.720*** (0.062)	–0.298*** (0.057)	0.222*** (0.016)
Treat × Week 16	15.388*** (2.214)	–11.117*** (2.137)	0.039 (0.048)	0.756*** (0.062)	–0.337*** (0.062)	0.221*** (0.016)
Customer Effects	Yes	Yes	Yes	Yes	Yes	Yes
Week Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,3916	59,132	103,916	103,916	59,132	104,502

Notes. Std. Errors in parentheses. * p < 0.05, ** p < 0.01, *** p < 0.001.

Findings

We find that members to the subscription program significantly increase their weekly product spending via H at the retailer after joining the program (by about 17.66 Euros per week) and that this contribution somewhat increases over the subscription period (column 1 in Tables 1 and 2). As consumer average online spending via H fulfillment prior to joining the subscription program is 117.26 Euros per week, the total economic contribution of the subscription program is substantive. Interestingly, however, the online product sales contribution is offset by changes in consumers' behaviors intended to extract economic benefits from joining the retailer's subscription program, as follows.

First, subscribers' average weekly offline spending on products sold at the stores decreases after the start of their subscription program (by about 6.13 euros per week), and these effects intensify over time (column 2 in Tables 1 and 2). Second, consumers' average weekly spending on fulfillment fees for their online orders – considering an average weekly spending for subscribers equal to the subscription fee divided by the duration of the subscription program - decreases after they join the program (by about 0.07 euros per week) (column 4 of Table 1).

We also observe an increase in the frequency of H orders placed by consumers after joining the subscription program (on average, consumers placed 0.815 more H orders per week (up from 1.04 orders) after becoming subscribers (column 5 in Table 1), at the expense of consumers' store visits. At the same time, however, consumers visited stores 0.132 fewer times per week, on average (a decrease from an average of 1.43 weekly visits prior to program enrollment), after joining the program (column 6 of Table 1). Moreover, the increase in the frequency of H orders was reflected in a greater proportion of these orders delivered during premium time slots, which carry higher value (opportunity cost) for the retailer. The share of weekly H orders delivered during premium time slots increased by 20.5 percent (column 8 of Table 1). According to the results in Table 2 (columns 4 and 5) the subscription effects on the frequency of H orders and on offline visits intensify over time. The same is true for the effect on the use of premium slots for the delivery of H orders (column 6 of Table 2).

Based on the increase in the average frequency of H orders per week and the expansion in the proportion of H orders placed for delivery during premium slots, we estimate that subscribers experienced an average increase in the value of H fulfillment received of 1.44 Euros per week. Given that subscribers also decreased their weekly expenditures in H fulfillment fees by 0.07 Euros, we estimate that the total fulfillment benefit they received from the program is equivalent to 1.51 Euros per week (1.44 – (-0.07)).

Conclusions

Our main findings can be summarized as follows. First, we found that subscribers do impose on retailers added operational burdens as they change their behavior to extract economic benefits from joining the subscription program, namely increased frequency of online orders and increased proportion of online orders in premium delivery slots. Second, there was an increase in the weekly value of the fulfillment service received by subscribers that included lower expenditures per week in online fulfillment fees by consumers following their subscription to the program. Finally, subscribers' average weekly offline spending on products sold at the stores decreases after the start of their subscription program.

These findings have a number of implications for the design of subscription programs and associated fulfillment operations. Specifically, retailers can respond to these effects by adjusting several subscription program design parameters, individually or jointly. Regarding operational burdens, retailers may discourage the associated behaviors by

imposing restrictions on the number of online orders and/or the number of online orders in premium slots that could be placed during the subscription period; alternatively, they may impose minimum order values. Regarding the value of the fulfillment service received by subscribers, the excess value that we found subscribers to be receiving may serve as a benchmark to increase the fee consumers pay for the subscription program; alternatively, retailers could shorten the length of the subscription period. Regarding the reduction in spending at offline stores, retailers may consider customizing the fee consumers pay for the subscription program according to the distance between consumers and fulfillment stores; specifically, subscription program fees for customers living far away from the stores could be higher than for those living closer to stores.

Future research should examine consumers' sensitivity to these subscription program design parameters.

References

Bell, D., Gallino, S., Moreno, A. (2017), "Offline showrooms in omnichannel retail: demand and operational benefits", *Management Science* 64(4) 1629-1651.

Betancourt, R. (2005), *The Economics of Retailing and Distribution*. Edward Elgar Publishing, Cheltenham, UK.

Chintagunta, P., Chu, J., Cebollada, J. (2012), "Quantifying transaction costs in online/off-line grocery channel choice", *Marketing Science* 31(1) 96–114.

Gallino, S., Moreno, A. (2014), "Integration of online and offline channels in retail: The impact of sharing reliable inventory availability information", *Management Science*, 60(6) 1434-1451.

Iyengar, R., Park, Y., Yu, Q. (2021), "The impact of subscription programs on customer purchases", *Available at SSRN 3529681*.

Lim, S., Rabinovich, E., Park, S., Hwang, M. (2021), "Shopping activity at warehouse club stores and its competitive and network density implications", *Production and Operations Management*, 30(1), 28-46.

McCarthy, D., Fader, P. (2017), "Subscription business are booming. Here's how to value them", available at https://hbr.org/2017/12/subscription-businesses-are-booming-heres-how-to-value-them

Wagner, L., Pinto, C., Amorim, P. (2021), "On the value of subscription models for online grocery retail", *European Journal of Operational Research*, 294 (3), 874-894.

Wang, L., Rabinovich, E., Richards, T. (Forthcoming) "Scalability in online platforms for local grocery food: an examination of indirect network economies", *Production and Operations Management*.

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