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# Optimal Omni-channel E-retail

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***Abstract*— In this paper, we develop an optimization model for minimal cost e-fulfillment of goods in a business to customer (B2C) scenario. In particular, we focus on an Internet enabled retailer or e-retailer fulfilling the online orders. We formulate and solve the least cost optimization problem to determine the best choice among the following three options: (a) dedicated fulfillment, (b) outsourcing the fulfillment to a third party, or (c) supplier dropshipping the items to the customer. The e-retailer wants to maximize his profit margins and reduce the delivery lead time. The main players in our model are: e-retailer, dropshipper, third party logistics, and the customers. All these agents are strategic in revealing their true supply costs and not on the lead times. The problem is divided into parts: allocation and payment. The allocation part is solved as an optimization problem. We propose two allocation techniques. The first optimization formulation (SSOF) considers minimizing all the costs in a single iteration and the second optimization formulation (MSOF) does it iteratively. We propose incentive compatible payment structures corresponding to the two optimization formulations. Later, we formulate the payment schemes of the agents using a multi-unit VCG auction. We present an example to illustrate the optimization process.**

## I. INTRODUCTION

In e-retail, customers place orders online and pay either online or on delivery. The e-retail players include major retail chains, Web-only stores, and individuals selling on aggregate sites such as eBay, Amazon, Alibaba, and Flipkart. The order-to-deliver process poses several challenges, particularly in emerging markets such as India. The product is home delivered and customer prefers to pay cash on delivery. The customer can reject delivery or can return after a stipulated period. In this paper, we consider three options of fulfilment: the e-retailer can (a) deliver products from his local warehouse, (b) can outsource delivery to a 3*PL* (third-party logistics), or (c) pass on the order to the dropshipper to fulfil. The channel through which the shipment gets fulfilled and delivered remains a black-box for the customer, thus called omni-channel. E-retail is booming around the world, in particular in emerging markets due to the rise of mobile Internet.

### *A. Rise of E-retailer Emerging Markets*

The growing penetration of connected devices among consumers, combined with digitization and supply chain improvements, has quickened customer migration to e-platforms. Thus consumer base has increased so widely that

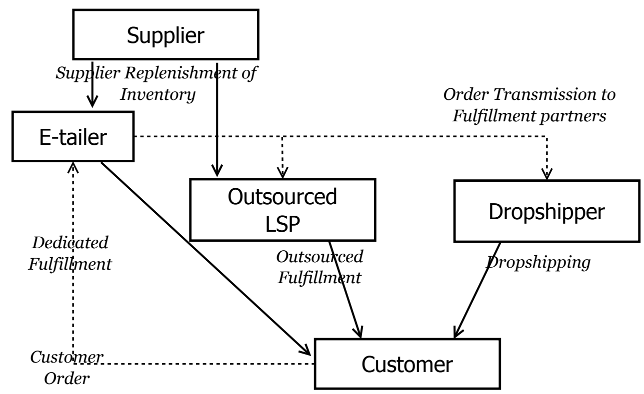


Fig. 1. Fulfillment operations of an e-retailer as described in [3]

there is a need of identifying the algorithms that make the flow of online retail easy with respect to scalability. There are various examples to quote that portray the growth of online retail worldwide. Chinese giant Alibaba set the standard for the world's emerging e-commerce scene with its record-breaking IPO in 2014, making the financial potential of this burgeoning industry glaringly clear. Major Indian local players such as Snapdeal and Flipkart, both of which entered the market fairly recently and raised USD 1bn in funding in 2014, are proving themselves worthy competitors of global giants such as Amazon and Alibaba. E-retailer merchants have to be able to offer products and services for competitive prices in multiple currencies, delivered in the promised timeframe, for which a solid infrastructure is critical. The design of the procurement and payment strategies are also important issues.

There was not much attention paid to the e-retail order-to-delivery process by the academic researchers. The supply chain networks literature deals with procurement, manufacturing, distribution, and retailing, and concentrates on inventory management through the supply chain and matching the supply with the demand. There is vast literature on these topics and there are several software providers. Here we deal with the online ordering and home delivery process. The customer pays either through a credit card or pays on delivery. The e-retailer either keeps stock of the products and delivers to the customer or passes on the order to the supplier for fulfillment. The coordination is assumed to be perfect, i.e., once the order is accepted, it is fulfilled within the time frame promised. There is not much academic literature available dealing with this topic. Viswanadham et al. [3] formulate the online retail problem as an optimization

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problem. Here our formulation and solution go much beyond their work.

### B. Contributions

Following are the major contributions of this paper:

- We propose two types of optimization formulation (SSOF and MSOF) that solve the procurement and delivery aspects on the same lines as proposed by Chen et al. [1].
- We formulate the payment scheme for the fulfilling agents using multi-unit VCG mechanism ([1], [2]).

The above mentioned optimization formulations can used in two different scenarios which has been elaborated later in the paper. There are various parameters on which the agents may be strategic, like the supply cost, lead time, QoS, etc. We only consider the strategic behavior of the agents on the supply cost. In this paper, we work in a setting where the e-retailer has multiple options or players for delivering the shipments. We formulate an optimization problem for solving the allocation (which player delivers how much and to which customer) and later define the payment scheme (which e-retailer pays to the agents using the famous VCG payment structure [2]). The objective is to find a systematic approach to mapping of procurement operation to each customer residing at various geographic locations.

This paper is organised as follows. In Section II, we formulate the base model for e-retailer for all the three options. In Section III, we formulate the optimization models for both Single and Multi stages. In Section IV, we describe the payment schemes for the partners using multi-unit VCG auction. We demostrate the different cases where both the optimization strategies can be used by giving an example in Section V. In Section VI, we conclude by giving the future direction in this area of research.

## II. PROBLEM FORMULATION

### A. Terminology

- **Dedicated in-house Fulfillment**: The e-retailer can own a warehouse of its own to fulfill the requirements of the customer. So, there can be a case that the e-retailer wants to keep a minimum of some quantity of the product in the warehouse. The stocks in the warehouse come directly from the supplier end.
- **Dropshipper**: There might be cases where the e-retailer may get out of stock in case of higher demand. So, it has its reputation at stake in case it is not able to meet the demands of the customers. The dropshipper orders goods from its own supplier and manages its own warehouse.
- **Outsourced Fulfillment (Third Party Logistics)**: Here the e-retailer may want to keep some inventory with the third party service provider. In this case, the inventory is maintained by this 3*PL* and it gets its stocks from the same supplier from where the e-retailer has it. The fulfillment house also handles the transportation and charges the cost accordingly to the hiring company for each item.
- **Total Order Cycle Time** : The time after the customer receives receipt of the order until the delivery has been made.
- **Lead Time** : The time after the fulfilling agent is given the charge of the shipment until the delivery is made.

### B. Base Model

Consider an e-retailer (social planner) who provides a platform (website or mobile application) to order products or services online. Customer visits any one of these modes and orders the products. After successfully passing by the payment gateway, she is given a promise-to-ship date. Each customer has certain requirements, called the demand vector. Customers may be distributed at varied geographical locations. The e-retailer can fulfill the customer orders through three channels:

1) Dedicated in-house Fulfillment
2) Dropshipper
3) Outsourced Fulfillment (Third Party Logistics)

Each fulfilling agent has a delivery location preference. Also each agent might have multiple warehouses where the stocks are available. After every **t** time units, the e-retailer looks into his database for the orders that have been placed. The e-retailer knows the following details:

- Supply cost function of each agent in the supply chain. This function gives us the supply cost associated with a shipment quantity.
- Lead time function of each agent in the supply chain. This function gives us the lead time associated with a shipment quantity.
- Co-ordination cost associated between the e-retailer and the agents. This cost is constant and does not depend on the shipment quantity which the agent has to fulfill.

The idea is that it may not always be possible for the e-retailer to fulfill the demands, so it has to think about some other options or channels to meet the demands. There is also an increasing trend of e-retailer to have asset-less fulfilling mechanism where he just acts as an orchestrator and does the matching between the fulfilling agents and the customers. The customer is unaware of the channel through which her order is going to be fulfilled. This makes sense as the customer just wants that the product should be delivered on time and other Quality of Services should be met. These days, e-retailers give the customer an option to choose the channel of service.

The main question here we want to focus on is the allocation of delivery locations to the fulfilling agents based on some cost parameters and Quality of Service. All these agents are strategic in the sense that they may not always want to tell their true supply costs at the time of allocation and the QoS promised. All the agents, namely, e-retailer, dropshipper, and 3*PL*, are strategic agents which implies that when asked about the cost and capacity related information of the good or service, they might not always tell the true valuations.

Each fulfilling agent has an associated quality index in the range [0,1]. The e-retailer specifies a minimum quality threshold which every fulfilling agent should abide by. After the delivery has been made, the customer may keep the product or return it if the claimed quality threshold of the product by the e-retailer is not met. So the quality of the agent who has delivered the product falls down. This is a real-world problem, and the best of our knowledge, there has been no relevant literature in this area.

### C. Assumptions

Following are the assumptions that have been made in the proposed model:

- We assume for simplicity and ease of analysis that, the e-retailer sells only one type of good or service (homogeneous good). Later, we can extend it for multiple types of products.
- Only one dropshipper and $3PL$ is there in the model, however there could be more than one of these contributing agents in the whole scenario. This assumption has also been made for ease of analysis.
- Each of the agents, namely, dropshipper, $3PL$, and the e-retailer, does not have any capacity constraints. So, whatever quantity e-retailer wants the agent to deliver it can deliver. This assumption has been made as we are not addressing the situation when the product goes out of stock in the inventory of the e-retailer and the fulfilling agents.
- Each fulfilling agent has a location constraint, e.g., an e-retailer can only deliver to locations $X$ and $Y$, whereas the dropshipper will prefer to deliver to locations $Y$ and $Z$. This assumption is a real-world scenario as location preferences exist, for instance, an e-retailer located in India, gets an order whose delivery location is Barcelona, Spain, and only one fulfilling agent has got the inter-country trading permissions.
- The dropshipper and $3PL$ will have some expectations over the quantity which the e-retailer will take from them in **t** time horizon. So, this means that the e-retailer will have to at least take that amount of goods from the dropshipper and the $3PL$. As the dropshipper cost may be high, he is just in the model to make sure that the possibility of out of stock inventory reduces. But in case the resources are in abundance, then the probability that dropshipper will get order, reduces. So, to make sure every agent gets orders, this constraint has been put.
- The cost of the returned item is borne by the e-retailer himself.
- We assume that e-retailer has done a prediction analysis, in a particular time frame how much order could be placed by the prospective customers. Also, the prediction analysis would never under-estimate the number of orders that can be placed however, over-estimation is possible. So, lets say that in the first iteration of the prediction analysis we over-estimated the number of orders then in the second iteration we can deduct that left over amount from the new predicted amount.

TABLE I
ABBREVIATIONS FOR THE AGENTS

| | |
|---|---|
| $e$ | e-Retailer or e-retailer |
| $d$ | Dropshipper |
| $3PL$ | Third-party logistics |

### D. Notations and Abbreviations

Table I presents the abbreviations used for the agents.

TABLE II
NOTATIONS

| | |
|---|---|
| $\mathbf{R}$ | Cost of selling a unit product to the customer |
| $N_e$ | Set of warehouses owned by e-retailer |
| $N_d$ | Set of warehouses owned by dropshipper |
| $N_{3PL}$ | Set of warehouses owned by $3PL$ |
| $N$ | $N_e \cup N_{3PL} \cup N_e$ |
| $M$ | Set of customer locations where product has to be delivered |
| $q_m$ | Demand at customer location $m$, where $m \in M$ and $q_m > 0$ |
| $q$ | Demand vector $(q_m : m \in M)$ |
| $y_{nm}$ | Quantity shipped from warehouse $n$ to customer location $m$ |
| $z_k$ | $\sum_{m \in M} y_{nm}$, total quantity shipped by agent $k$ |
| $Y_k$ | Allocation vector $(y_{k_1}, \ldots, y_{k_{\lvert N_k \rvert}})^T$ |
| $\tau_{nm}$ | Cost of shipping one unit from warehouse facility $n$ to customer location $m$ |
| $T_k$ | Minimum unit of product sale from each agent $k$ |
| $\mu_d$ | Fixed cost of dropshipping fulfillment |
| $\mu_{3PL}$ | Fixed cost of outsourcing fulfillment with $3PL$ |
| $\omega$ | Weighing factor to scale time in terms of cost |
| $C_k(Y_k)$ | Supply cost function for agent $k$ ($\mathbb{R}^{\lvert N_k \rvert} \to \mathbb{R}$) |
| $F_k(Y_k)$ | Quoting cost function from agent $k$ to e-retailer ($\mathbb{R}^{\lvert N_k \rvert} \to \mathbb{R}$) |
| $L_k(Y_k)$ | Lead time function for delivering $Y_k$ to customers ($\mathbb{R}^{\lvert N_k \rvert} \to \mathbb{R}$) |

In Table II, we have used the indicator $k$ where $k \in \{e, d, 3PL\}$. The functions $C_k(Y_k)$ and $F_k(Y_k)$ take $Y_k$ as input. $C_k(Y_k)$ is the cost realization of agent $k$ if he is asked to deliver quantity $Y_k$. This realization is private to the agent, i.e., he may not quote the same valuation to the e-retailer. $F_k(Y_k)$ is the value which agent $k$ bids or quotes to the e-retailer.

Also, these functions are non-decreasing, convex, and closed, with $C_k(\mathbf{0}) = F_k(\mathbf{0}) = 0$ for each agent $k$. These functions correspond to the fact that in bulk consignments, discount may be given from the fulfilling agents site to the e-retailer site. This means as the quantity of the products asked from them increases, they may offer low prices accordingly. The function $L_k(Y_k)$ is the lead time function that the fulfilling agent $k$ quotes to the e-retailer for quantity $Y_k$.

We have put e-retailer as a fulfilling agent but he would not be strategic with respect to the cost. In e-retailer's case, $C_e(Y_e) = F_e(Y_e)$ since the e-retailer is the planner in the model.

### E. Objective

We aim at maximizing the profit margin of each agent and minimizing the lead time keeping in mind the QoS provided to the customer. To achieve this, the e-retailer has to elicit the true supply costs and lead times from the fulfilling agents.

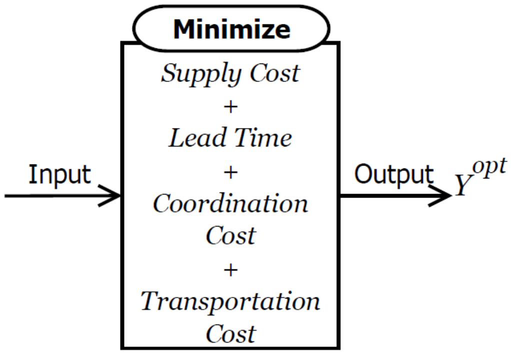


Fig. 2. Single stage optimization formulation

Intuitively, this leads to minimizing the profit margin of the fulfilling agents. But at the same time, he has to be in the business, so he has to always promise some market and profit to the agents. If he denies these primary concerns of the agents, then he might not always be able to meet the demands of the customer (his reputation is at stake). This boils down to the problem of how to design the payment structure of the fulfilling agents so that it is always beneficial for them to quote their true supply costs and lead times.

## III. OPTIMIZATION MODELS

### A. Single Stage Optimization Formulation (SSOF)

In single stage optimization problem, the supply cost, lead time, coordination cost, and transportation cost, are minimized together and thus allocation of the delivery quantity to the agent is done as shown in Fig 2. This is on the same lines as Auction T by Chen et al. [1] for the supplier-manufacturer environment, which does not consider the lead time. We define the optimization problem as follows.

**Minimize**

$$\sum_{Y_k \in \{Y_e, Y_d, Y_{3PL}\}} \Big( F_k(Y_k) + \omega L_k(Y_k) \Big) + \sum_{n \in N} \sum_{m \in M} \tau_{nm} y_{nm} + \mu_d + \mu_{3PL}$$

**Subject to**

$$\sum_{n \in N} y_{nm} = q_m \qquad \forall k \in \{e, d, 3PL\},\ \forall m \in M$$
$$y_{nm} \geq 0 \qquad \forall m \in M,\ \forall n \in N$$
$$\sum_{m \in M} y_{km} \geq T_k \qquad \forall k \in \{e, d, 3PL\}$$

To make the optimization problem into single multi-criteria objective function, we use a weighing factor $\omega$, that converts the time into monetary unit. The objective function is a maximizing function which is the profit margin of the e-retailer. The constraint part is as follows:

- The first constraint ensures that all the customer order are fulfilled by any of the three channels.
- The second constraint ensures that the minimum unit of sale from each warehouse is 0.
- The third constraint ensures the minimum unit of sale from all three sources of fulfillment.

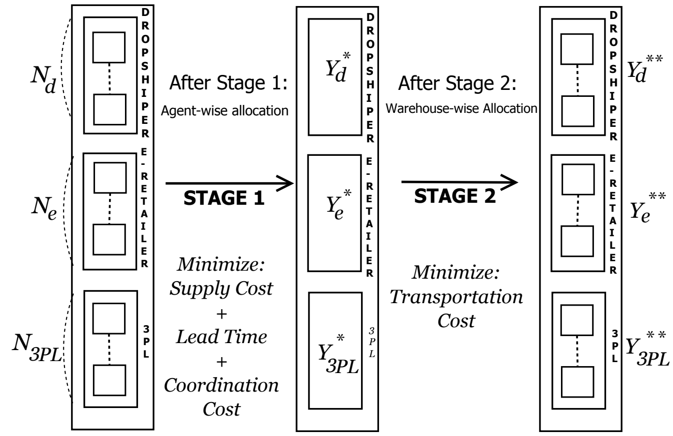


Fig. 3. Fulfillment operations of an e-retailer as described in [3]

Our basic objective is to maximize the total revenue the e-retailer gets from the customer, deducting the total cost incurred by the e-retailer for delivering the products to the customer site. As $\mathbf{R}$ is constant, this maximization problem becomes equivalent to the minimization problem as mentioned above. So, we are trying to minimize the total cost incurred by the e-retailer for delivering the products to the customer site.

Let $\pi_1(\mathbf{q})$ be the optimal value of the objective function for a given $\mathbf{q}$. Define $\mathbf{Q} = \{\mathbf{q} : \mathbf{q} > \mathbf{0}, \pi(\mathbf{q}) < \infty\}$ and we restrict $\mathbf{q} \in \mathbf{Q}$ to ensure sufficient supply capacity. Since $F_k(\cdot)$ is closed, for any $\mathbf{q} \in \mathbf{Q}$, an optimal solution exists.

### B. Multi Stage Optimization Formulation (MSOF)

In multi stage optimization problem, we perform the optimization stepwise as shown in Fig 3. First we minimize the supply cost, lead time, and coordination cost, and get the quantity which each agent has to deliver to the customer without the warehouse-wise allocation separately. Then in the second step, we minimize the transportation cost and obtain the warehouse-wise allocation of quantities to be shipped by the agents. This is on the same lines as Auction S by Chen et al. [1] for the supplier-manufacturer environment, which does not consider the lead time.

The first optimization step is:

**Minimize**

$$\sum_{Y_k \in \{Y_e, Y_d, Y_{3PL}\}} \Big( F_k(Y_k) + \omega L_k(Y_k) \Big) + \mu_d + \mu_{3PL}$$

**Subject to**

$$\sum_{n \in N} y_{nm} = q_m \qquad \forall k \in \{e, d, 3PL\},\ \forall m \in M$$
$$y_{nm} \geq 0 \qquad \forall m \in M,\ \forall n \in N$$
$$\sum_{m \in M} y_{km} \geq T_k \qquad \forall k \in \{e, d, 3PL\}$$

In this step, we get the agent-wise quantity allocation without getting the warehouse-wise allocation (as each agent might have more than one warehouse).

**Minimize**

$$\sum_{n\in N}\sum_{m\in M}\tau_{nm}y_{nm}$$

**Subject to**

$$\sum_{n\in N} y_{nm} = q_m \qquad \forall m\in M$$
$$\sum_{m\in M} y_{km} = \sum_{m\in M} y^*_{km} \qquad \forall k\in\{e,d,3PL\}$$

In this step, the allocation for transportation of products, warehouse-wise for each agent, is determined. We denote it by ${y_{nm}}^{**}$. We denote the optimal quantity vector by ${Y_k}^{**}$. As discussed before about the optimal solution existence for SSOF, similarly we can show that optimal solution exists for MSOF.

## IV. MECHANISM DESIGN

The optimization problems do not capture the uncertainties associated with the fulfilling agents not being truthful about their valuations of the supply cost and the lead time. So, we propose payment mechanism for the fulfilling agents in order to elicit true valuation on these parameters as in [1].

We design an auction mechanism where the fulfilling agents quote their supply cost and lead time according to their bidding function $F_k(Y_k)$ and lead time function $L_k(Y_k)$ respectively, as described in Section II. The e-retailer is the Social Planner who runs the auction and the strategic players are the e-retailer himself, dropshipper, and the $3PL$. We assume that the agents are strategic only over the supply cost and not over the lead time.

We choose VCG auctions as the mechanism to define the payment of the fulfilling agents. The choice is justified because these mechanisms are both **incentive compatible** and **allocatively efficient**. So, the e-retailer's payment to a supplier is based not only on the quotations submitted, but also on the contribution of the supplier to the system by participating in the auction.

Let $\pi^{-k}(\mathbf{q})$ be the optimal value of the objective function with the additional constraint $Y_k = 0$ (this implies that fulfilling agent does not participate in the auction). Now we define the payment structure of the optimization problems: SSOF and MSOF.

*1) SSOF Payment Scheme:* The e-retailer pays the fulfilling agent $k$ an amount of $\psi_k^{SSOF}(\mathbf{q})$. The formula for payment for agent $k$ is defined as:

$$\psi_k^{SSOF}(\mathbf{q}) = \pi^{-k}_{SSOF}(\mathbf{q}) - \pi^{k}_{SSOF}(\mathbf{q}) + F_k(Y_k^*) + \omega L_k({Y_k}^*)$$

The term $\pi^{-k}(\mathbf{q}) - \pi^{k}(\mathbf{q})$ is the bonus payment made to the agent $k$, representing the value he adds to the system by participating in the auction. So, the e-retailer pays the agent her bid $F_k(Y_k)$ plus her contribution to the system. This payment structure belongs to the general truth-inducing VCG family described in [2]. Consequently, the rational agents will bid their costs, $F_k(Y_k) = C_k(Y_k)$, irrespective of other agents' bids.

Total supply chain cost (TSC) in this case is the value of the objective function as $F_k(Y_k) = C_k(Y_k)$.

$$TSC^{SSOF} = \sum_{k\in\{e,d,3PL\}} \Big(C_k(Y_k) + \omega L_k(Y_k)\Big) + \sum_{n\in N}\sum_{m\in M}\tau_{nm}y_{nm} + \mu_d + \mu_{3PL}$$

*2) MSOF Payment Scheme:* The e-retailer pays the fulfilling agent $k$ an amount of ${\psi^2}_k(\mathbf{q})$. The formula for payment for agent $k$ is defined as:

$$\psi_k^{MSOF}(\mathbf{q}) = \pi^{-k}_{MSOF}(\mathbf{q}) - \pi^{k}_{MSOF}(\mathbf{q}) + F_k({Y_k}^*)$$

Similar to SSOF, the fulfilling agents still submit their true bids or quotations to the e-retailer. The total payment done to the e-retailer by all the agents is as follows:

$$\lambda(\mathbf{q}) = \sum_{k\in\{e,d,3PL\}} \psi_k^{MSOF}(\mathbf{q}) + \sum_{n\in N}\sum_{m\in M}\tau_{nm}y^{**}_{nm}$$

Total supply chain cost will be:

$$TSC^{MSOF} = \sum_{k\in\{e,d,3PL\}} \Big(C_k(Y_k^{**}) + \omega L_k(Y_k^{**})\Big) + \sum_{n\in N}\sum_{m\in M}\tau_{nm}y^{**}_{nm} + \mu_d + \mu_{3PL}$$

## V. EXAMPLE

We set up the ground for the experiment by taking the following data. All the three fulfilling agents namely, the e-retailer, dropshipper, and 3PL, have only one warehouse. There are two customer delivery locations with demand of 50 units each. The minimum unit product sales for e-retailer, dropshipper, and 3PL, are 10, 10, 14, respectively. For simplicity, we assume the fixed cost of dropshipper and outsourcing fulfillment to be 0. Let the Quoting cost and Lead time functions be as follows:

$$F_k(Y_k) = \sum_{m\in\{1,2\}} (y_{km})^2$$
$$L_k(Y_k) = \sum_{m\in\{1,2\}} y_{km}$$

We randomly generate the transportation cost 5 times $\tau_{nm} \sim$ U(50,100) and calculate the payment for the agents $(\psi_e, \psi_d, \psi_{3PL})$, total supply chain cost (TSC) and transportation cost (TC), and $y_{nm}$'s for SSOF and MSOF respectively. Later we take the average of all values as depicted in Tables III, IV and V for 5 different values of $\omega$. We denote the total payment of all fulfilling agents by $\psi$.

TABLE III

PAYMENT TO EACH AGENT, TOTAL PAYMENT, TSC AND TC FOR DIFFERENT VALUES OF $\omega$ IN SSOF

| $\omega$ | $\psi_e$ | $\psi_d$ | $\psi_{3PL}$ | $\psi$ | TSC | TC |
|---|---|---|---|---|---|---|
| 1 | 438 | 335 | 1453 | 2226 | 10454 | 7485.2 |
| 2 | 6204 | 346 | 1480 | 8030 | 10554 | 7485.2 |
| 3 | 6265 | 358 | 1507 | 8130 | 10654 | 7485.2 |
| 4 | 6389 | 369 | 1534 | 8271 | 10754 | 7485.2 |
| 5 | 6450 | 381 | 1561 | 8392 | 10854 | 7485.2 |

### A. Experimental Results

Following are some implications of the experimental results:

- We can see that the total supply chain cost in SSOF is low as compared to MSOF. This is due to the fact that in SSOF, we minimize all the costs of the supply

TABLE IV
PAYMENT TO EACH AGENT, TOTAL PAYMENT, TSC AND TC FOR DIFFERENT VALUES OF $\omega$ IN MSOF

| $\omega$ | $\psi_e$ | $\psi_d$ | $\psi_{3PL}$ | $\psi$ | TSC | TC |
|---|---|---|---|---|---|---|
| 1 | 4814 | 789 | 1421 | 7024 | 10106 | 7278.6 |
| 2 | 4868 | 807 | 1449 | 7124 | 10206 | 7278.6 |
| 3 | 4923 | 825 | 1476 | 7224 | 10306 | 7278.6 |
| 4 | 4978 | 844 | 1503 | 7325 | 10406 | 7278.6 |
| 5 | 5033 | 862 | 1531 | 7426 | 10506 | 7278.6 |

TABLE V
QUANTITIES TO BE SHIPPED BY THE AGENTS TO CUSTOMER LOCATIONS IN SSOF AND MSOF

| | $y_{11}$ | $y_{12}$ | $y_{21}$ | $y_{22}$ | $y_{31}$ | $y_{32}$ |
|---|---|---|---|---|---|---|
| SSOF | 30 | 32 | 5 | 7 | 16 | 10 |
| MSOF | 22 | 32 | 0 | 18 | 28 | 0 |

chain together, but in MSOF, we first minimize supply cost and then transportation cost. So, if the supply cost and transportation cost are negatively correlated, then we may end up choosing very low supply cost agent whose transportation cost is very high, which increases the TSC in MSOF as explained in [1].

- Secondly, we see that the payments in MSOF is low as compared to SSOF. This is due to the fact that the contribution of the agent is only based on supply cost in MSOF unlike SSOF. So, as the correlation between the supply cost and transportation cost for an agent increases, the payment for that agent decreases.

### *B. MSOF vs SSOF*

Let us look at an example where an e-retailer has a niche product and a daily consumable item to sell.
CASE 1: Selling a niche product means that the product is available at less outlets and customer will be willing to pay reasonably any amount to get the product. So, an e-retailer will minimize the supply cost initially and then the transportation cost. As he can add directly the transportation cost to the total price of the product. This suggests that the e-retailer would be in favor of using MSOF in this case.
CASE 2: Selling a daily consumable product like vegetable should take into account that the total price that is paid by the customer should be less and there is a competition for selling it. This implies that minimizing all the cost, i.e., the supply cost and the transportation cost in a single go, is better. So, using SSOF will be beneficial for the e-retailer as it would overall reduce the price of the product.

## VI. CONCLUSION

In this paper, we presented an optimization model for e-retailers and considered the cases when the partners can be strategic. We addressed this very important real-world problem. Our solution, we hope, will have several practical applications. Another issue of consideration is that most e-retailers are not making profits. This is a known fact because of the discounts offered to attract the customers and also the home delivery costs. Two issues of importance are returns and cash on delivery, which affect the profitability. In future work, there is a need to consider these risks associated with the online retail.

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