System Dynamics Based Simulation Study On Storage and Distribution Integration of Electronic Commerce Enterprise

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ABSTRACT
With the strong advocacy of national policies and the rapid development of electronic commerce, offline logistics operation has become the key to efficient and fast e-commerce. This paper will use the system dynamic method to build an integrated warehousing and distribution system of e-commerce, applying the computer simulation to analyze the change of each parameter after the target inventory and delay time have changed. Suggestions will be put forward at last: building of an info-sharing mechanism, reducing the delay time via active coordination, predicting the target inventory of distribution center on time. Through these to reduce the average cost and the possibility of short supply at distribution center, and thus guarantee the delivery quality and speed, optimize buyers’ shopping experience, form a virtuous circle and enhance the overall competence of the supply chain.

Keywords: e-commerce; integrated warehousing and distribution; system dynamics; simulation

INTRODUCTION
According to the latest data from iResearch, the 2015 annual China e-commerce trade reaches 16.4 trillion RMB, increasing 22.7% on the same period last year. This includes 3.8 trillion online shopping, which increases 36.2% on the same period last year, and becomes a pivotal part of e-commerce development.

And according to The 2016（first half year）China E-commerce User Experience and Complaint Monitoring Report, published by China e-commerce study center, the numerous complaints received by China E-commerce Complaint and Mine-rights Public Service Platformand big data monitoring show: the national online shopping buyers’ complaints relating to e-commerce sellers received by the platform in the first half of 2016 increases 4.16% on the same period last year. High fund occupation in E-commerce logistics, high cost workers, unreasonable packing, delayed supply, and poor service quality become obstacles on the way to well developed e-commerce. “Logistics distribution being able to achieve the end distribution of online trading commodities will complete the entire e-commerce activities” [1].

As iResearch reports, though C2C market share was surpassed by that of B2C in 2015, it is still large and complete, and has the potential to enlarge in the future.

As analyzed above, this paper studies the integration of storage and distribution of e-commerce business enterprises, and builds system dynamics model, with simulation of Vensim. This study will help e-commerce enterprises provide their agents and sellers with on-time and high quality distribution service, increase their sales, improve customer satisfaction, foster a good image of products and company, and promote a healthy development.

SYSTEM DYNAMICS OVERVIEW
System Dynamics[2], founded by Professor Jay W. Forrester at MIT in 1956, studies the complex information feedback system. Its methods are being employed in various fields like social studies, economics, enterprise management and ecology [3].

LITERATURE REVIEW
Forrester built the simulation model of supply chain involving factory, warehouse, distributor, and retailer with the application of system dynamics [4]. John D. Sterman used system dynamics to build a Delay-Inventory Management model [5]. XIANG Zhouruan proposed a basic framework of building a system dynamic model from a three dimensional distribution to get the an effective scale of distribution center [6].LU Jun-qiang built a system dynamics model combining distribution center and market inventory, and did simulation analysis from the aspects of allowing shortage or not, reaching the target of cost reduction and service quality promotion [7]. According to the theory of system dynamics, LI Xu built a model of market distribution center inventory [8].

Through simulation analysis, he put as inventory unit cost increases, inventory level should be pared down to optimize the annual revenue of supply chain. CHEN Wen-jia, together with other scholars, used system dynamics to build a distribution center for three-store-distribution, combining actual simulation, and gave suggestions on optimizing distribution center operations [9].LIU Sheng-liang and others employed system dynamics for simulation analysis on retailing distribution and inventory, optimizing the retailing distribution logistics and inventory, enhancing the overall system competence as well [10]. ZHONG Shen took advantage of system dynamics and simulation model for catering business distribution and gave further suggestions [11]. Through modeling and simulating relief materials reserve strategies, MAN Jiang-hong gave advices on planning relief material reserve [12]. CHEN Jun applied system dynamics on distribution efficiency of military logistics bases [13]. YUD Bao-qin based system dynamics theory on online purchasing, constructed a measuring mechanism of online purchasing-distribution, analyzed the cause-and-
effect of logistics quality [14]. LUO Jian-feng used system dynamics to construct a control model of distribution center inventory, and pointed significance of introducing system dynamics to logistic system analysis [15]. DONG Yuan-ming constructed a dynamic simulation model for FMCG (fast moving consumer goods) distribution center based on system dynamics, and simulated with the aid of Vensim, to quantifiably and perceptually present whether to newly construct a distribution center on the basis of current distribution center number [16].

With the boom of e-commerce in recent years, scholars are applying system dynamics in e-commerce warehouse and distribution. Literature 17-23 study and illustrate different aspects of e-commerce logistics and distribution based on system dynamics.

MODELING E-COMMERCE DISTRIBUTION CENTER STORAGE SYSTEM

As shown in the chart below, through signing authorized sales contract with e-commerce enterprises and paying certain amount of margin, agent sellers forward the confirmed order through system interface to self-built storage and distribution center of e-commerce enterprise. After receiving order info, storage and distribution center will begin the sorting and packaging at first time, and inform logistics enterprises to pick up and deliver on that day (orders from evening to early morning can be delayed to the next day), transferring the delivery info via platform to agent sellers, who then feedback to buyers (or feedback automatically).

![Chart 1: E-commerce Storage and Distribution system Dynamics Flow Chart](image)

Order info flow: online buyer→agent seller→warehouse center→branded logistics

High quality service flow: buyer←branded logistics→warehouse center(big customer)→agent seller→buyer

Fund flow: online buyer→agent seller→terminal(quota)settlement→e-commerce enterprise(warehouse center)

Advantage analysis

Sellers can leave out warehouse related cost, which includes fields, workers, equipments, consumables, etc. In addition, warehouse and distribution center can sign a long-term cooperation agreement to become the big customer and enjoy preferential treatment, overcoming seller’s difficulties concerning package, delivery. On-time delivery and uniform package helps promote product and e-commerce enterprise image, enhance, enhance buyers’ experience, building a positive circle for agent sellers and enterprises. Agent sellers only need to pay off all the additional fees of packages and logistics at regular periods, or when reaching a certain amount of settlement.

System Boundary Analysis

To build the system dynamics model of distribution center is first to determine the system boundary. For the purpose of system modeling, this paper studies the system of warehouse and distribution center concerning: the target inventory, order rate, en route cargo quantity, time needed for cargo arrival, distribution rate, single order cost, daily holding cost of each product, total cost, daily average cost, and daily order quantity of each agent seller. The system study boundary above does not take into account some minor or unquantifiable factors, like market economy form, price index, enterprise scale, maximum inventory of distribution center, sales promotion on holidays, or policies and regulations. In addition, assumed conditions by modeling are as follows:

(1) assuming suppliers can provide any number of cargos to distribution center.
(2) assuming suppliers can provide cargos with 100% qualified rate, leaving out returned subsystem.

(3) assuming logistics delayed when suppliers distribute cargos to distribute center.

(4) assuming no delay occurred when cargos were distributed to agent sellers, and branded logistics have the capability to pick up all the packages in the same day.

(5) assuming the management platform of distribution center can check the inventory in real time, making order warnings in time based on model needs.

System Dynamics Flow Analysis
System dynamic flow chart is the organic combination of basic variables and the symbol. System dynamics is introduced with factors such as level variables, rate variables, auxiliary variables, constants, and is constructed into a more thorough system chart—flow chart, a more complete, specifically describing the system composition, and the overview of interaction mechanism between system behavior and system elements, and can clearly show the quantitative relations[2] between various factors.

In this paper, we study the construction of an e-commerce system dynamics model of warehouse distribution center. As mentioned above, the modeling tool VENSIM is used to construct the system dynamic flow chart of e-commerce warehouse distribution center, as shown in chart 2.

System Dynamics Formulae
After building the model, a formula system on system dynamics is needed to be set up to further determine the relation between variables. A few core formulae are as follows:

1) \[ \text{OrderCost} = \text{OC} \times \text{IF THEN ELSE} (\text{INTEGER} (\text{Order}/1000) = 1, 0, 1) \]
   One supplier makes a statement that as long as the order is over 1000 pieces (at least enough for suppliers paying a car running a trip), the relevant expenses shall be the responsibility of the supplier.

2) \[ \text{Demand1} = \text{INTEGER} (\text{RANDOM UNIFORM}(1, 1000, 388)) \]
   Since the sellers actual sales are influenced by many factors, sales generally have maximums and minimums, random numbers are used here for better representatives.

3) \[ \text{OA} = \text{DELAY FIXED} (\text{Order}, \text{LT}, 0) \]
Due to the inevitable delay in the delivery from suppliers, delay function is thus is used.

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>VARIABLE DECLARATION</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>OC</td>
<td>Cost per order</td>
<td>yuan</td>
</tr>
<tr>
<td>HC</td>
<td>The daily holding cost of each piece of goods</td>
<td>yuan / piece / day</td>
</tr>
<tr>
<td>SC</td>
<td>The daily shortage cost of each out of stock</td>
<td>yuan / piece / day</td>
</tr>
<tr>
<td>DI</td>
<td>The target inventory</td>
<td>piece</td>
</tr>
<tr>
<td>LT</td>
<td>The required number of days from order to arrival, delay time</td>
<td>day</td>
</tr>
<tr>
<td>Cost</td>
<td>Total cost</td>
<td>yuan</td>
</tr>
<tr>
<td>Average</td>
<td>Average daily cost</td>
<td>yuan / day</td>
</tr>
<tr>
<td>Stockout</td>
<td>Out of stock quantity</td>
<td>piece</td>
</tr>
</tbody>
</table>

**SIMULATION AND SIMULATIONRESULT ANALYSIS**

Before simulation, correctness of the model should be checked. Perform VENSIMCheck Model and function of UnitsCheck. Model checking before simulation. The simulation interval length $L = 1095$ days (3 years), step length $DT = 1$ day. The initial value takes target inventory value, cargosen routetakes 0, single ordering less than 1000 pieces cost 3000 yuan.

**Simulation Determines Target Inventory of Distribution Center**

After considering various costs, the daily holding cost is 1 yuan / piece / day, 150 yuan/piece/ day when being out of stock. The goal is to determine the target inventory, under which minimizing the possibility and number of being out of stock. After many times simulation, target inventory is set for 2900 pieces, the average cost and the shortage of inventory under this target is shown in chart 3 and chart 4.

**Average**

![Average](chart3.png)

**Stockout**

![Stockout](chart4.png)
Considering the features of short duration and inconvenient storage of a warehouse distribution center, target inventory is determined under the inventory cost is 10 yuan/piece/day, determine the.

After many times simulation, target inventory is set for 2300 pieces, and the average cost and the shortage of this target inventory is shown in chart 5 and chart 6.

![Chart 5: average cost simulation result under HC=10 and DI=2300](image)

![Chart 6: simulation result under HC=10 and DI=2300 in shortage](image)

Analysis: from the simulation results above, daily inventory cost of each product affects the target inventory of warehouse distribution center. In fact, under the same condition, higher shortage cost will also affect the target inventory value. In the actual operation of warehouse distribution center and e-commerce enterprises, target inventory should be adjusted according to commodity kinds, low and peak seasons.

**Effects of Simulation Supplier Delivery Delay on System**

Only change the constant value of delay delivery from supplier to the warehouse distribution center, but keep the target inventory DI = 2900 conditions without change. With several simulations, the change of the average cost of warehouse distribution center is shown in chart 7, and shortage situation under different delay time are shown in chart 8, chart 9, chart 10 and chart 11.
Analysis: chart 7 shows that delay time affects the average cost, in LT = 3 and LT = 4 cases, the average cost increases in times, bringing great pressure to e-commerce enterprises on cost. The chart 10 and chart 11 show that shortage is also frequent, bringing great cost pressure to e-commerce enterprises when shortage cost is high, at the same time bringing inconvenience to agentsellers who are cautious of delivery speed, and also bringing bad shopping experience to buyers.

Known from the analysis above, in actual production and operation, e-commerce enterprises should actively communicate with suppliers, try to shorten the delay time from the aspects of delivery time and transportation selection. Agent sellers, warehouse...
distribution centers and suppliers should also use the information platform to set up the information communication mechanism, process orders on time, and work hard to shorten the delay time and achieve win-win cooperation.

CONCLUSION AND SUGGESTIONS
Based on the system dynamics, this paper studies the dynamic behavior of the e-commerce storage and distribution integration system quantitatively. With the analysis of the simulation results, suggestions on the operation of the distribution center are as follows:

(1) Actively build a communication mechanism between sellers, warehouse distribution centers, suppliers, achieving information sharing in a reasonable scope to reduce the average cost of warehouse distribution center and the occasion of warehouse distribution center being out of stock, optimize buyers' shopping experience, form a benign circle and improve the overall competence of the supply chain.

(2) Active coordination. E-commerce enterprises should actively coordinate with suppliers, try to shorten the delay time from several aspects, reduce the cost, and reduce the occasion of being out of stock.

(3) Reasonable and timely forecast. Warehouse distribution centers should reasonably choose the forecast method of target inventory, timely adjust the target inventory, and improve the accuracy of demand forecast. Distribution centers should reserve certain goods before receiving orders, and timely adjust inventory under exceptional situations to avoid being out of stock or backlog of goods. Due to the complexity of the warehouse distribution system, this paper only focuses on the change of the modeling parameters after different goods inventory and delay time have changed, leaving the external social factors (such as price index) and the changing variables' effect of distribution center inventory adjusting time on the result of simulation, which would be furthered in next research.

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