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Distribution Network Design for E-Retailing Application: A Model Suggestion for Local Retailer in Izmir

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ABSTRACT

Purpose – The rapid development of technology, acceleration of internet with this development and increase of number of electronic devices that connecting to internet brings important changes in all business applications. The retailing sector, connecting businesses and end consumers, has also changed from classical approach, and consumers started to prefer e-retailing channels versus traditional stores. Therefore, businesses, which have to deliver products to those consumers, are also forced to make critical changes in supply chains. On the other hand, businesses that aim to completely change distribution networks in supply chains adopt a strategy called cross-docking to take the lead over competitors and gain cost advantages. Therefore, in this study, aim is to reveal whether a conventional retailer that does not apply e-retailing can gain by using e-retailing application in coordination with cross-docking strategy.

Design/methodology/approach – In application part, it is emphasized that business, which continues retail activities in conventional way, also uses its stores as cross-docking terminals for e-retailing. For this purpose, a mixed integer programming model has been created and it is aimed to have optimal solution for minimizing number of stores and total cost.

Findings – In numerical example, it was decided that company which has currently seventeen stores in eleven different regions in Izmir should use nine of these stores as cross docking terminals.

Discussion – In numerical example, it was decided that company which has currently seventeen stores in eleven different regions in Izmir should use nine of these stores as cross docking terminals.

1. INTRODUCTION

In 1994 Rayport and Sviokla (1994: 142) mentioned that in the future there would be changes on relationship between buyers and seller in means of a lot of areas. Those areas can be listed as the content of relationship, context of relationship and infrastructure of tools of relationship. After 25 years from their study, it can be said that all the transactions they mentioned were occurred with the help of changes in technology. Previously what is called as *marketplace* (a traditional market where the buyers and sellers trade face-to-face) has evolved to *marketspace* (a virtual market which creates Internet based location insensitive trade area) (Berry and Brock, 2004: 208), and as a result, the structure of retailing has also changed. Retailing, which has been reshaped with the introduction of the internet into the lives of consumers and renamed as *e-retailing*, provides advantages in this new form to consumers; by being cost-effective, time saving, having a wide breadth and depth of products, presenting ease of search, giving chance of more personalization and favorable prizes (Harris and Dennis, 2002: 249). E-retailing provides advantages over traditional marketing in utilities of marketing known as form, time, place and possession (Shaw, 1994) by enabling marketing to accelerate, globalize and integrate with technology. Especially with the irrepressible rise of handheld technologic device usage, the retailing industry strongly moved to electronic channel (Shankar et el., 2010: 111).

The share of online retail sales on total retail sales are increasing worldwide and the 7,4% share at 2015 had nearly doubled with an increase to 14,1% at 2019 (Clement, 2019). This almost doubling trend has caused all kinds of applications in this field to gain importance. This new and open to any kind of innovation makes it a must to revise every element of the marketing mix the rules of marketing, where classic marketing practices

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are no longer valid (Quelch and Klein, 1996). Although there is a change in all marketing decisions, it is obvious that the distribution function becomes more important due to the disappearance of face-to-face communication and the virtualization of the store environment. According to Pitt et al. (1999: 20-21) the major effects of web based marketing on distribution channels can be grouped under three categories as (1) the distance is no more important, (2) the time became homogenous and (3) the location is no more relevance. With that change in the way to reach to customers, the businesses need to pay attention to their logistic operations and the flow of goods and services among actors of supply chain which are suppliers, producers, distributors and customers. There are two ways to achieve these goals as the optimization of the flows of goods and the improvement of the existing network and distribution network design problems involves the analysis of both of those ways (Ambrosino and Scutella, 2005: 610).

Distribution network design makes it available of businesses to have an integrated decision making from both *strategic level* that concerns on supply chain network design, *tactical level* that focus on medium term decisions that realizes the strategic and *operational level* that includes short term decisions for an efficient the supply chain (Bilgen and Ozkarahan, 2004; Stevens, 1990: 25 - 26). Although these three decision levels seem to be distinct from each other in terms of definition, it can be clearly seen that three of them are intertwined in applications and their independent handling in distribution network design will fail. For example location and warehouse selection seems to be strategic decisions and routing is a tactical decision in theoretical perspective. However if the businesses select the location area without thinking how to distribute the goods from the distribution point to customers the result won't be cost effective. At this point, what businesses need to do is to determine the right distribution strategy by considering the supply chain. Businesses have three options on hand as selling directly to consumers without intermediary (which is not a possible way if you are not the producer or if you are using e-retailing, using warehouses (which can carry so much cost risk) and cross-docking (which is a new concept that includes using temporary storage places to is cost effective and guarantees faster transportation). This study is designed based on this idea and deals with the processes of determining the right cross-docking facilities for businesses to deliver products to the consumer with less cost. This study is both trying to figure out a classical warehouse selection and a routing problem on hand, through a scenario that assumes that a retail chain operating in the province of Izmir aims to develop the customer network through mobile distribution. After the literature review on retailing, e-retailing and distribution network design, model will be suggested and described.

2. RETAILING AND E-RETAILING

According to Levy and Weitz (2007: 7) *retailing* is "the set of business activities that adds value to the products and services sold to customers for their personal and family use" and *retailers* are the last stage of distribution channel that link manufacturers and consumers. The more utility added to goods and services means the more satisfied consumer and by the way shows the success of the retailer. The utilities that marketing can add to a product can be listed as form utility – which is creating products from materials in a way that consumer will use easily, time utility – which is making it possible for consumers to find the products and services when they want or need, place utility – which is making it possible for consumers to find products and services where they want or need and possession – which is transferring ownership to the ones that want (Shaw, 1994: 48).

There are many functions that retailers should undertake in ensuring that these utilities reach consumers which are breaking the bulk, holding stock, taking risk, creating place, planning time, assortment of products and services, extending services and creating demand for products and services (Madaan, 2009: 5 - 6). Besides, as a result of the rapid changes in technology, it has been inevitable that all these functions and transactions that mediate these functions also have to change and have to be redefined. As a result, the conventional retailing concept also needs to be redefined with a new concept that the concept of retailing has become imperative to adopt a new structure that internalizes technology. By the way *e-retailing* concept has emerged and the way businesses reach to consumers and communicate with them has revolutionized with all aspects of commerce, marketing, retailing and advertising activities of product and services.

With the need of that revolution, the online shopping experience started in 1979 by Michael Aldrich as a B2B channel and e-commerce, and in 1992 Charles Stack commercialized the retailing part of the business by establishing books.com, the world's first online bookstore (DigitalAge, 2019). From that time, *e-retailing*, which can be described as the sale of goods and services via Internet or other electronic channels for personal or

household use by consumers, also became popular by firms to gain competitive advantage with eliminating time, working hours, multiple production obligations, costs, location, size constraints (Harris and Dennis, 2002: 244). Also, according to Siddiqui and Khan (2016) customers prefer e-retailing because they can buy anything that they want anytime, have much more options for each products and services than conventional stores, can compare products, features, prices etc. as many as they want, can follow discounts and offers so have the ability to buy with lower prices and do not have one payment option that force them to buy with one option.

Considering the above advantages, e-retailing has been highly preferred by consumers as can be expected and reached 3.5 trillion U.S. dollars (Clement, 2019). But that does not mean all goes well. People often have reservations about e-retailing because of problems such as personal security problems (sharing payment information, sharing personal information etc.), credit card related problems (such as extra and unannounced money collections, and not sending the product despite collection), seller-related problems (such as faulty product delivery, missing product delivery, non-acceptance in the case of return shipping and no refunds), promotional problems (posting incompatible with the visual, not giving enough information in the explanations of promotions, the information provided that does not reflect the truth etc.) and transportation-related problems (such as damage to the product during shipment, not delivering the product on the specified date, not packaging and transport of the product as required, high costs of shipping) (Consumer Affairs Victoria, 2004; Harris and Dennis, 2002; Miyazaki and Fernandez, 2001)

Both the advantages and disadvantages listed create new working areas to businesses and also shape the future of the researches and trends of e-retailing. For example the credit card security problems are trying to be solved by online security services given by banks of the consumers so that they will feel themselves in more safe position. The problems that occur as a result of the visual side of promotions led businesses to work on simulation programs and people could see how the product they buy will fit their life by using real time platforms. For example Filli Boya, a Turkish paint firm, by creating an mobile phone application called as Mimar Benim (The Architect is Me), offers users the opportunity to visualize how coloring their house will be looked like in real life and gives advices on which colors to buy and amount of the colors they will need to paint their walls so that creates a competitive advantage among other retailers. Also retailers started to create just in time communication channels to solve the problems of consumers by chat features like giving Whatsapp numbers, online assistant service etc. so that consumers will ask the questions in mind and will decrease the risks of their buying, have a successful buying decision and will be satisfied.

With all these trends, resolving distribution-related problems plays a key role in e-retailers gaining competitive advantage. It is thought that it should be especially emphasized as it is a double-sided problem both in terms of keeping in mind the questions of the consumers who have the chance to have the product they bought in traditional retailing instantly, and the delivery of the product purchased by the consumer, which is a very serious cost item for the e-retailer. It is thought that it should be especially emphasized. In addition, it is an inevitable fact that businesses that go through regulations in this field will outstrip their competitors. It is anticipated that a very serious problem will be eliminated by meeting the expectations of consumers in terms of flexibility, speed and robustness regarding delivery (Angelovska, 2018; Dreyer, 2015; Thompson, 2006).

3. DISTRIBUTION NETWORK DESIGN

Supply chain can be defined as "an integrated manufacturing process wherein raw materials are manufactured into final products, then delivered to customers (via distribution, retail, or both)" (Beamon, 1999: 336) and includes three or more businesses with downstream and upstream connections by means of product, service, information, data and financial assets. At a traditional retailing model the supply chain was including the carriage of products and services to retailers and consumers were undertaking the transport activities after purchase. With the increase in the use of mobile devices, there have been significant changes in the structure of the supply chain, and the process that ended with the transportation to the retailer in the traditional structure has expanded to carry it to the direct transportation node of the consumer. Also the changing conditions with renewed technology started to offer opportunities through real time collaboration, 24/7 availability, online procurement, and access to worldwide markets to all stages of supply chain (Eng, 2006: 682) and in line with this development process, studies in the field of supply chain have begun to attract

attention both by researchers who take a theoretical perspective, and by managers, business owners and supply chain employees, who are practitioners with a more applied perspective (Lancioni et al., 2003; Shapiro, 2004).

Businesses should take supply chain to hand as a whole with the awareness that all the decisions they will make for this whole in reaching the consumer are the determinants of the business's market success. By the way, it can be said that a well-designed, modelled and implemented supply chain can be described as a critical success factor for businesses. According to Sharma et al. (2008: 256 - 257) as the first stage of supply chain management *network design* is the most important part of that decision chain as it is long lasting and all the other decisions of modeling and implementation are prepared according to the design of chain. Also it has a critical role on both consumer side by creating the way to take product and service from supplier to demand point and business side by being decisive in terms of costs. Paksoy (2005: 435 - 436) suggests that network design problem, which includes sub-problems such as determining the numbers and locations of the modeling elements, determining the amount of physical flow between these elements, has a strategic importance in supply chain management. Distribution network design decisions can be classified as strategic decisions because they cause changes in the entire flow of the business; and includes decisions such as determination of distribution points and warehouse locations, determination of their capacities, determination of distribution routes, deciding how and how the resource will be supplied and examining customer expectations. Also as those decisions include problems as cost management and vehicle distribution, it can be said that not just strategical but operational and tactical decisions are also matters for distribution network design.

According to Ramezani et al. (2013) as the other strategical, tactical and operational management decisions the distribution network design also include some steps to follow and Lee and Kim (2002) and Paksoy (2005) suggests that those steps can be listed as: *(1)* Identification of problem, (2) Setting goals and methods to use and (3) Formulization of model. A distribution network can be effective only when it is planned in accordance with the determined needs; goals are determined in accordance with this plan; methods are selected in accordance with these goals and modeled in accordance with the chosen method. Simchi-Levi et al. (2000: 112 - 113) suggests that as a supply chain decision which starts with a manufacturer or supplier and includes carrying of goods and services to customers, the businesses have three distribution strategies as (1) *direct shipment*, which includes shipping directly without visiting any distribution center; (2) *warehousing*, that the stocks are carried out and required products are transferred to consumers by using warehouses; and (3) c*ross-docking*, that distribution is done from warehouses to consumers but not by using classical storage approach but rather by being executed as a temporary storage system. According to Ertek (2010) cross-docking facilities operate as transfer points, not as warehouses where materials are stored in the classical sense. These facilities are places where the flow of incoming product is synchronized with the outgoing product flow for the purpose of eliminating material storage. Therefore, the planning of the cross-docking components, determining their goals and model formulation is critical for determining the distribution network strategy.

4. DISTRIBUTION NETWORK DESIGN FOR E-RETAILING APPLICATION

The retail businesses that carry out their activities traditionally need to satisfy their customers whose shopping perception changes with technological developments. E-retailing is a rapidly developing area in this regard, and it contributes to businesses, which are continuing their retailing business, both to fulfill the attraction of selling more with electronic commerce and to gain an advantage over their competitors. In this study, a research is carried out on the change that will occur in the operations, if a retail chain operating in İzmir province shows electronic retailing activities. In this context, the main purpose of the research is "to design a distribution network that chooses cross-docking facilities from alternatives and provides optimal physical goods flow from supply sources to consumption points, and to design a model using cross-docking system based on a sample application".

The e-retailing distribution network, which is desired to be established, aims to deliver products to the planned cross-docking terminals from the central warehouse and then to the houses / workplaces of customers who place orders from the terminals. In the model designed for distribution network, the sales points of the retail chain are considered as a set of alternative cross-docking terminals. Calculations are made to reveal the product flows to be made from the warehouse to the terminals, and to reveal the flows to be carried out to the customers as a result of the consolidation at the terminals.

The purpose of the distribution network design model is to decide on which points for selecting the terminals. At the decision stage, it is desired to minimize the total cost (transportation and terminal operating costs) and minimize number of terminal points. While designing the distribution network, two scenarios were created to decide which terminals to use from the alternative terminal cluster. In the first scenario, the total cost of the distribution network is tried to be made to a minimum. Transporting and operating costs are taken into consideration. In the second scenario, the number of terminals is tried to be made to a minimum because of controlling more effectively.

Model Formulation

- *Indices – Decision Variables and Parameters*

i = Warehouse i = {1}

j = Terminals j = {1,…,N_j}

k = Customers k = {1,…,N_k}

X_{ij} = quantity of products from node i to node j (tons per year)

X_{jk} = quantity of products from node j to node k (tons per year)

Y_j = existence of node j or not {0,1}

Z_j = quantity of mixed products in node j (tons per year)

Z_k = quantity of demanded products from node k (tons per year)

A_i = quantity of mixed products in node i (tons per year)

C_a = transportation cost of unit mixed product (currency / km*ton)

C_s = transportation cost of unit demanded product (currency / km*ton)

C_j = operational cost of node j

U_{ij} = distance from node i to node j (km)

U_{jk} = distance from node j to node k (km)

Ts_j = capacity of node j (tons per year)

- *Objective Functions*

Min Z_1 = $$\sum_i \sum_j X_{ij}\, U_{ij}\, C_a + \sum_j \sum_j X_{jk}\, U_{jk}\, C_s + \sum_j C_j Y_j$$

(scenario I)

Min Z_2 = $$\sum_j Y_j$$

(scenario II)

- *Subject to*

$$\sum_j X_{ij} \le A_i \qquad \forall(i)$$

$$\sum_i X_{ij} = Z_j \qquad \forall(j)$$

$$\sum_k X_{jk} = Z_k \qquad \forall(j)$$

$$Z_j \le Ts_j \; Y_j \qquad \forall(j)$$

$$Y_j \in \{0,1\}$$

$$0 \le X_{ij}, X_{jk}$$

$$0 \le Z_j, Z_j$$

Numerical Example

The retailer manages its operations from a single central warehouse. In the model, the mixed products will be brought to the terminals from the central warehouse. The most convenient alternative locations for e-retailing have been determined in every district where the retailer operates. Terminal alternatives within the borders of İzmir will be selected from 17 stores that are in the retail chain of the business. Products consolidated to the order in the terminals will be shipped to be delivered to customers. Customers' districts are 11 central zones of city and demand is calculated according to population of these zones. Transportation cost change between mixed products and demanded products according to their vehicle type and capacity in city. Table 1 show the product quantity and transportations costs.

Table 1. Cost Parameters

quantity of mixed products in central warehouse (m^2 per year)	4500
transportation cost of mixed products (TL/km*m^2)	0,125
transportation cost of demanded product (TL/km*m^2)	0,062

Operational cost of cross docking terminals and capacity of them are another crucial dimension to decide which terminals will be open. Operational cost of cross docking terminals according to capacity of them alternate to regarding the socio-cultural specifications and rental costs of district. Table 2 shows this data set.

Demand of customer zones also differs from district's demographic features. Level of income, population age, educational background etc., affects the demand for e-retailing. Table 3 illustrates demand of customer zones.

Table 2. Operational Cost and Capacity of Terminals

Terminals	Operational cost of Terminals (TL / year)	Capacity of Terminals (m^2 / year)
j_1	270000	480
j_2	240000	300
j_3	190000	480
j_4	170000	600
j_5	250000	360
j_6	200000	540
j_7	220000	240
j_8	180000	420
j_9	220000	420
j_{10}	180000	480
j_{11}	160000	540
j_{12}	180000	360
j_{13}	240000	300
j_{14}	180000	360
j_{15}	180000	540
j_{16}	200000	360
j_{17}	220000	420

Table 3. Demand of Customer Zones

Demand of customer zones	k_1	k_2	k_3	k_4	k_5	k_6	k_7	k_8	k_9	k_{10}	k_{11}
(m^2 / year)	350	600	700	500	440	350	100	400	550	600	300

Customer zones are clustered as district of city, and planned cross-docking terminals are existing retail stores of company. Distance between of them are average values and important for deciding terminal. Table 4 indicates these measures.

Using this data set, it is desired to decide which terminals to be used to minimize the total cost. The MILP (Mixed Integer Linear Programming) model, which is used in accordance with the distribution network design studies, is applied for the e-retailing network design and two scenarios are solved using the LINGO 18.0 (Linear, Interactive and General Optimizer) optimization program.

Table 4. Distance between Terminals and Customers

Distance (km)	k_1	k_2	k_3	k_4	k_5	k_6	k_7	k_8	k_9	k_{10}	k_{11}	i_1
j_1	7	31	30	18	46	13	30	31	37	10	10	35
j_2	8	32	31	16	31	14	29	21	38	11	10	36
j_3	20	13	5	11	28	22	48	40	17	10	32	35
j_4	19	7	4	14	25	21	48	39	15	10	30	39
j_5	11	22	20	3	36	12	44	30	28	10	27	28
j_6	14	20	20	2	36	10	42	30	26	8	26	28
j_7	9	20	18	2	35	8	42	25	25	7	25	30
j_8	10	17	15	2	33	14	40	30	24	6	23	31
j_9	8	16	16	4	32	10	38	25	23	4	20	47
j_{10}	27	10	16	25	9	30	56	47	12	19	40	51
j_{11}	21	4	12	19	15	24	51	41	7	14	34	46
j_{12}	23	7	18	20	18	25	52	43	9	14	36	48
j_{13}	24	7	15	21	15	27	53	44	10	16	36	52
j_{14}	1	20	19	13	35	8	36	20	25	7	17	31
j_{15}	4	18	17	8	33	11	33	21	24	4	16	35
j_{16}	5	19	18	10	35	15	32	22	25	5	15	41
j_{17}	12	30	28	21	45	19	19	26	36	16	4	41

Results

At result of the study, the total cost was calculated as 1.771.322 TL. It has been revealed that there will be nine cross-docking terminals to be used to operate annually at this minimum cost level. These terminals were decided as $j_1, j_3, j_4, j_6, j_8, j_{10}, j_{11}, j_{15}, j_{17}$. Table 5 demonstrates the product flow from terminals to customers.

Table 5. Product Flow from Terminals to Customers

	k_1	k_2	k_3	k_4	k_5	k_6	k_7	k_8	k_9	k_{10}	k_{11}	i_1
j_1	160	-	-	-	-	-	-	-	320	-	-	480
j_2	-	-	-	-	-	-	-	-	-	-	-	-
j_3	-	-	40	-	440	-	-	-	-	-	-	480
j_4	-	-	600	-	-	-	-	-	-	-	-	600
j_5	-	-	-	-	-	-	-	-	-	-	-	-
j_6	170	-	-	20	-	350	-	-	-	-	-	540
j_7	-	-	-	-	-	-	-	-	-	-	-	-
j_8	-	-	-	-	-	-	100	-	20	-	300	420
j_9	-	-	-	-	-	-	-	-	-	-	-	--
j_{10}	-	-	-	480	-	-	-	-	-	-	-	480
j_{11}	20	460	60	-	-	-	-	-	-	-	-	540
j_{12}	-	-	-	-	-	-	-	-	-	-	-	-
j_{13}	-	-	-	-	-	-	-	-	-	-	-	-
j_{14}	-	-	-	-	-	-	-	-	-	-	-	-
j_{15}	-	140	-	-	-	-	-	400	-	-	-	540
j_{16}	-	-	-	-	-	-	-	-	-	-	-	-
j_{17}	-	-	-	-	-	-	-	-	-	420	-	420
	350	600	700	500	440	350	100	400	340	420	300	4500

5. CONCLUSION AND DISCUSSIONS

Technological devices are updated day by day and have new add-ons. With these new add-ons, it progresses in facilitating the lives of people and eliminates many constraints such as time, place and transportation by undertaking some of their daily activities. Considering that the habits of people evolved gradually with this simplification, businesses also have to renew themselves. Therefore, although it may seem tempting for businesses that continue their traditional activities, the decision to integrate into the increasingly appealing attraction of the internet emerges as a structure that contains many contradictions as it will affect all of its activities. In this contradictory structure, the factor that businesses emphasize the most is to decrease the cost and maximize profit, as can be expected. Accordingly, it is considered that the factors such as warehouse, transportation and stocking are the most critical factors in profit maximization and cost minimization in the transformation of a conventional retailing enterprise to e-retailing which is a sales-distribution option where retail businesses make their sales online and eliminate traditional customer store visits, allowing the customer to access the product, when and where they prefer.

In this study, it is planned to make a simulation to determine how a traditional retailer can cope with the distribution related activities that may arise in the transformation of e-retailer in line with the minimum cost and maximum profit expectation. Therefore, it is thought that a model for retail businesses that want to sell more with electronic commerce applications and gain technological superiority against their competitors will be obtained through this study. In the implemented model, it is worked to open several cross-docking terminals that will minimize the total costs of enterprises and meet customer demand. The mixed integer decision model created was studied on a sample application.

According to the application, it is set out from a real business that is located in İzmir with 17 stores in 11 regions. This business, which is named as X enterprise, is currently only retailing in traditional ways. Therefore, cross-docking distribution is planned under the assumption that e-retailing will be more effective than creating a new warehouse space by using the warehouses in these 17 stores. The model is asked to decide which stores to use as a terminal for e-retailing. In the model, based on the thought that using each store as a terminal will cause administrative problems and bring operational costs, the minimum number of terminals

and minimum cost objectives are emphasized. A generally accepted distribution network design model; MILP (Mıxed Integer Linear Programming) was applied and two scenarios were solved in accordance with optimization program by using LINGO 18.0 (Linear, Interactive and General Optimizer). In the problem solved for these objectives, it has been concluded that the enterprise can carry out e-retailing in the most optimal way with nine terminals.

It can be said in literature; although researchers have mentioned the importance of switching to online models from traditional retailing models, these studies generally focus on service practices that reflect the consumer perspective, beyond the opportunities that a transition can provide for the retailer (Kuruzovich et al., 2008; Lee et al., 2011; Shankar et al., 2010 etc.). From this point of view, it is thought that this study is important as it has retailer-oriented perspective rather than a consumer-oriented one. Also, this study differs from the researches with a retailer perspective (Ambrosino and Scutella, 2005; Lewis and Talalayevsky, 2004; Paksoy, 2005 etc.) in terms of working separately with two scenarios and proposing to manage a model that will bring profit to the business by using the existing retail stores as a warehouse.

Distribution network design decisions are central determinations that are crucial for businesses that expand from conventional retailing to e-retailing. Making these decisions requiring revision in many issues motives the companies to deal with the solution methods that they should remark. At the end of the study, it is thought whether the methods to be obtained by considering the tactical, operational and strategic decisions together will be useful for the businesses. In order to facilitate these decisions, this study was conducted through hypothetical costs in terms of contributing to the field. It was planned as a premise and it is planned to guide a more comprehensive field study through real data. In addition, it is thought that it provides significant accumulation to the studies to be carried out by combining with many areas such as the distribution of consumers, the structure of human resources and differentiation in financial decisions.

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