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Emergence of Consumer Impulse Buying Behavior with Agent-Based Modeling Approach

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Abstract

Because of the dissemination of Impulse Buying (IB) behavior in consumers its academic studies have increased over the last decade. Because in large stores, sales have to be increased, the behavior of consumers in IB to be taken into account by the researchers and managers of the stores. The purpose of this paper is to model agent-based the IB behavior of consumers (customers), with regards to the factors of discount and swarm in the purchase. In terms of executive purpose and with Agent-Based Modeling (ABM) approach, the present paper examines the existing reality of consumer IB behavior. This paper develops consumption models, examines and analyzes Consumer Behavior (CB) under the NetLogo software environment. In comparing the optimal points of discounts and sales volume in both discount and swarm-discount functions that lead the stores to maximize profits and sales volume simultaneously, it can be debated that with running this model (swarm-discount) stores would be gaining more sales by less discounts. Results could describe customer behavior by implementing discount and swarm factors. Understanding the customer behavior prepared the comparing possibility of customer behavior in store in each introduced mathematical model. The contributions could be considered in two points of view. On the applicable view, this research can provide the managers and decision makers with significant information, includes possibility of forecasting sales volume and incomes of any policies in stores, so the comparing of policies and strategies analysis would be possible. This method is rather less expensive, because of virtual environment nature. Users of this model can study other sections by changing the research assumptions.

Keywords: Agent-based modeling, Consumer behavior, Discount, Impulse buying, Swarm.

1 | Introduction

Impulse Buying (IB) has become one of the most common Consumer Behaviors (CBs) in modern society, and researchers have shown interest in this issue for decades by examining CB [1], [2]. From buying to fun buying, the importance of IB lies in the fact that IB has become part of consumers' daily activities and therefore IB has attracted the attention of marketers and consumer researchers [3], [4]. The complexity of IB and its incompatibility with logical selection models encourages researchers to continue their activities in the field of IB behavior [2] and [5]-[8]. IB is an important research topic among CB researchers not only because of its complexity, but also because of its widespread popularity across a wide range of product groups [9].

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Simulation of consumer swarm movements shows that paying attention to the information of what consumers are buying in the store is useful for increasing sales volume for products and it shows that what some consumers are buying is trustworthy to be in the basket of others [10].

This research, based on the consumer basket in the store and discounts applied to the products with the agent-based approach, helps the stores to achieve more sales and profits. The model also using self-organizing strategies as the basis of agent-based models suggests that in the process of consumer decision-making to buy more, should focus on other consumers' swarm movements and discounts. Swarm-discount simulation explains a model in which all store visitors share their thoughts and ideas on what they are buying and what is so-called valuable and others make decisions based on average buyer behavior and discounts. The proposed model uses only the information about the customers who are buying in the store, and after the buyers leave the store, their behavior is no longer considered. This indicates that the model convinces customers to buy more at the time of purchase. So, the store sales are maximized.

Agent-Based Modeling (ABM) is a simulation method that facilitates the study of complex and dynamic systems that consist of a high number of heterogeneous actors, which cannot be analyzed through other similar models. Compared to other modeling methods, ABM is new. Until the early twentieth century, it was merely a scientific concept with no real application. The application of this modeling method was started by researchers between 2002 and 2003 and the reasons for its use were: feeling the need for a better understanding of the behavior of systems that was not possible in previous methods; development and advancement in modeling techniques derived from computer science such as object-oriented modeling, UML and state diagrams and rapid growth in the processing power of CPUs and computer memory. Agent-based models require faster processing and memory than their traditional competitors. Agent-based models structure is related to graphic editors or related commands defined in the relevant software and the behavior of agents can be detected in different ways [11].

So far, many researches have been conducted on modeling consumers' behavior in IB, including [12]-[26]. However, what has been done so far in the field of IB research is the study of this phenomenon with statistical methods and therefore, Studies show that the understanding of IB behavior based on the ABM and simulation approach is done for the first time and this shows the new aspect of the paper. Considering that the application of simulation approaches in the field of real-time purchase is unprecedent, therefore, the innovation of this research is that by presenting a simulated and applied model for IB behavior, a basis for explaining other models and developing the required knowledge for this phenomenon can be provided. In this paper, Behaviour Perpective Model (BPM) has been used to study the IB behavior. This model can be mentioned as an operational model in consumer choice [27], [28]. This model is based on Skinner's three-term theory and shows that the individual's behavior and response are due to the response to stimuli, which leads to consequences that are reinforced or reduced.

The main question of the present study is that, what is the IB behavior of consumers in chain stores where customers are in a state of uncertainty and many uncontrollable factors affect their IB behavior?

This paper has implemented impulsivity as one of the main indicators of individual stimulus in implementing the swarm-discount agent-based model and studies and simulates the IB behavior of consumers with different impulsivity in real time that is associated with rapid response and impulse consumer choice.

The rest of the paper is segmented as follows: in the Section 2, the research background is briefly stated. In the Section 3, the methodology of the research is presented step by step with the conceptual model. In the Section 4, the results and findings are mentioned. In the Section 5, we will discuss conclusions, and at the end, the summaries and suggestions are presented.

2 | Research Background

In *Table 1*, the most important researches in the field of IB have been discussed.

Table 1. Overview of IB history (source: research-findings).

Researcher & Year	Research Title	Findings & Results
Mehregan et al. [12]	Simulating IB behavior in the market: an ABM approach.	The results showed that there is a strong relationship between individualism and IB. There is also a positive and significant relationship between the extremism of a culture and IB in that culture. In these communities, a strong desire to have fun and enjoy life, leads customers to unplanned and IB.
Hasasi et al. [13]	Investigation of motivation in IB of Shahsvand Zarrin customers using fuzzy logic.	Perception of the store environment in the study was examined in the three categories of factors. The first category includes environmental factors such as: light, temperature, smell and music; the second category is design factors includes: layout, product and classification and the third category is social factors include: the presence and influence of sales staff. In examining these three categories of factors, the researcher could not determine that the proportional existence of these three categories of factors causes people to be more motivated to buy impulsive.
Naemi et al. [14]	Investigating customer IB behavior in Chain stores (case study: Refah Stores).	The results showed that the pre-purchase trend has a direct and significant effect on IB; Also, pre-purchase readiness has a direct and inverse relationship with IB. The results also showed that individual characteristics (tendency to enjoy shopping and tendency to buy immediately) have a high impact on IB.
Iberahim et al. [15]	Visual merchandising and customers' IB behavior: a case of a fashion specialty store.	Visual merchandising is an extremely important element as the first visual cue that affects buying behaviour of customers. This study aims to identify determinants of visual merchandising that influence customers' IB behaviour. This study focuses on five elements of visual merchandising which are window display, mannequin display, floor merchandising, promotional signage and lighting. Investigation was conducted at a popular fashion specialty store in Kuala Lumpur.
Mathur [16]	A review of IB behavior: definition & affecting factors.	In general, the factors in this article are divided into two parts, internal and external. Internal factors include: mood (positive and negative effect), motivation (tendency to IB as a lifestyle), feelings and emotions, gaining experience, pleasure of IB, gender, personality traits, self-confidence and mental freedom. Also, the external factors of IB are: convenience in shopping, marginal need for goods, mass distribution, self-service, mass advertising, culture, store environment, social factors, social effects, etc.
Sermboonsang et al. [17]	Mindfulness-based transformational learning for managing IB.	The authors focus on applying mindfulness-related concepts to business education by relying on transformational learning techniques for reducing IB in a six-week Smart Consumer university class. A transformational learning program was designed including activities in the classroom as well as outside activities. They incorporated cognitive, affective, and conative aspects of student behaviors, aiming to effectively transform their impulse-buying behaviors.
Zafar et al. [18]	The impact of social media celebrities' posts and contextual interactions on IB in social commerce.	Findings indicate that the characteristics of the seller, facilities and services and the characteristics of the buyer have a significant impact on increasing IB in social media. In addition, IB moderates all relationships except negative emotions.

Table 1. Continued.

Researcher & Year	Research Title	Findings & Results
Zheng et al. [19]	Review of IB in mobile business: a study of smart and profitable investment.	This article identifies the key factors in IB in mobile commerce. After a thorough review of the theoretical foundations and research background, according to the motivational theory of purchase, it was found that people's culture and budget play a key role in IB of products. The findings showed that three factors: portability, visual appeal and interpersonal appeat have a significant impact on impulse mobile buying.
Fazelli Veisari et al. [20]	Optimization of viral marketing in online businesses using genetic algorithm-based decision tree.	The purpose of this study is to identify the components and develop a model to provide rules for optimizing viral marketing in businesses. The rules of viral marketing optimization were identified using the decision tree method. Findings in the qualitative section indicate that online persuasion, online trust, online support, online services, online attractiveness and online risk-taking are components of viral marketing. In the quantitative section and genetic algorithm, it was shown that the online risk component could not be used as an effective component for modeling and extracting viral marketing rules, so it was removed from the six components.
Hayat et al. [21]	Investigating the impact of corporate social responsibility on IB.	Dimensions are: environmental welfare, social welfare and economic welfare. Hypotheses is also designed in this context. The results showed that environmental welfare and economic welfare leads to increasing buyers' confidence and a positive and significant relationship with IB.
Hayu et al. [22]	Investigating the effect of website quality and government regulations on impulse online buying behavior.	This article is an experimental study and examines the effect of website quality on impulse online shopping behavior among some graduate students of Bangladesh University. The results showed that the quality of the website and government regulations have a significant impact on students' impulse online buying behave.
Hosseini et al. [23]	The effect of price promotions on IB: the mediating role of service innovation in fast moving consumer goods.	With the global economic integration, the development of international activities reduce trade barriers in the exchange between countries, and the intensification of competition. Knowledge of customer preferences and encouraging them to buy has become vital for the survival and development of enterprises (specify consumer goods or fast rotation). FMCGS, the aim of this study is to explain the impact of price promotions on the process of immediate buying in goods of Isfahan that based on an infinite population.
Kaveh et al. [24]	Predicting and benchmarking the factors of customer attraction in insurance companies by the model of network data envelopment analysis and the theory of dynamics of bass publishing.	The purpose of this study is to predict and rank the factors of customer attraction in Mellat Insurance Company of Shiraz during the three years 2019 to 2021. For this purpose, the system dynamics model and network data envelopment analysis have been used. In order to formulate the factors of customer attraction, first the causal-loop diagram and then the stock-flow diagram were simulated. Then, this operation was performed for different scenarios and the simulated results were entered as the input of the network data envelopment analysis model. Based on the obtained result, the best and most efficient factors of customer attraction were selected and the interaction of these factors and their impact and the success of customer orientation was addressed.

Table 1. Continued.

Researcher & Year	Research Title	Findings & Results
Hosein Panahi et al. [25]	Investigating the effect of marketing on social networks with the mental image of customers of insurance companies in Kurdistan province.	The purpose of this study is to investigate the relationship between social marketing and image. It is the mentality of the customers of insurance companies in Kurdistan province. The results showed that there is a significant relationship between social marketing and customers' mental image. Also, among the three variables of social marketing affecting the mental image of insurance companies' customers, according to the respondents, communication programs with an average of 2.29 and behavior management programs with an average of 2.25 and symbolic programs with an average of 1.15 are ranked first.
Shahri Mejarshin et al. [26]	Investigating the effect of effective factors on actual purchase with the mediating role of purchase intention and the moderating role of iranian product type.	The main purpose of this study is to investigate the effect of factors affecting the actual or final purchase of Iranian goods by evaluating the mediation effect of purchase intention and the moderating role of Iranian product type. The results show that the variables of product knowledge, perceived quality, and perceived value have a positive and significant effect on the intention to buy Iranian goods, also the variables of product knowledge and perceived value have a positive and significant effect on the actual purchase of Iranian goods.

Table 2 compares the proposed approach with some other studies related to IB behavior which was seen in *Table 1*.

Table 2. Innovation of the present research compared to other researches (source: research-findings).

Authors	Evaluation Method	Simulation Model Solving Software									
		Vensim	Arena	NetLogo	AnyLogic	ED	Statistic	Discount Factor	Swarm Factor	Discount-Swarm Factor
Mehregan et al. [12]	Agent-based simulation	-	-	✓		-	-	-	-	-
Hasasi et al. [13]	Inference and Fuzzy	-	-	-		-	✓	-	-	-
Naemi et al. [14]	Inferentative	-	-	-		-	✓	-	-	-
Mathur [16]	Descriptive - Review	-	-	-		-	✓	-	-	-
Zheng et al. [19]	Inference	-	-	-		-	✓	-	-	-
Hayat et al. [21]	Inference	-	-	-		-	✓	-	-	-
Hayu et al. [22]	Experimental and descriptive inference	-	-	-		-	✓	-	-	-
Current paper	Agent-based simulation	-	-	✓		-	-	✓	✓	✓

According to the topics discussed in the previous sections, in *Fig. 1* shows behavior perspective model in five dimensions and 24 indicators.

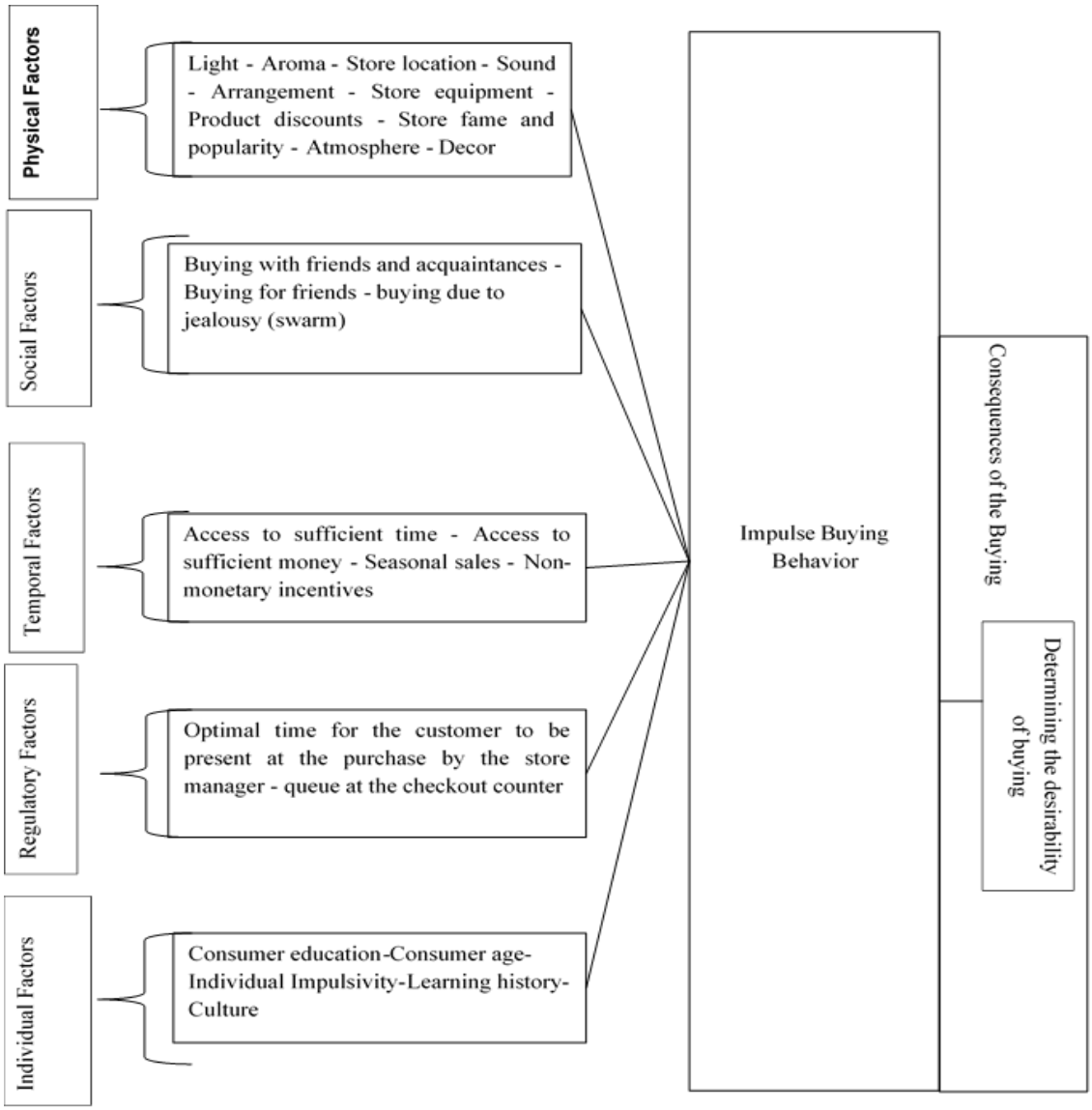


Fig. 1. Behavioral perspective model [16], [18], [21].

3 | Research Methodology

This paper is based on the philosophy of positivism. In terms of orientation, it is fundamental in the modeling stage. It is practical in the model testing phase in large stores. On the other hand, since this paper has been tried to investigate and develop applied knowledge in identifying factors of IB and modeling existing relationships among consumers in terms of research purpose, this research is considered as fundamental research. Standard data has been used to obtain consumers' initial probabilities in buying products. In this paper, we have used raw data of Crossref database to collect standard data. The present paper is executive in terms of purpose and with the ABM approach, it examines the existing reality of the consumer's IB behavior. This paper examines and analyzes CB under the Netlogo software environment by developing consumption models. Fuzzy screening method was used to identify and select the dimensions and criteria of IB behavior.

3.1 | Fuzzy Screening Method

In fuzzy screening method, each decision-maker expresses their opinion about the degree of importance of each criterion. This assessment is defined in the form of a qualitative scale in *Table 3* [29].

Table 3. Qualitative scale for evaluating criteria [29].

Linguistic Word	Defined Icon	Punctuation Icon
Extremely important	S_7	OU
Very important	S_6	VH
Important	S_5	H
Medium	S_4	M
Low- Important	S_3	L
Very Low- Important	S_2	VL
Unimportant	S_1	N

3.2 | Consumers' IB Probabilities Using Discount

Everyone likes discounts and bargaining. This research does not ignore this issue because of the importance of this factor, which was discussed in previous sections. In fact, in modeling this section, customers are affected by the discount and this issue leads to an increase in the buyers of products and items in the store. In this section, the customer profile, including the desire of each customer to buy each product, will be combined with the probability of buying that is obtained from the discount model that how this is done will be explained in future sections. An important point that has been emphasized in many researches is that regardless of the weighting of factors in the previous section, all researchers believe that the discount will lead to increased sales [21]. In many researches, it has been found that the sales volume resulting from the price reduction does not have a linear proportion to the discount of products and items inside the store [30]-[32]. This issue can be identified with price elasticity of demand. As a result, considering the confirmation of the non-linear relationship between sales volume and discount of goods, the logarithm of changes in the number of customers proportionate to discount changes should have a linear relationship with the discount, *Eq. (1)* shows this.

$$\log\left(\frac{\P f_{onsale}(x)}{\P x}\right)\mu x. \tag{1}$$

In the above equation, by replacing the *Eq. (2)*:

$$\begin{aligned} &b=\log(1-\alpha), c=\log(\log(\frac{1}{1-\alpha}))\rightarrow e^c=\log(\frac{1}{1-\alpha}).\\ &\frac{e^c}{b}=\frac{\log(\frac{1}{1-\alpha})}{\log(1-\alpha)}=\frac{-\log(1-\alpha)}{\log(1-\alpha)}=-1, d=1-\mu. \end{aligned} \tag{2}$$

Now, by replacing the above parameters, *Eq. (3)* is extracted which are named as discount equation.

$$f_{onsale}(x)=1-e^{x\log(1-\alpha)}-\mu. \tag{3}$$

In the above equation, x is the discount, μ is the location parameter and α is the shape parameter. Also, to more accurately estimate the effect of two parameters (μ, α) on the percentage of changes in the number of customers, the model is repeatedly implemented in Matlab and it was observed that the numbers (0.3, 0.1) showed the lowest error in simulation performances so that the error size for the above numbers was estimated to be less than (0.02)%.

To understand the issue, the mean error measurement of the discount equation with two parameters (μ, α) and with numbers (0.3, 0.1) is shown in *Fig. 2*.

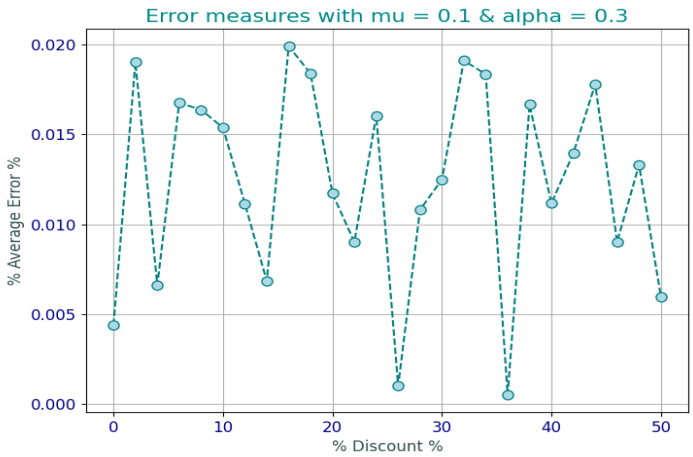


Fig. 2. Measurement error diagram in the discount equation (source: research-findings).

3.3 | Consumers' IB Probabilities Using Swarm

The swarm factor is based on the choices of other consumers and their shopping basket and it is in such a way that the consumer puts the product in their shopping basket and their purchase feedback through the purchase of the product is sent to other customers. Therefore, the probability of buying the product increases because of what is pleasing to others. This model is designed in such a way that consumers will not react to the shopping basket of others, until the number of sales of that product reaches the level of the consumer's IB threshold. Therefore, the level of threshold and number of sales of products is very important in influencing the purchase of others. To calculate this section, one of the most famous growth models called continuous logistic growth model has been used.

This model was proposed by Pierre-François Fairhurst in 1838 to calculate population growth in dynamic processes such as artificial neural networks, ecology, economics, demography, sociology, statistics. A logistic function is a common S-shaped curve (sigmoid curve) with *Eq. (4)*:

$$y = \frac{1}{1+\exp(-l(x-x_n))}. \tag{4}$$

In the above equation x is the percentage of buyers, x_0 is the midpoint of the sigmoid function and l is the shape parameter. To more accurately estimate the effect of these two parameters (x_0 , l) on the percentage of changes in the number of consumers, the model was run many times in Matlab and it was found that numbers (0.1, 50) have the least average error in simulation. So that, the average error size for above numbers is estimated less than (0.023)%.

3.4 | Reproduction of New Possibilities for Consumers Considering Discount and Swarm Factors

According to previous topics, the probability of buying products of each consumer in the store is affected by discount and swarm factors. So that, discount and swarm factors will change the probability of each consumer buying. In order to track the probability of buying each product for each consumer, the law of total probability as described in *Fig. 3* is used.

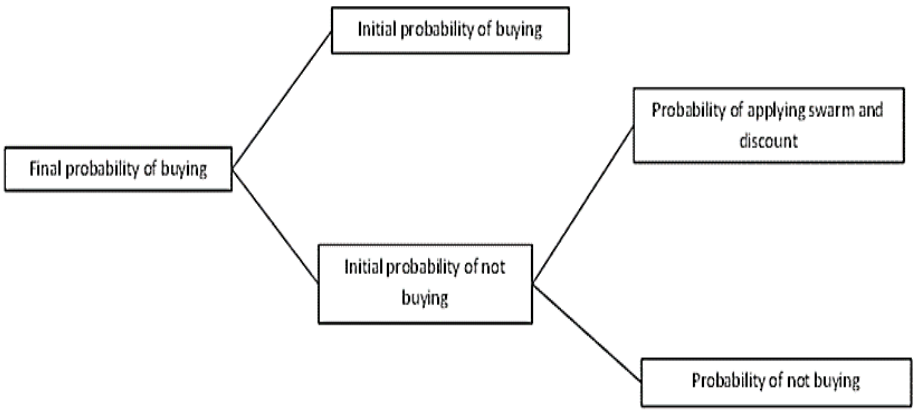


Fig. 3. Probability of buying [33].

So we have

$$p_{NewBuy} = p_{profile} + (1 - p_{profile}) \times F(x). \quad (4)$$

F(x) is the aggregation of the swarm and discount model and p_Profile is the initial probability of buying explained extensively in previous sections.

3.5 | Reproduction of New Customer Probabilities in Netlogo Software

In the implementation of the simulation model, when a customer enters the store, a random number between zero and one is allocated to the consumer by the software that if the new calculated probability of the consumer buying the goods that has increased with the discount and swarm factors is smaller than the random number chosen by the system, the product will be bought by consumers and placed in shopping basket. Otherwise, the customers will refuse to buy it. In fact, random number will calculate the customer in the buying or not buying area [34]. The equations of this paper are proposed for the growth of the buyers resulting from swarm and discount and promotion of buying probability. Therefore, according to the Executive Model of Research (*Fig. 4*), after reviewing the theoretical foundations of the research, important factors in IB is identified. Then, standard data are prepared and important IB parameters are selected. After that, for simulation Netlogo software is selected, and then coding steps are performed to investigate consumers' behavior and interactions between them. In the final step, after validating the model and confiming its validity, the model is implemented and the results are explained.

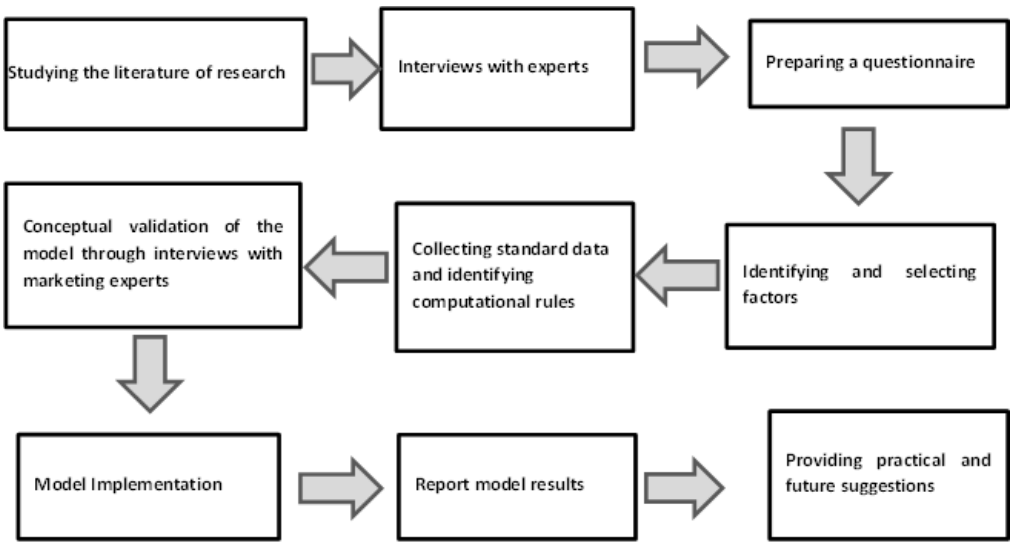


Fig. 4. Executive model of research (source: research-findings).

3.6 | Conceptual Model of Research

After reviewing the literature, the indicators of IB behavior are classified into Physical, social, temporal, Regulatory and individual dimensions in behaviour perspective model. Then, using fuzzy screening, the number of indicators is adjusted to 17 indicators. These indicators with content validity are confirmed and are finalized. In *Table 4*, the final results of the first part of the paper (fuzzy screening) are observed. In this section, 17 indicators from 24 indicators are accepted.

Table 4. Identified IB factors resulting from fuzzy screening (source: research-findings).

Perspective	Factors	Perspective	Factors
Physical	Store Location	Regulatory	The desired time of customer's presence in the store in terms of the store manager
	Layout		queue for paying bills
	Decor		Attitude and Impulsivity
	Discount	individual	Past Learning History
	Reputation and popularity of the store		Ability to carry
Social	Shopping with friends and family	temporal	Access to enough money
	Shopping for others		Leisure time
	Swarm		Special Occasions
			Seasonal sales

Acceptable indicators are identified in 5 dimensions. Then, research background has been used to classify the indicators. Experts'opinion has been used to confirm the indicators. Finally, the conceptual model of this paper, which emphasizes on discount and swarm factors, is summarized as described (*Fig. 5*).

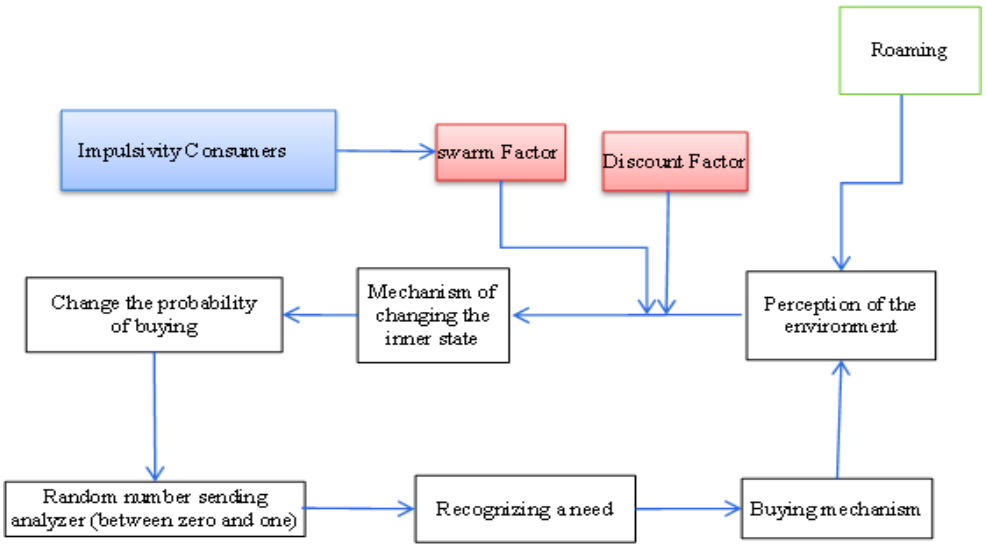


Fig. 5. Conceptual model of research (source: research findings).

4 | Research Findings

In the implementation step of the simulation, assumptions have been made to be applicable in the executive structure of the model of this paper. The total numbers of items inside the store are 10,000, which is equally distributed among 12 types of goods. To equalize the number of goods in the store, the number of goods 1 to 4 in the store should be one more than other goods. *Table 5* shows the number of products in the store.

Table 5. Number of goods in store (source: model-assumptions).

Number of Goods in the Store	Type of Goods	Options	Type of Goods
833	7	834	1
833	8	834	2
833	9	834	3
833	10	834	4
833	11	833	5
833	12	833	6

The number of customers in the store is 1000 customers, which is due to the number of standard data provided to the researcher. At any time, any customer cans assessment one product. This section is designed to avoid distractions caused by other products. In fact, in this simulation, at any moment, one product is in the customer's sight and customers decision to buy or don't buy that product. Customers will not be able to buy the same product more than once. This paragraph helps to reduce the chances of suggestions about an unusual pattern. In other words, the customer who buys 100 items of a product should not have the same effect as the time when 100 customers each buy one item of that product.

4.1 | Making an Agent-Based Model

The simulation performed in this paper is a virtual supermarket. So that it contains an acceptable image for running and testing the model. In this simulation, the characteristics of the consumer, including the probabilities of initial purchase of products and specifications of goods (type of goods and price of each product) are used. On the right side of the panel, the number of buyer agents (consumers) is specified, which in this simulation, the information of 1000 customers in the software is defined. The proposed model is programmed in such a way that the discount or swarm-discount model can be implemented at any time and the IB of each consumer can be strengthened. The setup and move buttons will also perform the simulation. Consumer shopping basket includes all goods bought impulsely. By selecting each product by the consumer, the behavior of the buyer in the whole system can be identified each time the model is executed, and how that agent moves in the store will be determined. As soon as the simulation is performed, consumers enter the store and after spending a certain amount of time, each customer will start buying the goods. In the middle of the page, the product layout and access paths to each of these items and shelves are displayed (*Fig. 8*). When the simulation starts, customers enter and buy the items. It is possible to repeat products in various rows so that customers can deal with a product several times and increase the possibility of buying. Evidence shows that duplication of products in the store can lead to more sales for the store of up to 5 to 6%. In this simulation, you can use different and varied features and characteristics in the store, such as variety in product layout, various entrance and exit doors, increasing the variety of products and routes, all of the above will depend on the store to be simulated. There are three tab including interface, information and code in NetLogo software, which can be seen in *Fig. 6*.

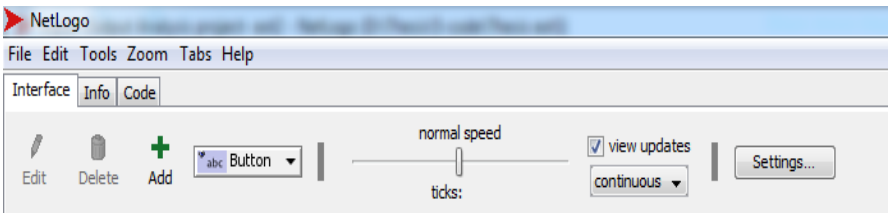


Fig. 6. A view of Netlogo software tabs.

Coding is done in the code tab. First, two types of factors, including customers and products and their characteristics, are defined in the software. The attributes of each factor are defined using the following commands (*Fig. 7*).

Fig. 7. A view of the definition of variables.

Using the following commands, agents are created in the model (*Fig. 8*).

```
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;SETUP AGENTS;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

to setup
  ca
  reset-ticks

  load-csv
  draw-store
  create-agents
  set-globals
  set rand-time-sell random-normal time-sell 2
  ;;show rand-time-sell

end
```

Fig. 8. A view of coding in Netlogo.

4.2 | Model Implementation

To run the model in the interface tab, first press setup and move buttons. With setup button, it returns to the initial state each time. By pressing the move button, the model starts to run. In fact, this button executes the codes in the code tab line by line. By pressing setup button, customers line up behind the entrance doors of the store and enter the store by pressing the move button. The model execution view is visible in interface tab in *Fig. 9*.

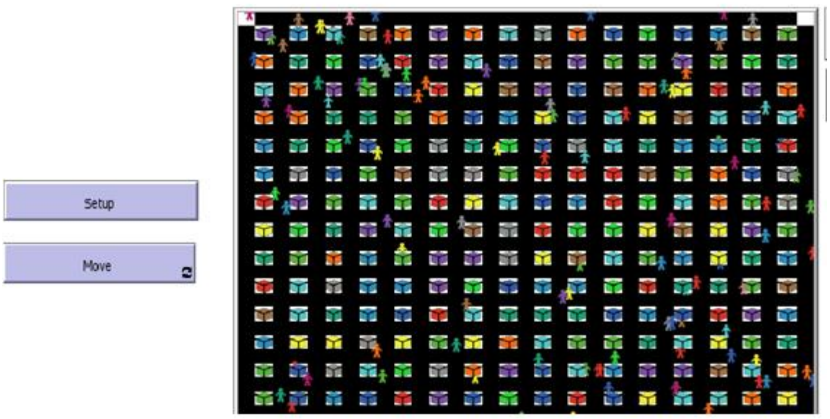


Fig. 9. Implement model.

4.3 | Discount Sensitivity Analysis to Increase Sales Volume

In this experiment, the effect of swarm and discount on the average sales volume has been investigated. The average purchase of the product by the consumer has been evaluated by reduction the price in both discount and swarm-discount models. To compare sales volume in both models, the results are summarized in *Table 6*.

Table 6. Average sales volume by implementing discount and swarm-discount model (source: research-findings).

Average Sales Volume	Applicable Model Type	Discount Rate
383.71	Discount	2
821.14	Swarm-discount	
1.830.31	Discount	10
3.843.65	Swarm-discount	
2.194.59	Discount	20
4.828.10	Swarm-discount	
2.510.57	Discount	30
5.341.57	Swarm-discount	
2.478.98	Discount	40
5.210.76	Swarm-discount	
2.825.09	Discount	50
5.495.10	Swarm-discount	

Based on the results obtained from various experiments according to the above table, customer behavior in the number of purchases of goods and items in each discount is plotted for both models to show what percentage of price reduction consumers are most stimulated to buy items and goods. Therefore, as shown in *Fig. 10*, with the implementation of the model resulting from discount and swarm-discount, the purchase volume of products with 30% discount moves upwards with a lower slope and the average customer purchase volume at this point reaches the relative extreme point. However, with the implementation of the swarm-discount model at the same 30% discount point, about 2,800 more goods have been sold, which shows the importance of swarm in IB.

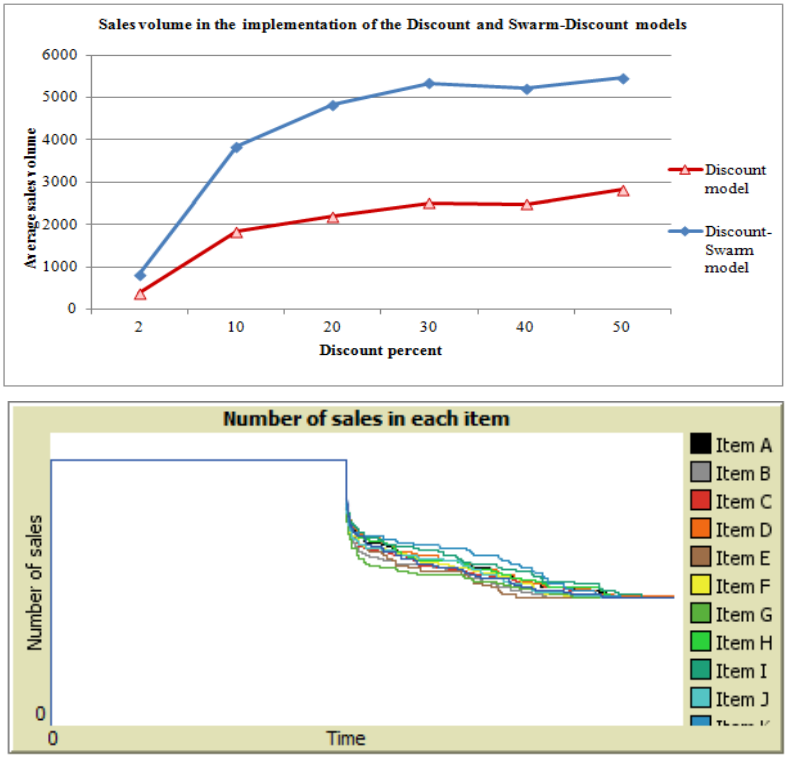
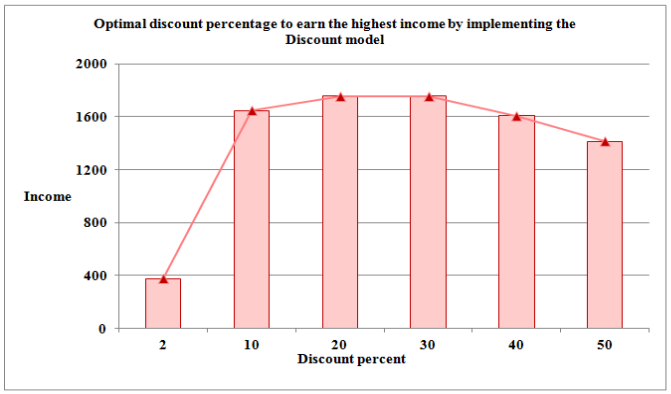


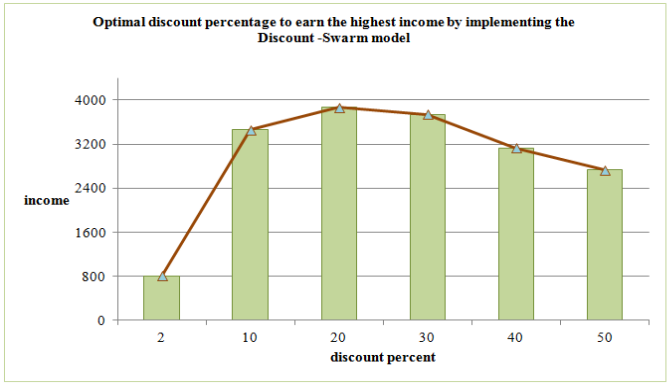
Fig. 10. Customers' IB behavior and calculating sales volume in discount and swarm -discount model in different discount points.

4.4 | Discount Sensitivity Analysis for Highest Revenue

In another experiment, discount and swarm -discount models are implemented to obtain the desired average percentage of the discount rate with the aim of earning the highest revenue. As shown in (*Fig. 11*), in discount and swarm -discount models, the revenue increases with increasing store discount. Revenue in the discount model increases up to 10% discount and stays up to 30% discount with a slight waiver. And as soon as the price of goods and products falls by more than 30%, the store faces a huge profit margin reduction and the store will lose profit. The same issue is tested with the implementation of the swarm-discount model. Results show that the discount in goods and products has been lost earlier and confidence in the swarm factor has increased the reliability of the model. So that, the store with 20% discount is achieved to highest revenue. If the store intends to increase the discount, it will face a decrease in profit margin. The charts below show the revenue trend of the store with the implementation of both models.



Discount	sales volume	Income
2	383.71	376.04
10	1830.31	1647.28
20	2194.59	1755.67
30	2510.57	1757.40
40	2478.98	1487.39
50	2825.09	1412.55



Discount	sales volume	Income
2	821.14	804.72
10	3843.65	3459.29
20	4828.10	3862.48
30	5341.57	3739.10
40	5210.76	3126.46
50	5459.10	2729.55

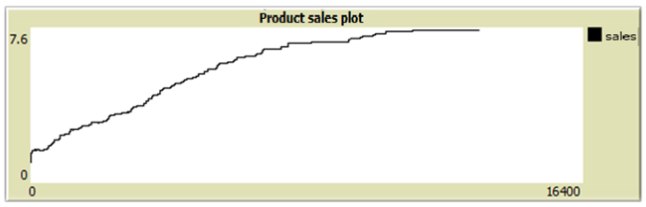


Fig. 11. Customers' IB behavior and optimal discount point for highest revenue.

4.5 | Discount Sensitivity Analysis for Simultaneous Maximizing Profit and Sales Volume

Earning the most profit as well as the highest sales volume at the same time is very important for a store. In this section, by combining the two goals of profit and sales volume, it is shown how and at what point, a store can take steps to achieve both goals. The following figure shows the intersection of sales volume and profit curves with the discount and swarm-discount function. By implementing the discount function in the model, it is suggested that the store should consider a discount (21/09)% in order to obtain the maximum profit and the highest sales volume at the same time. In addition, the store sales volume at this

optimal discount point (2.229) of the product is also displayed. Similarly, the model was implemented for the swarm -discount function, which with the implementation of the swarm -discount function, the discount to reach the optimal point of sales volume is (18.58). At this discount, the store will reach the sales volume (4.689) of the items.

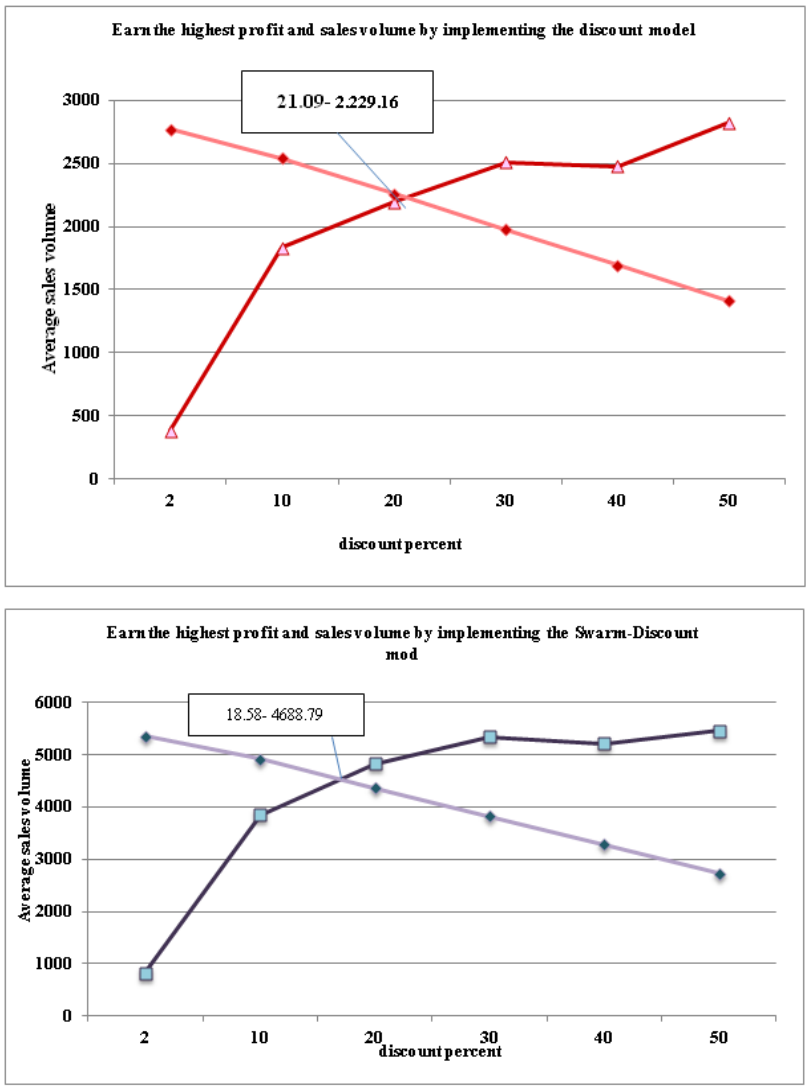


Fig. 12. Simulating customers' IB behavior and optimal discount point for highest revenue and profit.

Comparing and observing the results of the optimal discount points and sales volume in both discount and swarm -discount functions, which leads the store to maximize profits and sales volume at the same time, it is cited that by implementing the model (swarm-discount), less discount and more volume sales are achieved for the store. The results can be seen in *Fig. 12*.

4.6 | Analysis of Consumers' Impulsivity Sensitivity to Sales Volume

In another study and experiment that has been done in this study, the average purchase volume of consumers with different impulsivity has been analyzed. Therefore, a consumer who has lower impulsivity than other consumers has more goods from swarm factor in the basket and therefore, it is easier to choose your goods and put them in the shopping basket. As one's impulsivity increases to one, one's tolerance for purchase increases and the consumer responds later to the purchase of others. For this reason, people with higher impulsivity are considered customers with strict moral character and customers with low impulsivity are introduced to customers with neglectful character. In this experiment buyers have been studied with various impulsivity through the swarm-discount function. In this section, consumer instability is divided into ten groups o.1 intervals from zero to one and the average buying

volume of customers is measured. In *Fig. 13*, the average percentage of buyers is measured at different discounts and with different impulsivity.

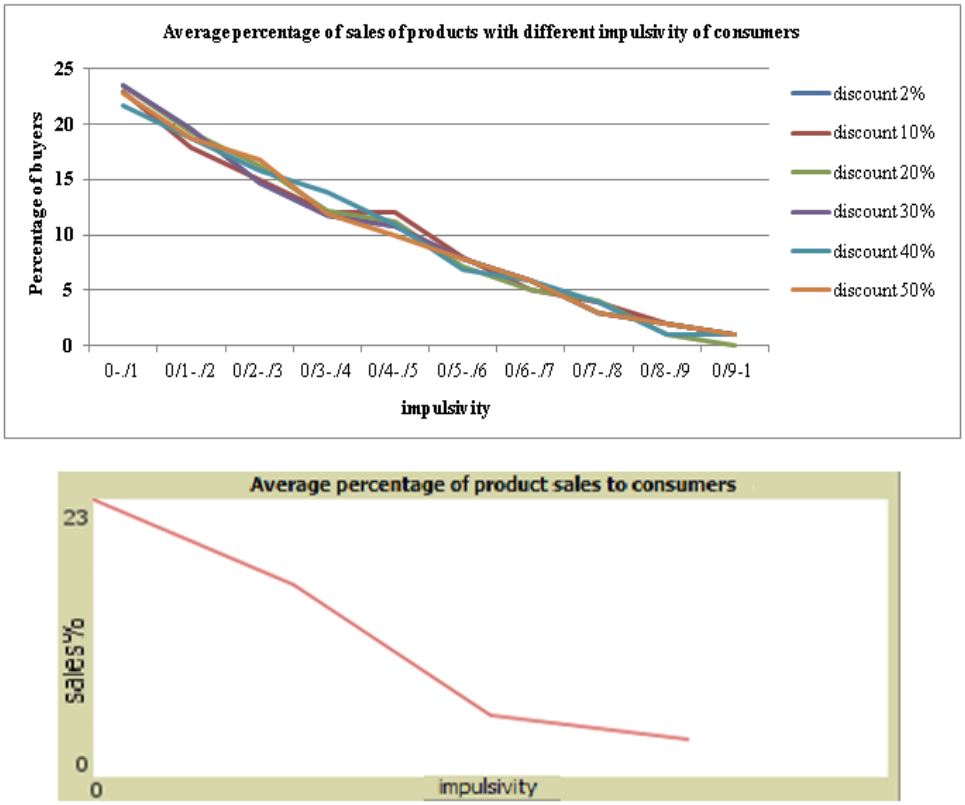


Fig. 13. Buyers with different impulsivity.

4.7 | Analysis of Modeling Results

The results are able to describe the behavior of customers in the store by discount and swarm factors. Understanding customer behavior in each of the introduced mathematical models allows to compare customer behavior in the store. Analysis of modeling results shows that the above factors are very effective in achieving the goal of large stores to increase sales volume and profitability by implementing a swarm - discount model and can show managers the optimal point of discount in the store.

4.8 | Model Validation

In order to check the conceptual validity of the model, the opinions of 15 experts and experts of IB were received during the face-to-face interview and after making the necessary corrections, it was approved. Then, according to 2 experts of agent-based simulation, the model explanation process is also approved.

To examine the limited conditions, Gilbert [35] states that it should be examined whether the corner states in the executive model work correctly or not? In this paper, the results of corner points considering the boundary values for discount and swarm parameters with other limited conditions, were examined. The results show that by applying high percentages of discount, the influx of consumers to buy products increases. And with the reduction of discounts, the desire to buy products has decreased. So that by applying high discounts, customers have made purchases in a short time. Also, in the swarm parameter, it was found that customers have reacted more to the purchase by buying others. These results are consistent with the real world. Therefore, these results show the accuracy of the implementation and the documentation of the program in the certain conditions.

5 | Conclusions

In this paper, consumers' IB behavior is defined as an economic analysis based on consumer relations and customer-product relationship with intervention of swarm and discount factors. By simulating customer behavior at the time of purchase, an attempt has been made to provide valuable information to managers, shareholders and decision makers. In the first section of this paper, a review of the literature and research background is performed. Most previous studies did not simulate customer behavior, and most researchers have used statistical methods to study the phenomenon of IB. Therefore, in this paper a model for IB is presented using simulation tools and agent-based approach in NetLogo software. An agent-based model with discount and swarm factors is designed, built, and implemented. In the design step, the dimensions of the problem were explained, then in the construction step, the coding was implemented in Netologo software. The goal of modeling customer behavior is to enable buyers to act like humans in decision making. The research model has investigated CB using agent-based approach to implementation as one of the new approaches in modeling. Also, the special advantage of this research compared to previous researches is considered discount and swarm factors and using the ABM.

The results of implementing the agent-based model introduced in this paper have advantages over other previous studies, the most important of which are: 1) the possibility of predicting sales volume in any amount of discount. 2) Ability to predict store revenue at any time. 3) Ability to predict the sales volume of each product during swarm to buy any product by other customers and 4) provide a software program with various factors without the need to solve the complexities of mathematical equations.

Conclusions of the research can be examined from two perspectives: from an applied perspective, the present research can provide important information for decision makers, managers and shareholders. This information includes the possibility of predicting sales volume and revenue forecast from the implementation of various policies in stores, which allows the comparison of each policy and the analysis of the performance of strategies in this paper. This method much less expensive in terms of financially and time than other methods.it is a feature of the model in a virtual environment. The researcher can check other sections by changing the amount of research assumptions. From a methodological point of view, the present study can be considered a creative aspect to predict buying volume, store revenue, etc. Previous research studies have shown that in most cases, statistical methods have been used to study IB. But this paper with ABM approach has presented a more flexible method than previous studies. In this method, by changing the data and changing the store policies, the effect of these changes on the outputs can be examined.

5.1 | Practical Suggestions

Due to the time-consuming algebraic models, managers, decision makers and store owners are recommended to use the agent-based approach and the method proposed in this paper to predict and estimate their outputs. This method can be very useful especially in developing countries such as Iran, because it is cheaper and faster than other methods. Due to the increase and variety of customers' manner in product selection, this method can increase sales and profitability stores and help customers to choose more desirable and logical products.

5.2 | Suggestions for Future Research

Although in this paper we tried to take into account discount and swarm factors to model customer behavior, but some very important factors that affect the buying process are ignored. Therefore, the following solutions can be used to develop this model. Modeling other IB situations in the buyer's decision: factors of time in the store, learning, amount of money available, the ability of the consumer to carry products and various positions of customers at the time of purchase can play a key role in IB. Therefore, the model should be examined in various situations and simultaneously with the factors introduced in this paper. Modeling other environmental factors for decision making: add factors such

as decor, layout, store location and other environmental factors that can play key roles in decision making in model. Modeling culture in the decision-making, since the different emotions can be influenced by personality, the culture is one of the factors influencing the IB and decision-making process. For example, in specific culture there may be more jealousy, while in another culture there may be more admiration than jealousy. Therefore, considering these factors, the model will be more complete. In addition, in-store section, product suppliers and all IB supply chains should be considered in the model. To better model the store, consider the capital, warehousing, Competitors and all the belongings of a store.

Due to the fact that the factors used in this study (discount and swarm) have a certain complexity and also there was not enough information to calculate the discount and swarm factor, the research faced many difficulties in the implementation process. Therefore, it can be said that the biggest problem in the field of interdisciplinary research is the lack of information. Also, the lack of information in the field of standard data led to the extension of thepaper. These are a set of limitations of this paper.

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Conflicts of Interest

The presented paper completely follows the publishing ethics, including plagiarism, misconduct, data forgery or duplicate submission and there is no commercial benefit to it.

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