Usage of Agent-Based Modeling and Simulation in Marketing

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Abstract—The aim of this study is to gain an understanding of whether there is a tendency of using agent-based modeling and simulation in marketing related issues within the last 14 years. For this purpose, we examined the content of ProQuest, Emerald and EbscoHost databases which provide great access to various journals from both marketing and technical disciplines. We used the keywords; marketing and agent-based simulation, marketing and agent-based modeling in the all fields. Search options are limited to peer-reviewed. Articles and conference papers published within the range of 2000 and 2013 were chosen from scholarly journals. This search resulted in 141 publications, by taking into consideration their abstracts, 89 of them found as irrelevant. Remaining 52 were classified into categories with respect to different marketing concepts and publishing years. In addition to this, marketing sub-categories and publishing years matrix was constructed in order to understand hot issues of marketing used in agent-based modeling and research opportunities of these two concepts.

Index Terms—marketing, agent-based modeling, agent-based simulation

I. INTRODUCTION

Nowadays, agent-based modeling has rapid increase in use of various disciplines. The dynamic nature and capability of modeling complex systems are some of its basic features which support the idea behind the intensive usage. One of the application areas of agent-based modeling and simulation is marketing. With the rise of the information age, companies have started using information and communication technologies for their operations including marketing. As a result of this, competition has become fiercer. Marketing is one of the crucial business areas to survive in today's organizations. Since today's business environment is volatile and very complex in nature, it is difficult to model issues related with marketing by using traditional techniques. Thus, agent-based modeling becomes more appropriate for this purpose.

In this study, we try to figure out whether there is a tendency of using agent-based modeling and simulation in marketing related issues within the last 14 years. The article begins with the literature review, continues with the methodology, and the presentation of results, and concludes with future research suggestions.

II. LITERATURE REVIEW

Marketing is a very broad concept which includes various sub-processes. In [1] The American Association defines the marketing as follows: "Marketing is the activity, set of institutions, and processes for creating, communicating, delivering, and exchange offerings that have value for customers, clients, partners, and society at large." Also in [1], authors present that there are 10 main types of entities to market which are goods, services, events, experiences, persons, places, properties, organizations, information, and ideas. This reveals that penetration area of marketing is much extended.

In [2] authors revealed that marketing provides being superior to your competitors in creating, delivering and communicating customer value. Therefore, marketing is at each and every step of business. In [3], it is stated that, with the rise of the information age, companies have started using information and communication technologies for their operations including marketing. As a result of this, competition has become fiercer. Since today's business environment is volatile and very complex in nature, it is difficult to model issues related with marketing by using traditional techniques.

In [4], it is indicated that, models have become less simplified and they can be added more characteristics of real systems with the agent-based modeling and simulation. Thus, complex and dynamic environments such as business environment and marketing processes are suitable to be modelled with agent-based modeling. In [5], it is specified that the one of the specific characteristics of agents in agent-based simulation is their adaptive behavior. In [4], it is revealed that agents can adapt their behaviors to current states environment, of other agents and of themselves.

III. METHODOLOGY

We examined the content of ProQuest, Emerald and EbscoHost databases which provide great access to various journals from both marketing and technical disciplines. We used the keywords; *marketing and agent-based simulation, marketing and agent-based modeling* in the all fields. Articles and conference papers are chosen from scholarly journals. Since the usage of agent-based simulation in marketing is a new research

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area, only the articles published between 2000 and 2013 were evaluated. This search resulted in 141 publications, by taking into consideration their abstracts 89 of them found as irrelevant.

 TABLE I.
 DATABASES CHOOSEN AND NUMBER OF PAPERS

 SELECTED
 SELECTED

Databases	Selected Papers						
	n	%					
ProQuest	45	85					
Emerald	4	10					
EbscoHost	3	5					
Total	52	100					

TABLE II. NUMBER OF PAPERS PER SUB-CATEGORIES AND THEIR REFERENCES

Sub-Categories of Marketing	Number of Papers	References				
Advertising	1	[6]				
Competition	4	[7], [8], [9], [10]				
Consumer Behavior	7	[11], [12], [13], [14], [15], [16], [17]				
Delivery	9	[15], [18], [19], [20], [21], [22], [23], [24], [25]				
Digital Rights Management	2	[26], [27]				
E-Commerce	3	[24], [27], [28]				
Innovation	16	[29], [30], [31], [32], [33], [34], [35], [36], [37], [38], [39], [40], [41], [42], [43], [44]				
Market-Orientation	1	[45]				
Processes						
New Market Entries	1	[46]				
New Product Development	4	[31], [47], [48], [49]				
New Technology Adaption	3	[50], [51], [52]				
Pricing	4	[44], [53], [54], [55]				
Service	3	[34], [56], [57]				
Value Creation	2	[34], [58]				

In fact, all articles were carefully screened to meet two criteria:

- All articles had to involve one of marketing concepts.
- All articles must use agent-based modeling and simulation as a method or recommend it as a further research.

Identification of all eligible papers for the content analysis was shared between two referees (i.e., the authors). One of them is a professor in marketing area and the other is a doctoral student in management information systems department. First, the doctoral student read and chose the related papers from a set of 141 papers and created Table I. As shown in Table I, 52 papers were selected for the analysis with the greatest number coming from *ProQuest Database*. Then papers are categorized into 14 different sub-categories of marketing. Some steps were taken to minimize judgment error and bias. Each referee independently created category names and put the papers into relevant categories. Then the results were compared for consistency. Category names were revised, some of them were combined and some of them were deleted and their papers were placed in other existing categories.

IV. RESULTS

First of all, each paper was categorized into one or more marketing sub-categories. Table II shows these marketing sub-categories, number of papers fall in each category and the reference numbers of these papers. You can find the references of these papers in the appendix. The marketing concepts are arranged in the alphabetical order.

A. Advertising

The first sub-category of marketing is advertising. There is one paper in this category. Reference [6] used agent-based modeling as a method to study the influence of the advertising budget and revision cycles of advertising policy on two firms.

B. Competition

The second sub-category of marketing is competition. There are four papers in this category. Reference [7] tried to understand how firms identify effective competitive positions by modeling and also examined how structural and managerial characteristics of the firm effect this decision. On the other hand, Reference [8] examined two types of competitive focus; external, where the choice of focal technology to be improved is influenced by information about other organizations and internal, where it is not influenced by others. Reference [9] constructed computational market model with technological competitions among standards and introduces simulations of different scenarios concerning standardization problems. In Reference [10], author approached to competitiveness from different point of view and claimed that if the firm's strategy is how complex the possibility of imitating it is difficult as well so they can get competitive advantage with this way. He modeled his idea with the agent-based simulation technique.

C. Consumer Behavior

The third sub-category of marketing is consumer behavior. There are six papers in this category. It is one of the sub-categories of marketing in which agent-based modeling is used intensively. In Reference [11], authors investigate the relationship between consumer behavior and the sales forecast and claimed that agent-based modeling is suitable technique in order to investigate this relationship. In Reference [12], consumer behaviors were examined over specific sector; energy market. Reference [13] examined consumer behavior over specific sector. They investigated electricity market. Reference [14] proposed a model for understanding a complex management issue - the customer loyalty in a public sports service. Reference [15] investigated the effects of retail performance on customer satisfaction with agent-based modeling approach. Reference [16] looked at briefly to agent-based model and its application on consumer behavior especially in telecoms and media markets. Reference [17] constructed a model for local heroin market and investigated the behaviors of consumer, dealers, street sellers, brokers and police.

D. Delivery

The fourth sub-category of marketing is delivery. There are nine papers in this category. Delivery is also one of the sub-categories of marketing in which agent-based modeling is used intensively. The subjects about delivery which are examined in the chosen papers can be summarized as following. Reference [18] examined relationships in dynamic retail market, Reference [19] examined supply-chain co-design, supply-chain planning, Reference [20] examined Reference [21] examined agile supply demand network design, Reference [22] examined building a supply network theory, Reference [23] examined the role of collaboration and sustainable relationships in supply-chain, Reference [15] examined retail performance, Reference [24] examined the effect of e-commerce on supply chain management, Reference [25] examined the role of intermediaries in electronic value chain.

E. Digital Rights Management

The fifth sub-category of marketing is digital rights management. There is one paper in this category. In Reference [26], digital rights management is defines as follows: "Digital rights management broadly refers to a set of policies, techniques and tools that guide the proper use of digital content." Reference [27] examined digital rights management which is directly related with e-commerce firms.

F. E-Commerce

The sixth sub-category of marketing is e-commerce. There are three papers in this category. Reference [24] examined the effects of e-commerce on the participants' supply chain operations, including inventory management and order fulfillment. Reference [27] examined digital rights management which is directly related with e-commerce firms. Reference [28] examined effects of e-commerce on firms' organizational structure.

G. Innovation

The seventh sub-category of marketing is innovation. There are sixteen papers in this category. It is the sub-category of marketing in which agent-based modeling is used most intensively. We can group these papers based on the innovation types. Reference [29], [30], [31], [32], [33] is about product innovation. Reference [34] is about service innovation. Reference [35] is about organizational innovation. Also we can group innovations as radical and incremental innovations. Reference [36] examined radical innovation their paper while Reference [37] examined modularity and incremental innovation. Reference [38], [39], and [40] modeled innovation diffusion. Reference [41] and [42] examined the subjects of "knowledge intensive innovation" and "knowledge integration and innovation". Reference [43] proposed a model to investigate the relationship between learning and innovation. Finally, Reference [44] introduced a model to find optimal pricing for the growth of innovation.

H. Market-Orientation Processes

The eighth sub-category of marketing is innovation. There is one paper in this category. Reference [45] compares different research techniques in his paper and offers agent-based modeling and simulation as more rigorous and fruitful technique than other techniques.

I. New Market Entries

The ninth sub-category of marketing is new market entries. There is one paper in this category. Reference [46] examined the effects of firms which enter the market on effectiveness and efficiency of existing firms.

J. New Product Development

The tenth sub-category of marketing is new product development which includes four papers in it. Reference [47] one of the papers in this category examined network externalities and network structure for new product development. Reference [48] covers the capability of firm for new product development. Reference [49] investigated the effects of incentives and organizational structure on new product development. Finally, Reference [32] examined innovation and new product development.

K. New Technology Adoption

The eleventh sub-category of marketing is new technology adoption which includes three papers in it. Reference [50] discusses four cases in order to figure out adoption processes of companies to the agent-based applications. Reference [51] applies four different agent-based simulation packages for electricity market and examined the common features of these packages and also examined technology adoption characteristics with these applications. Reference [52] reviews six articles in which technology adoption was issued. One of these studies used agent-based modeling as a method.

L. Pricing

The twelfth sub-category of marketing is pricing in which there are four papers. Reference [53] is about pricing proposed an agent-based computational model of the B2C electronic auction marketplace. In Reference [54], authors examined the influence of local network effects. switching costs, pricing, functionality enhancement strategies, and user network structures to understand de facto standardization through user standards adoption. In Reference [55], author covered the pricing of financial innovations. In Reference [44], he aimed to explore optimal pricing strategies for innovations with direct network externalities.

M. Services

The thirteenth sub-category is services. In this category, there are three papers in this category. Reference [34] described the emergence of service science, a new interdisciplinary area of study that aims to address the challenge of becoming more systematic about innovating in service. Reference [56] examined in their study, how value co-creation unfolds over time, and identified basic dynamics central to the modeling of

service systems. Finally, Reference [57] modeled healthcare services by using agent-based modeling and simulation technique and examined results.

N. Value Creation

The last sub-category is value creation. It includes two papers. In Reference [34], authors claimed that service innovation accelerates the value co-creation. Agent-based modeling and simulation was introduced as a good technique to reveal this relationship and also service system evolution. Reference [58] constructed a model in order to investigate C2C interaction affects learning performance and they conducted sensitivity analysis to investigate the needs of mutual learning between customers and provider in value co-creation.

O. Analysis of Papers According to Publishing Years

Table III shows the articles' publishing years, number of papers published in each year, their percentages and their reference numbers. Over the years the usage of agent-based modeling in marketing increases.

 TABLE III.
 CATEGORIZATIONS OF PAPERS ACCORDING TO PUBLISHING YEARS

Years	Frequency	Percentage	References
2000	1	2	[25]
2001	2	4	[10], [49]
2002	1	2	[16]
2003	3	6	[6], [28], [43]
2004	2	4	[12], [46]
2005	4	8	[7], [27], [30], [32]
2006	4	8	[19], [21], [50], [53]
2007	4	8	[22], [31], [48], [51]
2008	1	2	[34]
2009	3	6	[14], [17], [40]
2010	7	13	[11], [20], [24], [33], [36], [37], [38]
2011	9	17	[8], [15], [18], [29], [41], [45], [52], [54], [56]
2012	7	13	[9], [13], [39], [42], [47], [55], [57]
2013	4	8	[23], [35], [44], [58]
Total	52	%100	



Figure 1. Frequency of papers according to publishing years

In 2008 the only one paper was published so this year can be an outlier. The most number of papers were published in the years of 2011 and 2012. Therefore, we can say that agent-based modeling is getting used in marketing issues. On the other hand, in 2013 there are only three papers published, however the reason might be that further papers are accepted but not published yet.

V. RECOMMENDATION FOR FUTURE STUDIES

Most recently, delivery, innovation, pricing, and value creation are subjected in the papers. 2011 is the year that the most various and the most number of papers were published. "Innovation" has been the concept which is most subjected in the papers. The latter subjects that follow "innovation" are "delivery" and "consumer behavior". The least subjected titles are advertising, digital rights management, new market entries, market-orientation processes and value creation. These subjects can be the future research areas that agent-based modeling and simulation might be used as a method.

TABLE IV. MARKETING SUB-CATEGORIES AND PUBLISHING YEARS MATRIX

	Advertising	Competition	Consumer Behavior	Delivery	Digital Rights Man.	E-Commerce	Innovation	Market-Orientation Pro.	New Market Entries	New Product Dev.	New Tech. Adaption	Pricing	Service	Value Creation
2000				Х										
2001		Х								Х				
2002			Х											
2003	Х					Х	Х							
2004			Х						Х					
2005		Х			Х		Х							
2006				Х							Х	Х		
2007				Х			Х			Х	Х			
2008							Х						Х	Х
2009			Х				Х							
2010			Х	Х		Х	Х							
2011		Х	Х	Х			Х	Х			Х	Х	Х	
2012		Х	Х				Х			Х		Х	Х	
2013				Х			Х					Х		Х

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