Agent based simulation of word-of-mouth phenomena in FMCG markets

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ABSTRACT
The relevance of FMCG markets in everyday life and of the buying choices of each consumers makes a challenging and interesting field for deploying and studying agent based models. In this paper an agent based tool for analysing markets behaviour under several rate of information diffusion is described. This methodology allows for the study of tradeoffs among several variables of information like product advertisement efforts, consumers' memory span, and passing word among friends in determining market shares. Insights gained by using this approach on an hypothetical economy are reported.

KEY WORDS
Agent-based simulation, Consumer behavior, Fast moving consumer good market

1 Introduction

The diffusion of an Internet based economy, that includes even the less valuable transactions, is day by day more evident. The existing information infrastructure has allowed the exploitation of new methods to contract the purchases of goods and services, the most notable of which is probably the agent mediated electronic commerce [4, 5]. In this economy, autonomous agents become the building block for developing electronic market places or for comparing offers across several seller's websites (shopbots) [5, 9]. Our aim is to use an agent-based market place to qualitatively simulate the diffusion of products' awareness across the Internet and its impact on customer choices. As many commercial scenarios could be selected, we chose to investigate a simple commercial interaction. Different groups of consumers have to choose one product between a set of perfect substitutes that differ in price, advertised lifestyle associated with the product and the advertising effort to initially penetrate the market. Our objective is the to understand how a sequence of repeated purchases is affected by the trade off among the previous variables, the consumers' desires and limits, and the diffusion of the awareness about the existing products. The ultimate goal would be to capture the common experience of choosing, for instance, among alternative brands of Italian Pasta packages displayed in the webpage or on the physical shelf of our grocery store.

Some researchers take a very long term view about the ecommerce phenomena envisioning economies of shopbots [4, 5, 9]. We try to capture the commercial phenomena in more near future where customers are human beings with their intrinsic limit in information processing, having the need to trust the bought product and to feel supported, and reassured about their purchasing choice as their best possible choice. We share, however, with Kephart et al. the desire to analyse and understand how the information flow can affect such economy. Academics in business schools already report preliminary studies of these situations. For instance, Lynch and Ariely [3] try to understand the factors behind purchases made in a real world experiment of wine selling across different retailers' websites and Brynjolfsson et al. [10] discuss which factors seems to be more likely to impact the consumer choices in the electronic market place. To further extend our work, a more sophisticated approach to modelling the electronic market place may have to be selected in order to take into account negotiation protocols or virtual organisation formation as, for instance, described in [8] or to account for additional brokering agents as described in [11]. In the near future, we would like to investigate the emergence of information diffusion strategies by using a distributed genetic algorithm [7].

The paper is organized has follow: in section 2 a description of the market place is reported, in section 3 the performed experiments are commented and, finally, some conclusions are drawn.

2 The Virtual Market Place

The architecture of the agent based virtual market place is quite simple: one purchaising round after the other, groups of consumers, modelled as software agents, select which product to buy according to their internal status. The internal status takes into account the consumers' preferences for a product and her awareness about the product's benefits and image. This process based description of the buying experience matches what most people experience when selecting among alternative wholemeal breads or milk chocolate bars at the local grocery store [1]. In the simulator we represent both products and consumers as software agents. A product is a collection of an identifier, a price, an effort

to describe its features/benefits on the package, an effort to bound the product to the image of a lifestyle (brand) and an initial advertisement effort to penetrate the market. It is important to note that the scope of this work is to consider products that are substitute one for the others but differ in price or other characteristics. The idea to model products as software agents is new.

A consumer is a (software) agent operating on the market and driven in her purchases by a target price, a need for understanding the product benefits, the lifestyle conveyed by the product brand, and the initial marketing effort put into placing the product in the market. The consumer can remember only a constant number of products (memory limit) for a constant number of rounds (memory duration), and she may share with her friends her opinion about the known products. It is worthwhile to stress that the memory span limits the consumer awareness of the available products. For instance, if a consumer had a memory limit of 3, she would be aware of 3 products at most and she would make her choice only among those three products. A consumer will not remember a product, if its memory has already reached its limit, unless it is better of an already known product thus replacing it. However, round after round, consumers talk to each other and they may review their opinions about the products by updating their set of known products. Our interest lays in forecasting the product market shares (percentage of bought products) on the basis on the previous factors. In order to evaluate the feasibility of our approach, we developed from scratch a basic version of the market place simulator and performed some experimentation under constrained conditions.

In the following the detailed descriptions of both the simulator's architecture and the experimental setting is described. In the simulator, each product is defined by an identifier (Id), a selling price (Price), an effort in describing its benefits on its package, an effort to convey a lifestyle (image), and an effort to initially penetrate the market. As an instance, in the initial series of experiments, all the products prices and characteristics are selected to cover a wide range of significant offers as follow:
Product(Id, Price, Description, Image, InitialAdvertisement)
Product(0, LowValue, LowValue, LowValue, LowValue)
Product(1, LowValue, LowValue, LowValue, HighValue)
Product(2, LowValue, LowValue, HighValue, LowValue)
...
Product(15, HighValue, HighValue, HighValue, HighValue)
The constants 'LowValue' and 'HighValue' correspond to the values 0.2 and 0.8. The Price, Description and Image parameters are used to evaluate a customer's preference for the product, whereas the InitialAdvertisement parameter defines the initial awareness of the product among the customers. So, for instance, a product defined as Product(x, LowValue, LowValue, LowValue, LowValue) is especially targeted toward price sensitive consumers that do not care about knowing much on the product. And with an initial penetration rate of 0.2, on average, 20% of the consumers are aware of its availability at the beginning of the first buying round. Finally, it is worthwhile to note that, in the above list, odd and pair numbered products differ only because of a different initial advertising effort.

A similar representation choice has been made to represent customers. Four groups of consumers are considered. For the scope of the initial experiments, we concentrate on customers whose target product has a low price but differs in the other features. Consumer groups are represented as follows:
Customer(Price, Description, Image)
Customer(LowValue, LowValue, LowValue) (bargain hunters)
Customer(LowValue, LowValue, HighValue) (image sensitive
Customer(LowValue, HighValue, LowValue) (description sensitive
Customer(LowValue, HighValue, HighValue) (image and description sensitive
Through the selection of target values, we tried to capture the following categories of customers: the bargain hunters, the brand sensitive ones, the package sensitive ones (i.e. are interested in its nutrition values, its composition, its ecological impact, etc.), and those that are both brand and package sensitive. It is important to note that each customer does not necessary known the same products than other consumers because of the individual memory and of the initial random distribution of a product awareness among consumers. During each round, a consumer chooses to buy the product that most closely matches her preferences.

According to Bettman [1] and [2], we approximate the product matching process by means of a weighted average function defined as follows:
$Preference(product) =$
$(max(product.Price, target.Price) -$
$target.Price)^2 +$
$(min(product.Description, Description) -$
$target.Description)^2 +$
$(min(product.Image, target.Image) - target.Image)^2$

The preferred and selected product is the one with the lowest value of the Preference function among the ones known by the customer. Alternative expressions are under study.

Also each customer does not necessarily known the same products than the others because of the different distribution of the products depending on their initial marketing effort. The reported experiments aim to understand the impacts of the following factors in determining the final product market shares: customer preference definition, initial market penetration effort, number of friends in passing the word of known products, and memory limit.

In the initial group of experiments we aimed to investigate some hypothesis on the impacts of the diffusion of product awareness and shift in the consumers' behaviours [6]. The obtained results are promising and confirm the feasibility of the approach. They are however far from being

conclusive in term of hypothesis testing. Indeed in order to perform extensive and informative experiments, the virtual market place simulator should be completely re-engineered to facilitate its use and the definition of hypotheses/rules governing the consumers' behaviour.

3 Experimental Results

Goal of the experimentation is to show that our tool can capture some of the inherent complexity behind the determination of the product market shares by considering a variety of factors that impact on this economic phenomena. These factors include the customers' expectations for a product, the limited memory span and duration that consumers reserve to remember available products, and the diffusion of the product awareness among consumers by initial advertisement and further passing by word. Value ranges for this variables have been selected accordingly to past experience with consumers behaviour.

All the reported experiments refer to an hypothetical economy and are based on the following basic settings. During each round, 400 consumers (one hundred for each of the four consumer types) select which of the 16 products to buy. Only products that the consumer remembers (i.e. appearing in its memory list) compete for being purchased. The economic process is repeated for 100 rounds. For each experiments, the reported figures are averaged over 3 runs.

As a baseline for evaluating the economic process, we consider the situation where each consumer is fully aware of all the available products since the first round. As all the consumers are oriented towards products with low price but with different characteristics, it is straightforward to calculate that the product market shares stay constant over the 400 rounds and correspond to the values reported in Fig. 1. In the figure, ideal market share distribution in presence of a perfect product awareness or perfect information flow is shown. In the picture, the product's identifiers appear on the x axis, and the market shares on the y axis. Thus for instance, Product 6 will achieve a 9.3% market share. It is worthwhile to note that the product from 9 to 16 have a 0% market share because, in the range from 1 to 8, there exists a product with identical features but with lower price.

If we were in this ideal situation, every consumer would be able to make the best pick among the available products. Unfortunately, in the real world, full knowledge about the available choices is not common and product awareness is the results of a variety of factors including advertisement, passing by word among friends and memory capacity. The impact of these factors on the product market shares is taken into account in the following experiments.

Let us consider the case where consumers do not have any friends or do not talk about products to friends (average number of friends or avgf =0), they can remember only 2 products at the time (memory limit or ml=2), and they remember each product for 20 rounds unless either they keep buying it or they are told about by their friends. The initial (end of round 1) and final market shares (end of round

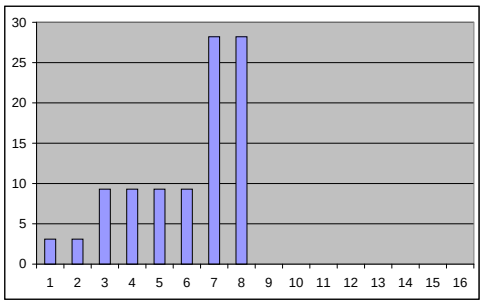

Figure 1. Ideal market share distribution.

100) appear in Fig. 2. In the picture, market shares when consumers do not talk each other (avgf=0) and remember at most 2 products (ml=2) for 20 rounds, are shown.

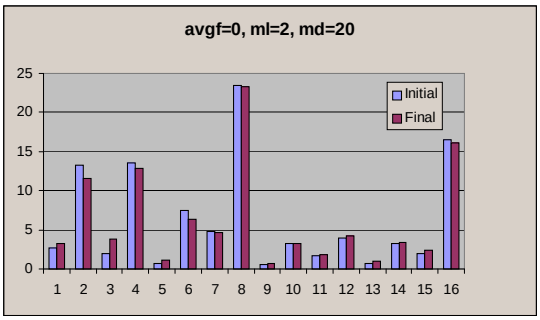

Figure 2. Market shares when consumers do not talk each other.

It appears that the initial and final market shares are very alike and that the higher the effort in penetrating the market the better the market share (compare odd and even numbered products). The market share distribution is biased toward low priced product, this is to be expected given the customers' preferences. But, still, some high price products achieve a significant portion of market because of the limited memory span of the consumers that would prevent him to compare and choose among more alternatives.

If we alter the previous scenario just by increasing the number of friends to 20, we obtain quite a different distribution of market shares, Fig. 3. In the picture, market shares when consumers talk to about 20 friends (avgf=20) and remember at most 2 products (ml=2) for 20 rounds, are shown. The pattern of the initial market shares is, of course, similar to that of the previous scenario but the final shares tends to converge towards the ideal ones. This can be interpreted that having many friends or collecting many opinions among the same market does actually empower the customer in making the best selection. It is interesting to note that the only initial advertisement cannot compensate for the further product comparisons communicated

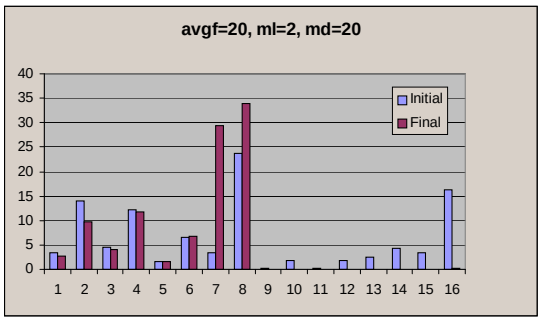

Figure 3. Market shares when consumers talk to each other.

among the consumers. However, the initial product advertising effort results in the consumers remembering and, then, choosing the more advertised products among the low priced ones.

From additional experiments not reported here, comparing the initial and final distributions of market shares it appears that exchanging information about products with friends and remembering a number of them is the key to make a successful choice in this scenario. Indeed this observation is at the very base for the development of several strategies to deal with comparative on-line shopping.

4 Conclusion

Concerning electronic shopping and, especially, comparative shopping engines, the reported experiments show the significance of exchanging information among economic agents. Indeed, this is the key to make good/bad buying choice. Obviously, buyers and sellers regards each choice from a different perspective. This observation and this approach can help the development of novel marketing strategies in the comparative on-line shopping environment.

References

[1] J. Bettman. *An information processing theory of consumer choice*. Addison Wesley, Reading, MA (USA), 1979.

[2] W. Hoyer. An examination of consumer decision making for a common repeat purchase product. *Journal of Consumer Research*, pages 822–829, 1988.

[3] J. J. G. Lynch and D. Ariely. Wine online: search costs and competiotion on price, quality and distribution. *Marketing Science*, pages 1–39, 2000.

[4] J. O. Kephart, J. E. Hanson, D. W. Levine, B. N. Grosof, J. Sairamesh, R. Segal, and S. R. White. Dynamics of an information-filtering economy. In *Cooperative Information Agents*, pages 160–171, 1998.

[5] P. Maes. Agents that reduce work and information overload. *Communications of the ACM*, pages 31–40, 1994.

[6] F. Neri. An agent based approach to virtual market place simulation. In *Congresso dell'Associazione Italiana Intelligenza Artificiale 2001 (AIIA01)*, pages 43–51, 2001.

[7] F. Neri and L. Saitta. Exploring the power of genetic search in learning symbolic classifiers. *IEEE Trans. on Pattern Analysis and Machine Intelligence*, PAMI-18:1135–1142, 1996.

[8] A. P. Rocha and E. Oliveira. Agents advanced features for negotiation in electronic commerce and virtual organisations formation process. *Agent Mediated Electronic Commerce - An European Perspective*, LNAI 1991, 1999.

[9] J. A. Rodriguez-Aguilar, F. J. Martin, P. Noriega, P. Garcia, and C. Sierra. Towards a test-bed for trading agents in electronic auction markets. *AI Communications*, 11(1):5–19, 1998.

[10] M. D. Smith, J. Bailey, and E. Brynjolfsson. Understanding digital markets: review and assessment. *Draft available at http:ecommerce.mit.edupapersude*, pages 1–34, 2001.

[11] M. J. Viamonte and C. Ramos. A model for an electronic market place. *Agent Mediated Electronic Commerce - An European Perspective*, LNAI 1991:3–28, 1999.