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Analysing Retailing Opportunities And Threats Using Agent-Based Simulation

Viktor Vojtko, University of South Bohemia, Faculty of Economics and Faculty of Agriculture, Ceske Budejovice, Czech Republic, vojtko@ef.jcu.cz
Marie Heskova, University of South Bohemia, Faculty of Agriculture, Ceske Budejovice, Czech Republic, mheskova@seznam.cz

Abstract

Kotler and Caslione have recently published a new book Chaotics which stresses the importance of scenario analysis in marketing, especially in turbulent times. The goal of this paper is to show how an agent-based simulator could be practically used as a valuable supporting tool for the marketing analysis of opportunities and threats on retail markets.

Keywords: Simulator, retailing, marketing, scenario

Introduction

As marketing is a very common and widespread approach in companies a lot of attention is being paid to rationally justify marketing decisions. The main difficulty is that there are many different and ambiguous influences which take place on markets, especially on the end consumer ones and our mental skills in such complex situations are quite limited (Sterman 2000).

Is there a way through? Could we somehow enhance our mental skills in complex situations? We think so. And we think it is also very much needed, especially in the uneasy situation of economic crisis. Computer modelling, with conceptual, optimization and simulation methods, has changed a lot in the last few decades. However, due to successful applications of data-driven approaches - e.g. data mining, GIS, neural nets and conjoint analysis - the research in model-driven (or knowledge- based) approaches is not fully reflected in marketing practice, especially in countries like the Czech Republic.

The main aim of this paper is, thus, to show how such a model-driven and, in this case, agent-based modelling approach may be potentially used in a broader frame of scenario analysis for useful marketing knowledge generation in the field of retailing.

Literary review

Philip Kotler and John A. Caslione (2009) provide in their new book *Chaotics* a very interesting general framework for marketing management in the time of crisis. The main idea behind this book is that due to turbulences of environment the marketing management efforts need to be oriented on greater flexibility and robustness and the key issue for that is scenario planning together with development of early warning systems.

We see this as an opportunity, especially for the model-driven approaches, to support decision making and aid knowledge generation in marketing. Due to Wierenga (2008, p. 9) "[t]he acceptance and use of marketing decision models has been a continuing problem" and we think the way of thinking proposed by Kotler and Caslione (2009) could help to change perceptions of marketing practitioners.

In this sense we would like to provide a short overview of the main schools of thought in the area of marketing decision support using models.

There are several research streams related to marketing models (Wierenga 2008) – or knowledge oriented marketing management support systems as mentioned by Wierenga and van Bruggen (1997) – that can be summarized for example in these two categories:

- *Customer decision making models* – markets, individual customers and their choices

- *Marketing mix models* – promotion, pricing, place, product and their particular or overall influence both on customers and competitors

The approaches to the making of marketing models have changed a lot during the last few decades. The main shift has been from a rather general view of customers (or very often consumers) as an homogenous group of people to a view that respects individual differences and heterogenity. This may be analogous to a shift from macro and micro level separation at first, i.e. modelling just macro or just micro level, to a synthesis of micro and macro level, i.e. involvement of interconnections of these two levels. Many methods have been developed and used (Wierenga & van Bruggen 1997) – from operation research applications to conjoint analysis models, neural nets, data mining or stylized theoretical modelling.

What we think is missing in this overview is that there are at least two research streams not mentioned at all by Wierenga (2008) and the interesting point is that both reflect the same shift from macro/micro level distinction to interconnection.

The first one – system dynamics and systems thinking – has been used for modelling of marketing problems since the 1960s (Forrester 1961, Senge 1994, Sterman 2000). However, these models were published mainly in books and different journals rather than the mainstream ones and, thus, their influence on marketing theoretical thinking has been marginal, although there have been many successful applications in practise.

The second research stream – agent-based modelling – seems to be more recognized and accepted now both by marketing researchers and practitioners (Ben Said, Drougoul & Bouron 2001, Buchta & Mazanec 2001, Bonabeau 2002, Twomey & Cadman 2002, Jager 2006, Vidal 2009). In the marketing area it is based on modelling of macro influences, individual customers and competitors (market agents) and their behaviour and interactions in time, which are very often irrational or bounded rational only. The behaviour of agents is thus determined by individual decision making rules according to the local and global environment. If stochasticity is involved than also a chance occurrence may take place.

This approach has two important merits. First, it provides a possibility for synthesis of data and knowledge about market behaviour. It means that it is possible to calibrate such a model with the real-world data (taken for example from a survey) in a meaningful way and, on the other hand, it is possible to compensate for missing data with theoretical knowledge. Second, the simulation of behaviour in time both on micro and macro levels provides a way for scenario development and testing according to Kotler and Caslione (2009) and the integration of the beforementioned customer decision making models and marketing mix models is possible too.

Agent-based model for retailing opportunities and threats testing

In the next part of this paper we would like to show an example of an agent-based model used for decision support and scenario development and testing in the way proposed by Kotler and Caslione (2009) in retailing. The model has been developed for the purpose of analysis of opportunities and threats related to placement of retail outlets, changes in their profiles and also changes in behaviour of households (consumers).

Because the model should support real decision making it has to be accompanied with two other layers (Heskova & Vojtko 2007) – user interface and learning environment (methodology, scenarios). We will show all the three layers here.

The first layer is the model itself. In this case the model has been built using NetLogo 4.1 modelling software (Wilensky 1999). It provides a possibility to make computational models not just using mathematical equations but also more complex algorithms. Other great features are, for example, easy involvement of time and space into the model behaviour using BehaviorSpace – a tool for performing experiments using multiple runs of simulations, data import and export capabilities and user interface support.

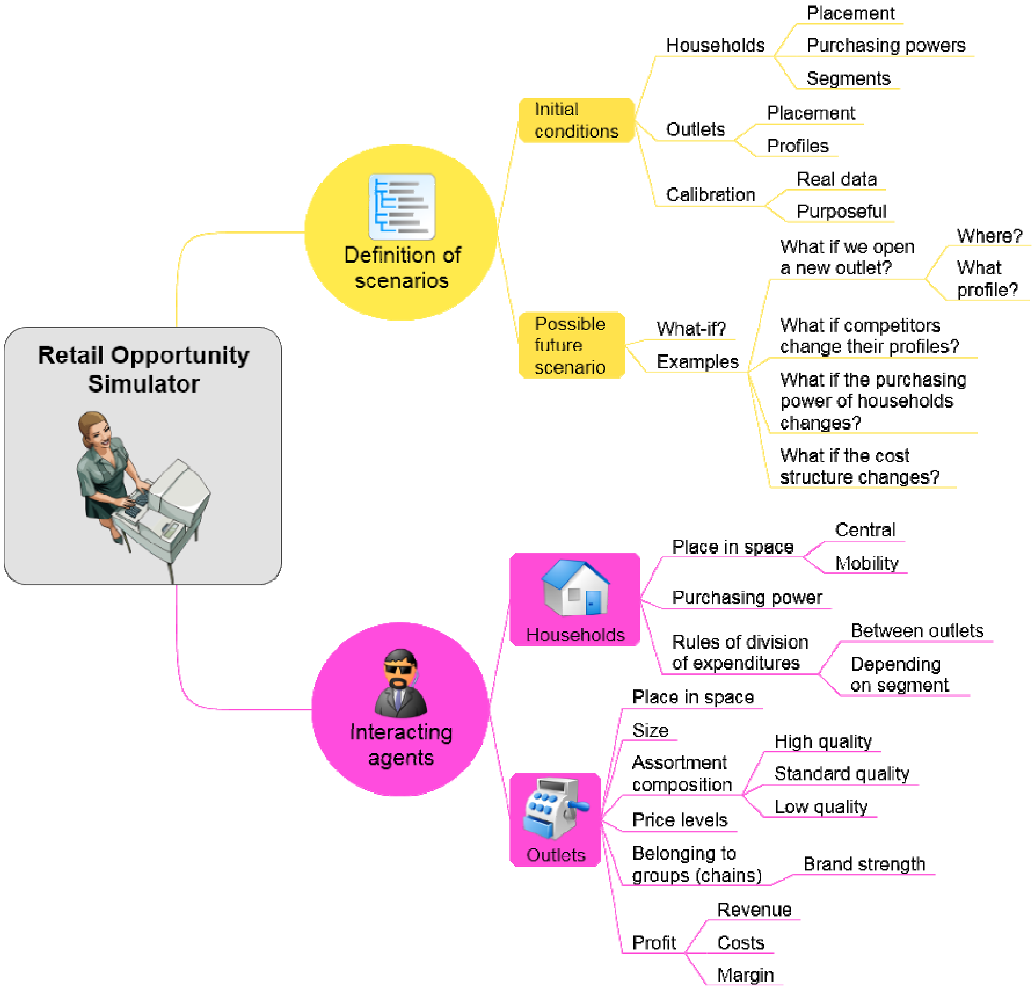

Fig 1. Retail Opportunity Simulator model overview

The purpose of the model is thus based on the following general scenarios that should be supported by the model inputs and outputs:

- What if we open a new outlet? Where should it be? What profile (assortment composition, price levels, size) the new outlet should have?
- What if competitors open or close outlets? What should we then change in the profile of our outlets?
- What if the purchasing behaviour of consumer households changes? E.g. purchasing power and decision rules changes due to economic crisis.
- What if the cost structure changes? E.g. funding of outlets in less-favoured areas by municipalities, private labels and changes in margins.

The model we have prepared for answering such questions as above is agent-based and combines interactions of two types of agents – households and outlets. Households solve two primary questions – how much should they spend in a certain time period (1 year) and where? And, according to their decision, outlet economic variables (revenue, costs, profit/loss) are calculated.

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The decision of households as to how much and where to spend is made according to their individual purchasing powers and number of satisfying suppliers in their proximity and further depends on the following factors:

- *distance to the outlet,*
- *perceived attractiveness of the place of outlet* (outlet size, proximity of other outlets, exogenous attractivity – e.g. train station or other often visited place),
- *perceived attractiveness of the assortment and price,*
- *influence of the outlet brand,*
- *relative weights of attractivenesses,*
- *noise (if turned on).*

The households belong to three main segments, i.e. lower, middle or upper class. Each segment members use different rules in their decision making. Lower class households are not very mobile and prefer the lowest prices available, middle class households pursue the best quality/price ratio and upper class households prefer the highest quality available. This division of segments and their decision making rules is in accordance to suggestions of Piana (2004).

Now it is possible to take a look on the user interface. In this case it is built using NetLogo tools and can be seen on Figure 2. The user interface is very important especially for practical use.

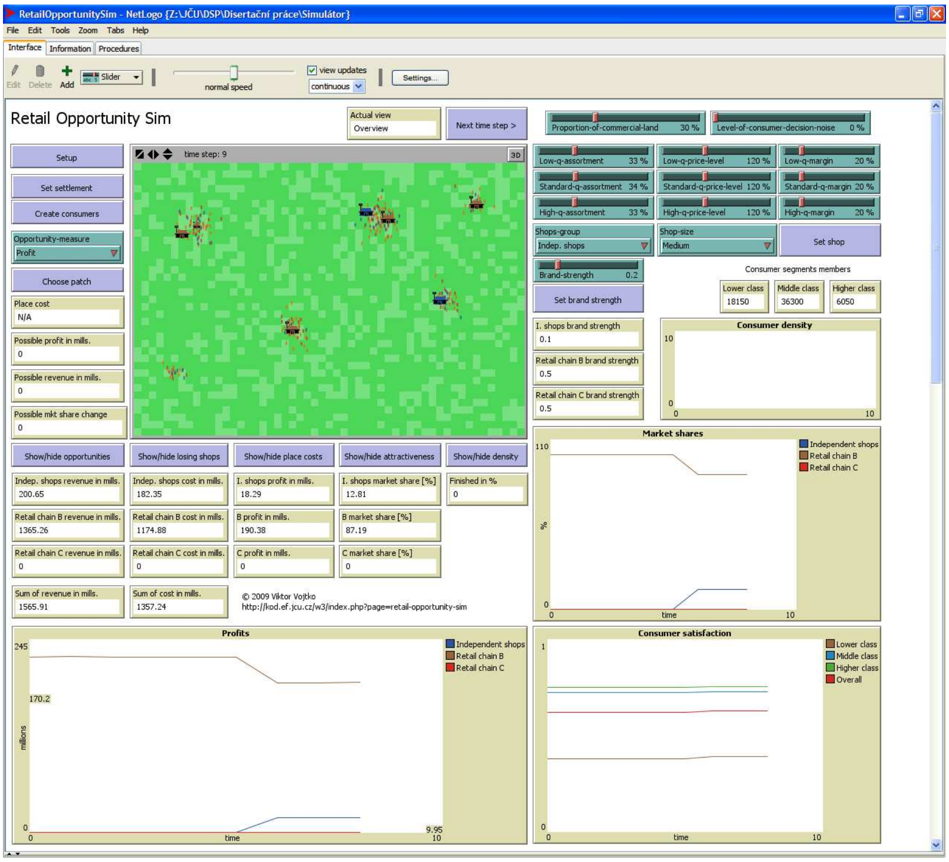

Fig 2. Retail Opportunity Simulator user interface

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The user interface allows inputs such as creating of settlements and generating households, creating of outlets with certain profiles (size, assortment composition, price levels, margins) and belonging to different groups (independent, chain B and chain C). Using these inputs it is possible to set initial conditions as well as other changes in time.

There is also a possibility to change the view of the map. The standard view shows households' and outlets' positions on the map. The other views are able to show:

- a map of calculated opportunities for a placement of new outlet with a profile set by beforementioned inputs,
- a map of actually losing outlets,
- a map of place costs (costs in different locations may differ, e.g. according to density of inhabitants),
- a map of exogenous attractiveness of various places,
- a map of density of inhabitants.

And of course there are the calculated outputs. First of all there are actual revenues, costs, profits/losses and market shares of the three groups of outlets. The profits/losses and market shares are also shown in figures as a time series which is supplemented by a time series of households overall satisfaction.

The last important part of the user interface is a way to move forward in time for scenario advancement. This is done by a button called Next time step >.

The third layer is learning environment. In this case this means the whole process (see Fig 3) of Retail Opportunity Simulator usage, additional materials, data for calibration and scenarios themselves.

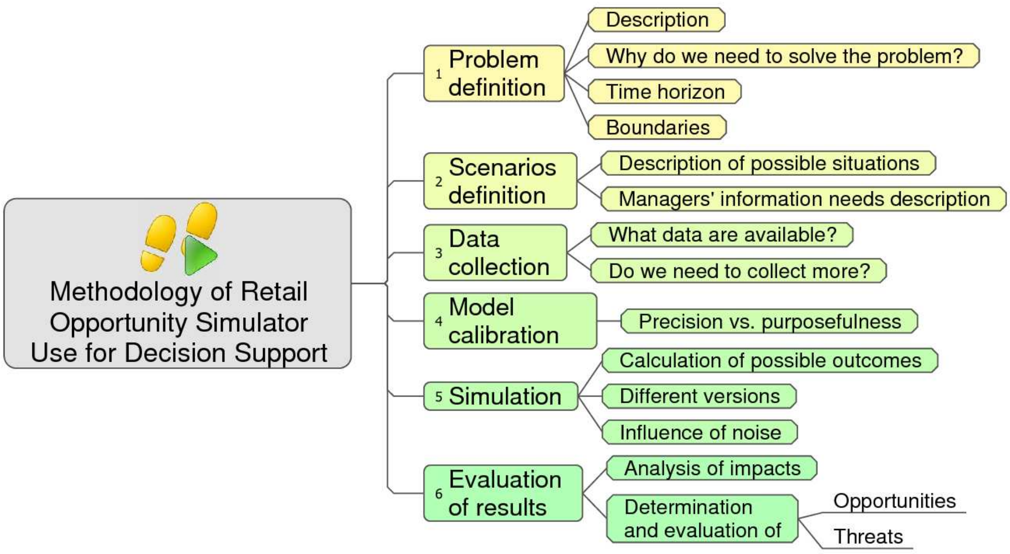

Fig 3. Methodology of Retail Opportunity Simulator use for decision support

We think the whole process is quite straightforward and thus we just stress the not so common approach to model calibration. Generally it is possible to set the initial conditions in two different ways. The first one is based on precise calibration – we need to have proper data and set everything accordingly, but in many real-life cases this is very demanding because the collection of data takes a lot of time and effort and may cost a lot too.
The second way is a purposeful calibration. In this case the model is not initially set according to precise data but mainly on purpose – e.g. with respect to caution. This can be done very quickly and easily with

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only a small amount of data, very often from public and internal sources. It is a very useful approach, especially in the context of opportunity analysis – if initial conditions are set with caution and the opportunity seems to be interesting then it means it should also be interesting when the calibration is precise.

Example of tested scenario

We have shown above what the Retail Opportunity Simulator intended for the scenarios development and testing looks like. Now we can show an example of a scenario that was already calibrated and tested using this simulator. The process of use of the simulator will then be clear and it is possible to evaluate both the process and results.

We could imagine now that we are in a role of marketing manager of retail chain C who needs to decide on the following questions:

- How many outlets should we open on the given market to be profitable? And where exactly?
- What about the competitors? Will they react? And how? Does it mean that we will be in danger then?

Let's say we have set the initial conditions according to some actual existing geographic area in the Czech Republic. The households are localised as well as the outlets belonging to two groups and their profiles are set. There is also another important factor – cost related to a place – which needs to be set accordingly because we can assume that these costs differ in relation to the density of inhabitants.

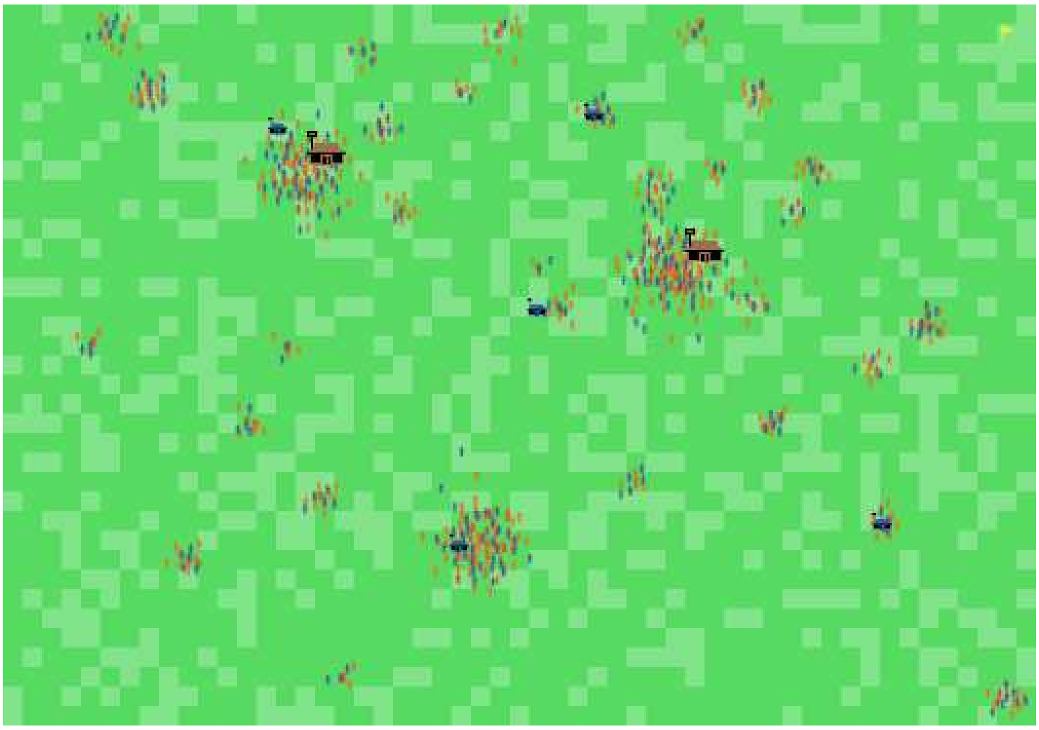

Fig 4. Households and outlets initial placement

First of all, we have to know our business model to be applied on the given market, i.e. at least the outlet size and related fixed costs, assortment composition, price levels for assortment types, margins for assortment types and brand strength. We should also know our overall goals and strategy in the given time horizon, e.g. if we want to maximize profit, revenue and market share or we want to maximize losses of competitors. If we set it and choose as the criterion maximization of profit we can estimate the best places in which to place such an outlet using the map of opportunities.

Fig 5. The map of opportunities for the given scenario – outlet 1

Lighter places on the map mean localities where the outlet should be profitable, black places are not available (e.g. due to municipal plans or no free land). The most profitable place on the map is white – if we want to maximize profit we should place the outlet there.

In this particular case the place is marked with a small yellow flag and the estimated profit is CZK 11.14 million per year.

Let's suppose we decide to place the new outlet here. What's next? We can, for example, try to place another outlet – in the same time as the first one. Would it be profitable? Let's try it. We just need to calculate the map of opportunies again (Fig 6).

We can see it has changed. The estimated change in profit of the best second outlet placement is CZK 5.07 million per year. It does not mean that the second outlet will have such a profit. It will be more because the change in the profit of the first outlet is calculated too.

Now we can easily deepen the scenario and try a what-if analysis of the situation with two outlets placed. We need to know how the situation will change according to reactions of competitors.

First of all, we can assume that it will take some time for them to react. Thus, we can move one time step (year) ahead. The impacts on groups of competitors can be seen directly on their calculated profits/losses, revenues, costs and market shares. In this case the independent outlets have lost 25 % of their revenues and the retail chain B has lost 32 %. That is a lot of money and reaction would probably be quite strong.

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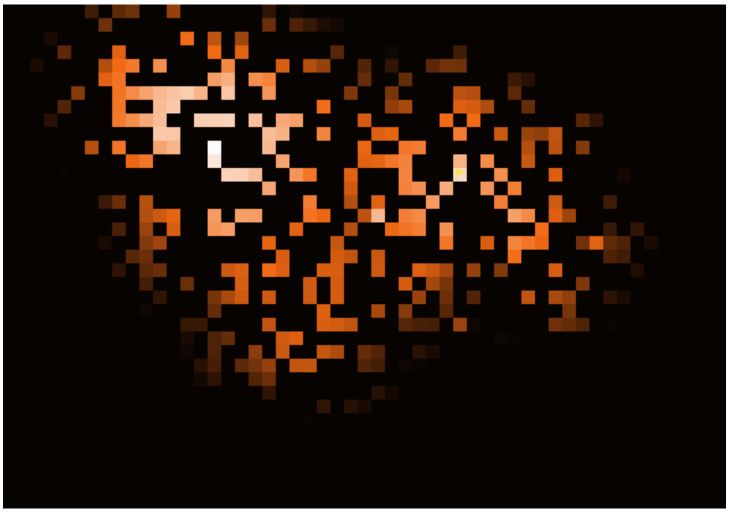

Fig 6. The map of opportunities for the given scenario – outlet 2

Let’s change perspective to the retail chain B. This part of the process is, in our opinion, the most valuable one when using the simulator because the change of view can be done easily and consistently and in the same way as changes of our own position on the market.

At first, we could try to change the main parameters of existing outlets, e.g. their price levels or brand strength. If we want to see the impact on the model outputs it is possible to just move forward in time and see the changes (the households have no memory so the calculated results are rather potentials than exact purchasing behaviour). Another possibility is to use the BehaviorSpace module of NetLogo to automatically set the parameters in given intervals and calculate the results. We can also try to use random changes in purchasing behaviour and see the possible impacts.

After the analysis of competitors’ moves it is useful to think about our own reactions and formulation of coherent policies – these can be evaluated easily using the scenarios.

Conclusions

We have both theoretically and practically shown that scenario analysis proposed by Kotler and Caslione (2009) could be greatly improved by the use of proper business simulators. We see it as a logical move and possibly a new research stream in the area of marketing decision support systems.

We have also shown that there are other interesting modelling approaches not frequently mentioned in marketing decision support systems literature. These are system dynamics and agent-based simulation approaches. Both are valuable and should be researched further.

The business simulator used here could be used, not only by retailing and franchising businesses, but also by municipalities in less favoured areas too. Both these subjects can then easily evaluate different scenarios of market development and set their behaviour and policies accordingly.

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