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TOWARDS AN ABM-BASED FRAMEWORK FOR INVESTIGATING CONSUMER BEHAVIOUR IN THE INSURANCE INDUSTRY

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Abstract. *This paper presents a framework that builds upon agent-based modelling for investigating the behaviour of consumers in the insurance industry. Consumers are modelled as agents and clustered in groups reflecting their income levels. Agents that model consumers are characterised by their socio-demographic features and interact with other insurance consumer-agents by means of local and global social networks. Furthermore, the environment in which they evolve models the impact of external factors such as mortality, disease and other accident rates as well as insurance culture. This makes that consumer-agents accumulate experience, improve their understanding and knowledge of financial products, and thus develop their perception of need for security and consider the usefulness of insurance services. In turn, the framework enables to model the construction of the customers' insurance product purchase decision.*

Key words: *insurance sector, consumer behaviour, agent-based modelling, insurance purchasing decision, insurance-agent action.*

Introduction

The ever-increasing competition in the insurance markets (both at the national and international levels) and the numerous types of insurance offers (both life and non-life), combined with the growing complexity of the products, make the analysis of the insurance sector more and more challenging. For example, factors such as ageing populations and the rise of health technology influence the variety of needs and offers in the insurance industry. Moreover, phenomena such as increasing gaps between the poor and the rich, economic crises, and new forms of family nests make that consumers' spending habits are evolving more and more rapidly.

This calls for new tools that would enable insurance service providers to model, analyse, and predict the evolution of the insurance market in order to better match supply and demand. In this context, having the right tools to understand consumer behaviour is highly desirable.

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During the last few decades, financial computing has established itself as a powerful means to automate the exploration, analysis, and prediction of financial products and mechanisms such as risk management, trading strategies and derivatives pricing by means of Monte Carlo simulations, time-series analysis and so on. More recently, Agent Based Modelling (ABM) has emerged as a new trend in financial computing. ABM has been reported as an efficient tool for various types of economic applications (Tesfatsion and Judd, 2006).

However, and to the best of our knowledge, no publications report on ABM specifically applied to the insurance sector, in particular when it comes to consumer behaviour.

Because the ability of ABM to model dynamic and heterogeneous systems has proven so powerful and efficient for a large number of applications, we believe that ABM can be a valuable tool for modelling and analysing consumer behaviour in the insurance sector. First of all, we have identified several publications (summarized in Section 2.2) which report on the successful application of ABM to the problem of consumer behaviour modelling and analysis for several types of markets and products. These have been made possible and efficient since ABM provides the mechanisms for modelling the self-determinism and the learning skills of the consumers and their social interactions. Therefore, *the first aspect of the aim of our work* is to evaluate whether or not the approaches proposed in those publications can be applied to the insurance sector. This is further motivated by the fact that we have identified certain features of the insurance sector, which make ABM potentially interesting for that sector, namely: i) the large number of possible economic agents (insurance service providers, customers, regulators) which take part in specific, distributed local interactions, and ii) the decentralised and dynamic nature of the economic processes related to that market. Therefore, *the second part of the aim of our work* has been to investigate how ABM can be used to model these features as well as the extent to which the resulting model can be used to reflect the purchasing decision and patterns of consumers for insurance products. To reach this aim, in this paper we propose a framework for investigating how and to what extent ABM can support the modelling of consumer behaviour in the insurance industry, in particular how their socio-demographic features and purchasing power influence their insurance product purchase decision.

The rest of this paper is organised as follows. Section 2 introduces ABM and summarises existing works which exploit it for modelling consumer behaviour. Section 3 introduces the problem of modelling consumer behaviour in the context of the insurance sector. Section 4 details the proposed framework and thus enables investigating consumer behaviour in the insurance sector by means of ABM. Finally, Section 5 discusses the results obtained with this framework, its current limitations, and presents ideas for future work.

2. State of the art

2.1. Agent-based modelling

In the scientific literature, ABM is characterised as a bottom-up approach for understanding systems and their behaviour and is thus a powerful tool for analysing complex, non-linear markets. ABM is opposed to traditional modelling which is usually based on a top-down approach. While in traditional modelling certain key-aggregated variables are observed in the real world and then reconstructed in a model where the correlation between aggregated variables is the focus of interest, in the agent-based approach the properties of individual agents and the processes upon which the system's behaviour is built, i.e. how the behaviour of individuals gives rise to the aggregated result, are in the centre of attention.

ABM is an essentially decentralised, individual-centric (as opposed to system level) approach. Generally speaking, when designing an agent-based model, the modeller follows a structured methodology composed of the following steps:

1. Construction of a population of artificial agents:
   1.1. agents' identification (the term "agent" in the context of business or economic modelling refers to real world objects – active entities and interacting elements which can be people, companies, projects, products, cities, etc.);
   1.2. specification of the inner structure of agents and of their decision rules, i.e. definition of their attributes (such as age, sex, income, goods or services preferences, shopping history, etc.) and behaviours (main drivers, reactions, memory, states, and actions based on decision-making algorithms such as a utility maximisation); both may vary across and within agents during the simulation of the model.
2. Parameterisation of agents' attributes and behaviours (e.g., using survey data and field research or making an initial best guess and later calibrating these values by comparing the output of the model with the real world system).
3. Construction of a relational parts system:
   3.1. agents' placement in a certain environment (the agents interact in some type of physical or social space);
   3.2. establishment of connections, if needed.
4. Execution of the simulation.

Artificial agents are created and designed to mimic the attributes and behaviour of their real-world counterparts. With ABM, the global (system-level) macro-observable properties and behaviour emerge as a consequence of attributes, behaviours and interactions among numerous individual behaviours.

2.2. Agent based modelling and consumer behaviour

Advances in computing have paved the way for an increasing number of agent-based applications spanning many domains, among others consumer behaviour. ABM approaches make it possible to get powerful insights into the dynamics of activities like customer behaviour in many socially-organised physical entities and/or environments where the primary focus is directed to specific product/service consumer markets or specific types of companies or institutions. Among the number of ABM applications that analyse consumer behaviour, some explorative models have been proposed in the literature.

Venables and Bilge (1998) propose a simulation model reflecting a real supermarket: here agents modelling customers are provided with real data shopping lists and their shopping path based on the shortest distance to a certain product (from the list). The model can identify the most popular paths, customer and product densities at each location; the length of the average shopping path can be manipulated, seeking to increase opportunities for impulse buying or make customer shopping done quickly. The model provides the dynamics of activities including customer behaviour in stores, patterns of customer demand, and can be used to redesign stores, i.e. to generate better customer throughput, reduce inventories, and shorten the time that products are on the shelves.

Brannon et al. (2001) present an agent-based simulation of a fashion-driven market where the interaction between two groups of influences is modelled:

- external (advertising, promotion, product placement in media) and personal (social communication);
- fashion leaders and followers.

The model is designed to investigate the effect of competitive activity and marketing expenditures on diffusion patterns, i.e. differences among various consumer segments aiming to determine the factors that cause diffusion to the population of agents.

Makoto (2000) discusses ABM for markets for which it is very difficult to predict sales, i.e. for which the consumer behaviour cannot be predicted by standard linear models because of factors such as the product short life cycles, skewed distribution of sales, a strong emotional element in product choice, the importance of peer pressure, etc. (the model is based on CD sales in the Japanese pop market). The model employs word of mouth (spreading ideas and information across a population and thus affecting the agents' purchasing decision) networks using data of demographics, preferences and social connectivity of product buyers (namely the consumers-agents are exposed to TV advertising and tie-in program, radio airplay and retail promotion, and then form perceptions towards a certain CD).

Zhang and Zhang (2007) present an agent-based simulation of consumer purchase decision-making and the decoy effect. The authors propose an algorithm to control agents' buying behaviours – a purchase decision motivation function that is based on consumers' psychological personality traits (price and quality sensitivity, susceptibility, loyalty, and follower tendency) and sociological interactions among heterogeneous consumer agents (impact of family, friends, opinion leaders, etc.) as well as between agents and brand managers (in the form of marketing activities) in a competitive market. The model reflects how the inner psychological process determines consumers' choices concerning competing brands. The multi-agent simulation performed by the authors demonstrates the emergent decoy effect phenomenon, revealing how the price/quality trade-off affects consumer choice, i.e. how consumers perceive and judge quality prior to purchasing a product.

Said, Bouron and Drogoul (2002) describe an agent-based interaction analysis of consumer behaviour. The model proposed by the authors is essentially focused on the interplay among individual behavioural and socio-economic profiles and the interaction rules, where the consumer purchase and adoption decisions in a market are determined by the behavioural profile described as a combination of elementary fundamental and operational attitudes related to a set of behaviour primitives such as imitation, conditioning, opportunism, innovativeness, and mistrust. In the model, these behavioural primitives are activated by different external stimuli such as promotions, rumours, innovations, and recommendations either positively or negatively affecting consumers' opinions (the weight of the effect depends on the behavioural profile of each consumer).

Advertising effectiveness is modelled in (Cao, 1999) using agent-based models and simulation. The author distinguishes the rational-emotional agent process model as differing from traditional modelling which is usually based on roughly rational agent behaviour. In order to model consumer behaviour more accurately, a psychological process with its five main activities (exposure, attention, comprehension, acceptance, and retention) is thus added to the agent interaction and negotiation decision function between the information-exchange and decision-making processes. The psychological process can reveal the most important psychological states of the consumer; they are: is noticed, awareness, adaptation, attitude, preference, and is considered. Concerning advertising effectiveness, five actors are proposed to be mapped into five kinds of agents (consumer, advertisement, product/service, medium, and environment); each agent is attributed significance factors and their values.

Finally, Challet and Krause (2006) discuss certain aspects of ABM validation and social imitation. The authors provide a simplified agent-based model designed to test and detect the presence of social imitation networks in consumer behaviour concerning purchasing decisions (based on a dataset of soap-buying). The authors propose a buying choice function where three factors of influence are taken into account: personal buying propensity, public information or global pressure (e.g., the effect of price, quality or advertisement of the product), and social pressure; the possible outcomes can be either no social interaction or the presence of a social influence network in which the collective opinion plays a central role. Moreover, the authors track the behaviour of individual customers using a logit regression model, which incorporates the factors that can affect customer choice of a product brand over time, namely promotion and the size of the discount offered; the model results in the evaluation of the impact of the promotions on the probability of brand-switching.

The review of the state of the art shows that ABM provides several mechanisms for modelling essential consumer features such as autonomy (e.g., the ability to take decisions), social communication (e.g., how people influence each other), and learning aptitudes (e.g., how experience is accumulated and digested). These mechanisms can be efficiently used for modeling consumer behaviour in different types of markets and for analysing different consuming properties and patterns as summarized in Table 1. However, to the best of our knowledge, there are no published works applying ABM to

TABLE 1. **Chronological summary of works applying ABM to consumer behaviour modelling and analysis**

Reference	Case study	Approach	Key findings
Venables and Bilge, 1998	Real supermarket	Exploitation of real data shopping list; simulation of the shortest distance to a product from the list.	Identification of the most popular shopping paths; prediction of customer and product densities at each location.
Cao, 1999	Study of advertising effectiveness	Focus on both rational and rational-emotional behaviour; involvement of psychological process and psychological behaviour states into agent interaction and negotiation function.	Proposal to take into consideration five agent-actors (consumer, advertisement, product/service, medium, and environment) with attributed factors and their values.
Makoto, 2000	Pop CD market	Employment of word-of-mouth networks by using data on buyer demographics, preferences and social connections.	Prediction of sales of products with short life cycles, skewed distribution, strong emotional factor and possible peer pressure.
Brannon et al., 2001	Fashion-driven market	Simulation of competitive activity, marketing expenditures and social communication.	Identification of the factors that cause diffusion patterns in the population.
Said Bouron and Drogoul, 2002	Generic study	Combination of individual behavioural and socio-economic profiles.	Demonstration of consumers' interaction based on their behavioural attitudes, behaviour primitives and external stimuli.
Challet and Krause, 2006	Soap purchasing	Building a buying choice function, involving factors of influence such as personal buying propensity, global and social pressure; usage of a logit regression model in which promotion and the size of the offered discount are involved.	Testing and detection of the presence of social imitation networks; evaluation of the impact of promotions on the probability of brand-switching.
Zhang and Zhang, 2007	Generic study	Construction of a motivation function (algorithm), employing psychological personality traits and sociological interactions.	Demonstration of the decoy effect, where perception and judgement of product quality are executed before its purchase.

consumer behaviour in the insurance sector. Therefore, in the next section we present our key ideas regarding specific aspects of consumer behaviour in the insurance sector, such as understanding of financial products, insurance culture, exposure to risk, and perception of need for security, and how they are related to more general socio-demographic aspects.

3. Consumer behaviour and the insurance sector

The work presented in this paper builds upon existing and well accepted consumer behaviour models: typically the hierarchical pyramid of needs, motivation factors, customer typologies and characteristics, activities and purchasing actions, extended to pre- and post- purchase processes and analysed underlying consumer behaviour features in the context of a very close marketing cohesion with other disciplines such as sociology and psychology. However, on top of the traditional factors and parameters used for modelling consumer behaviour in general, we model a number of specificities related to the insurance sector. We have considered several possible factors and subsequently, following a systematic reflection process, identified and selected the ones with the highest influencing likelihood. In particular, we have identified that the insurance product purchase decision is dependent on two factors: the perception of need for insurance that involves setting priority for objects to be insured, and the perception of affordability.

The perception of need for insurance is determined by a set of factors which are as follows:

1. Understanding and knowledge of financial products. It can vary from good down to sufficient and poor levels of awareness. Insurance product purchase decision is influenced by the type of education and/or profession or everyday work executed by a person. We suppose that people who have financial education and/or work themselves with financial products will be more prone to buy insurance products than those who have been searching for and individually analysed information about financial products; in this way both groups will have more awareness than those who have never been interested or have never clearly understood the essence of or the need for financial products.
2. Insurance culture. It demonstrates how much one's life is secured: highly or partly, based on a limited-choice or "forced" (obligatory), or not secured, i.e.:
   a) is insurance of both one's life and property a tradition continuing from one generation to another;
   b) is insurance of only one's property a tradition continuing from one generation to another;
   c) is insurance used to secure only the most important property owned;
   d) is only obligatory insurance, in case an object to be insured is owned, purchased;
   e) or there is no insurance at all.

3. Global network of interactions. It involves one's wide set of connections and communication paths with others: together with family and/or social networks, there is a network of advertisement and sales (includes sales agents and managers) and maybe other ones of complex large-scale nature. A worldwide network is a powerful channel to expand one's knowledge about insurance, to share experiences, to spread information, including rumours, recommendations, disqualifications, etc.
4. Perception of need for security. Here, an assessment of objects, which need security, is also included. In order to consider insurance as a possible security alternative, one should firstly get the perception of the need for security in general, which is under the influence of a great number of factors:
   4.1. one's experience, including both self experience and witnessing of others experience, derived from one's accidental events such as death, handicapping and physical injuries, serious diseases or/and loss or damage of one's property. Bad or good experience is a prerequisite to learn in order to avoid unexpected accidents;
   4.2. educational level. The higher educational level one reached (it goes from main or secondary school up to short after-school and high-school or university education), the higher need for security he/she perceives;
   4.3. local network. It involves one's tight interactions with relatively close people, i.e. family members (parents, children, siblings, grandparents) and/or a social net (classmates, group mates, colleagues, friends, friends of friends, acquaintances). This includes advices, warnings, etc.;
   4.4. ownership of property. A higher value of one's owned property calls for higher need for security. Moreover, the type of property (essential vs. superficial) calls for different levels of protection; an example would be the loss of one's job vs. the loss of one's gloves;
   4.5. mortality rate and disease spreading. A higher rate of deaths at work, home and in traffic accidents, fires, gunshots, predisposition to diseases such as cancer make one more incline to protect his/her life and his/her family and thus to purchase insurance products;
   4.6. exposure to risks, both professional (e.g., dangerous workplace) and private (e.g., one's house exposed to floods) raises risk awareness and in turn encourages the purchase of insurance products.
5. Family nest status. With age, one goes through the following main periods of his/her life: child status (decision is usually made by one's parents), student status (time to acquire education, get profession, occupation), parenthood status (time when children are raised and grown), grown children status (time when children are leaving parents' home), and retirement status. Each status brings one forward to take responsibility for his/her life and its quality. Children insurance, study insurance,

life insurance, unemployment insurance, pension insurance, and a number of other types of insurance can significantly contribute to a financially secured reality.

The perception of affordability for insurance is conditioned by one's purchasing power. Income level and the balance and distribution of earnings between expenditures and savings indicate the level of one's financial status and thus possibilities to use some of one's savings for insurance products. E.g., is all income spent and is there a need for borrowing money for surviving, does one's income just cover fundamental expenses (food, accommodation), is there any money left for some entertainment and "black days", or is there money enough for entertainment and more (savings)?

Regarding the insurance purchasing decision, we have also considered the potential importance of some other factors such as:

- geographical regions, namely the distance of one's living and working places from city centres, which could lead to higher knowledge of insurance products and to a better and easier access to mass events, higher exposure to advertisements as compared with peripheral areas, and possibly a stronger feeling of risks caused by more concentrated population in the cities;
- sex (male/female), where women, being more sensitive, could be considered as relatively more safety/security oriented human-beings than men.

However, we do not include these two factors in our framework since they can be treated as having subjective nature. We believe that the purchasing decision is not always necessarily affected by a closer access to mass events or advertisements – one can consciously, i.e. without any external impact, care of security and thus seek insurance. Similarly, we cannot strongly state that villages and towns are exposed to a smaller number of risks than cities – possibly the nature of risks differ in these areas. Taking the life of today's women as both active and dynamic singles/mothers and/or carrier/business women into account, it would not be reasonable to anticipate female as a more sensitive and safety-oriented gender.

A weighted combination of all the above-mentioned factors leads to the insurance product purchase decision which should be subsequently followed by the customer's purchasing actions. These include contacting insurance companies, discussing options with sales agents, and signing contracts.

Finally, some of the above-mentioned factors (general experience and perception of need for security) are influenced by one's experience with the purchased insurance product. In case an accident occurs during the time period covered by the insurance product, the customer's satisfaction level will be influenced by the quality of the services provided by the insurance company, which in turn influences his/her decision to renew or not the contract. In case the insurance product has not been used, the customer's decision will depend on whether he/she thinks that the product is useless or, on the contrary, makes him/her feel safe.

4. Framework proposal

4.1. Framework design

For analysing the insurance purchase decision process, we suggest a model which reflects the factors described in Section 3 as expressed in the following formula:

Insurance product purchase decision, % = (A×GExp + B×Edu + C×LNet + D××POwn + E×Mort + F×Risk + G×Know + H×Cult + I×GNet + J×Nest + K××PPow) × 100,

with **A, B, C, D, E, F, G, H, I, J, K** – weighting factors;
GExp – level of general experience;
Edu – educational level;
LNet – the size (number of people) of local network;
POwn – the value of owned property;
Mort – the rate of mortality, diseases and other accidents;
Risk – the level of exposure to risk;
Know – the level of understanding and knowledge of financial products;
Cult – the indicator of insurance culture;
GNet – exposure to global network impact;
Nest – family nest status, i.e. the number of people which are important in one's life;
PPow – purchasing power, i.e. the balance between one's income and expenditures.

In the formula provided below, the weight of perception of the need for insurance (α) is the sum of the weight of perception of need for security (γ) and of the weighting factors G, H, I, and J, where the perception of need for security (γ) is the sum of A, B, C, D, E, and F weighting factors, i.e.:

$\alpha = \gamma + G + H + I + J$, where

$\gamma = A + B + C + D + E + F$.

The sum of the weighting factors (δ), expressed in percentage, is calculated as the sum of the weight of perception of need for insurance (α) and the weight of perception of affordability (β):

$\delta = \alpha + \beta$.

Choosing the values of the weighting factors is not a trivial issue and is open for discussion. Ideally, they should be discussed by expert groups based on large sets of training data. As a starting point, we propose the following values for the weighting factors:

$\alpha = \beta = 1/2 = 0.5$;

A, B, C, D, E, F, G, H, I, J = 0.5/10 = 0.05;

$\gamma = \alpha - (G + H + I + J) = 0.5 - 0.2 = 0.3$

or equivalently

$\gamma = A + B + C + D + E + F = 0.3$.

We define the maximum possible value of the final insurance purchasing decision as 100 per cent (i.e. δ can take values from 0 to 1) and assume that there are two main contributing factor groups of one's decision – perception of need and perception of affordability; the importance of both to the final insurance purchase decision making is of the same weight, i.e. each group of factors impacts the final decision by 50 per cent.

Here are the values describing the tendency of the final insurance purchase decision:

If $\delta = 1$, the final decision is “purchase”.

If $0.5 < \delta < 1$, the final decision is “tends to be purchase”.

If $\delta \leq 0.5$, the final decision is “non-purchase”.

The closer the value to 1, the higher the probability that a person will purchase insurance.

We consider that 0.5 is the threshold value for the purchase or non-purchase decision, and we treat 0.5 as a “non-purchase” decision. The rationalisation for this is as follows: let's consider a person having a sufficiently high purchasing power but with no perception of need for insurance; he/she will not necessarily be willing to purchase it, and vice versa, a person with a high level of perception of insurance need will not purchase it, if he/she cannot afford it.

After defining that 50 per cent of the final purchasing decision is based on customers' perception of need for insurance, we further continue to justify the values of the factors in the first group.

In total, there are 10 factors involved in the above-mentioned group and 10 corresponding weighting factors, namely [A; J]. We assume that each factor affects the final purchasing decision equally, i.e. influencing it by 5 per cent (since $\alpha = 0.5$).

Knowing the weights of the individual factors, we can define the value of the perception of need for security (γ), which in our case impacts the final decision by 30 per cent.

It should be pointed out that the above model can only be used to find out the percentage of readiness to purchase insurance (one or several insurance products) of customers who have never insured themselves or their property before.

Thus, in order to reflect the 2nd or subsequent insurance purchases, we take the following additional factors into account: the quality of the insurance services provided to the customers (ranging from low to high quality) and the customers' opinion about the feeling of usefulness of the insurance products (varying from useless to giving the feeling of safety). We consider four different cases (see Fig. 1):

A. **High quality and good opinion.** Being well aware of threatening risks and of their consequences one might ever experience, and having experience with a satisfactory (minimum) level of quality of the provided insurance services, a consumer will tend to continue making insurance contracts with the same service provider.

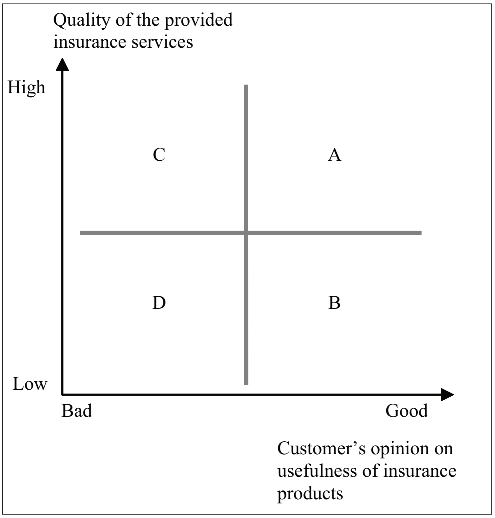

FIG. 1. **Four cases (A, B, C, D) for the 2nd and subsequent insurance purchasing, determined by the experienced quality of services and consumer's opinion about insurance usefulness**

B. **Low/no quality and good opinion.** If insurance makes a customer feel safe, but the service quality provided by an insurer has not been or is not satisfactory enough (e.g., an accident occurred and its administration from the insurer's side has not been sufficient enough or no coverage has been received), the consumer will most likely change his/her insurance provider and will nevertheless continue to purchase insurance products.
C. **High quality and bad opinion**. If a consumer receives good quality services but thinks that insurance is useless (e.g., no accident has occurred during the insurance time period and thus the consumer may start believing that it is only a waste of money), he/she could be provided with more information about insurance.
D. **Low/no quality and bad opinion.** The combination of these factors leads to a situation where a consumer has no intention at all to purchase insurance services.

The proposed overall framework for simulating the above-mentioned aspects is shown in Fig. 2. The next section describes its implementation.

4.2. Framework implementation

Many tools can be used for the implementation of and experimentation with agent-based models. For example, Allan (2009) presents a survey of agent-based modelling and simulation tools containing 43 software packages. Choosing the best suited toolkit is not trivial; one can, for example, use the online search engine described in (Nikolai and Madey, 2009) to narrow down the possible options. In this work, we use Netlogo (Wilensky, 2009) as it is sufficiently advanced for our purpose, yet simple enough to learn. In particular, its programming language is rich in terms of high-level constructs

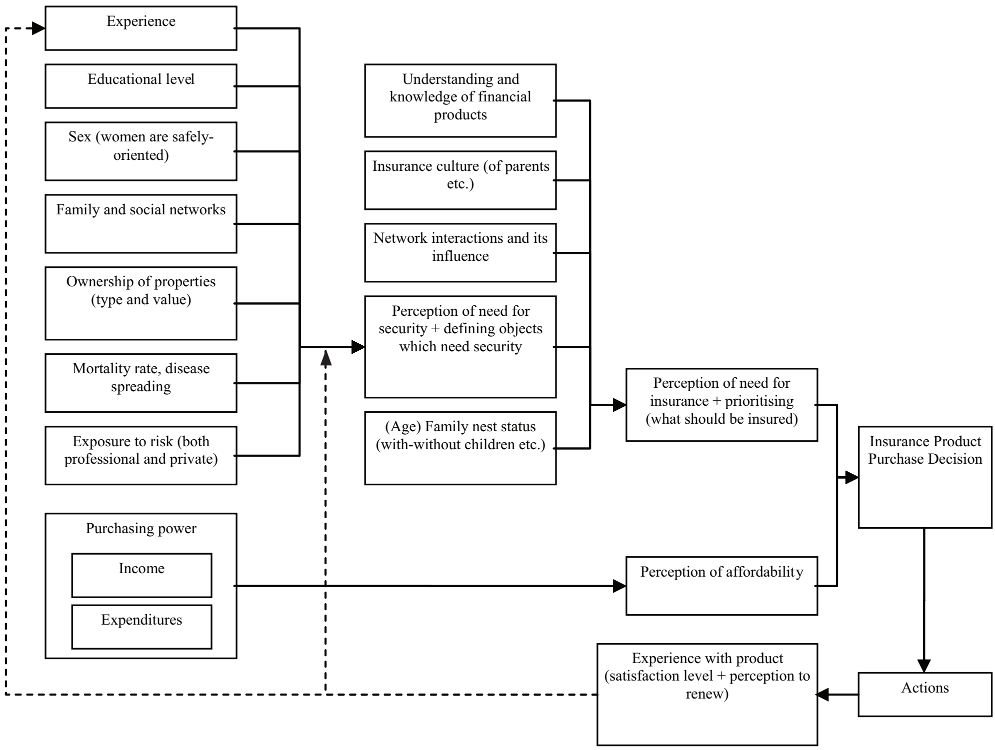

FIG. 2. **The proposed framework for agent-based modelling of consumer behaviour in the insurance sector. The model reflects the factors and parameters described in Section 3 and Section 4**

(e.g., for creating agents and describing their properties and behaviour, as well as for specifying the interaction rules between the agents) and many models are provided in the form of libraries which illustrate how to use these constructs. Moreover, Netlogo is supported on several platforms such as Windows, Mac OS and Linux, which makes that the current implementation of our framework can be easily executed on these platforms. Moreover, since the proposed framework has been designed in a modular and flexible way, it can easily be modified and extended with new features and implemented with other ABM toolkits.

The provided framework can be used to show and to calculate how and to which extent certain behavioural changes of all consumers, or different groups thereof, can affect the consumers' average insurance product purchasing decision. The persons composing the consumer population are modelled by means of agents implemented as "turtles" in NetLogo. Each person includes attributes that reflect the list of parameters discussed in Section 3.

A variety of inter-population groups, i.e. their different composition, can lead to changes in the average insurance product purchasing decision of the total population. The population can be grouped into several clusters of consumers, where each of them

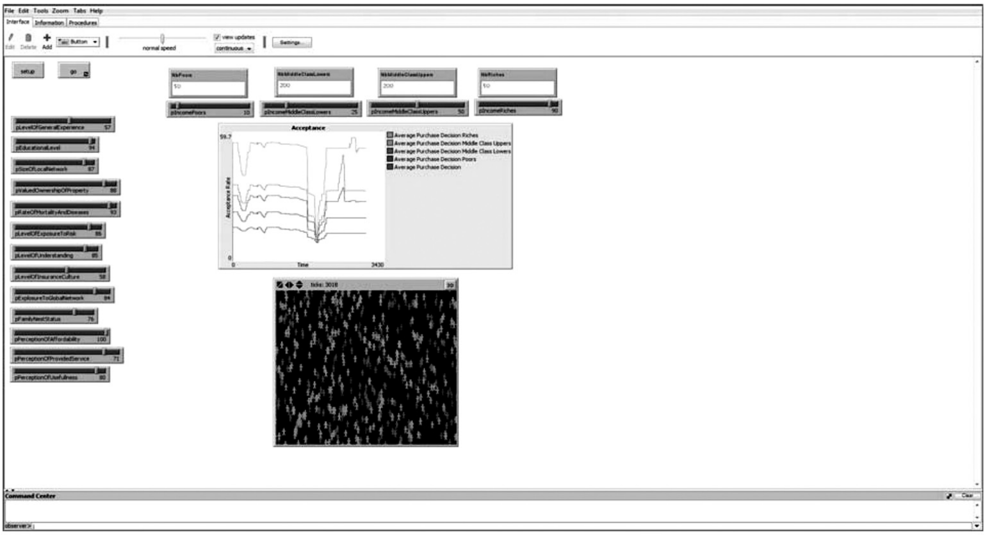

FIG. 3. **Screenshot of the framework implemented in NetLogo. The graph shows the variation of the average purchasing decision for different income groups when various attributes of potential buyers are modified**

has certain specific features: different experience, education, occupation, number and type of networks, purchasing power, etc. The different groups of people composing the population are modelled by means of "breeds" in NetLogo.

We believe that affordability is one of the major contributing factors of one's decision to purchase or not a certain insurance product, and thus in our model 50 per cent of the final purchasing decision is based on customers' purchasing power (see Sub-section 4.1). To reflect heterogeneity in terms of purchasing power, we divide the population into four different groups:

1. Low/no purchasing power (expenditures are larger than or equal to income; money is spent for the main/primary needs only: food, accommodation, and the most needed clothes).
2. Lower middle class purchasing power (expenditures are slightly smaller than income; the main needs are satisfied, but very few money is left for other purposes).
3. Upper middle class purchasing power (expenditures are to a certain degree smaller than income; the main needs are satisfied and, moreover, some money is appointed to entertainment).
4. High purchasing power (expenditures amount to a relatively small part of income; one can afford any kind of entertainment on top of satisfying his/her main needs).

In our model, the number of people belonging to the four above-mentioned groups and the average level of their income (per cent) can be freely chosen and varied in order to observe their respective and combined effects. Figure 3 shows a screenshot of the simulation with a population composed of the four different income level groups with the two above-mentioned parameters, where the population is segmented following the average of a Western country pattern, i.e. 10, 40, 40, and 10 per cent for each group, respectively, and where other factors are typical of each member of population and where a certain factor's level can be set up as an option.

Conclusions

In the provided framework, the acting agents are the population members who are either potential or current users of insurance products. The insurance consumer-agent is characterised by its socio-demographic features such as general experience, education, family nest status, purchasing power, and property owned. It interacts with other insurance consumer-agents via local family and social networks as well as representatives of global networks such as advertisement, sales, marketing, mass events, etc. All together, they act in an environment where they are under the impact (get informed) of rates of mortality, diseases and other accidents as well as specific insurance culture. In this way, the consumer-agents form their motivational "baggage" concerning insurance: they get and accumulate general experience, consciously or unconsciously improve the understanding and knowledge of financial products, and thus gradually develop the perception of need for security and consider the usefulness of insurance services. Each step leads to the construction of the final decision-making and subsequent actions.

The work presented in this paper paves the way for a tool which enables a deeper insight of consumer behaviour in the insurance sector. However, the proposed framework is subject to some limitations which we discuss together with our ideas for future work.

The first types of limitations are inherent to the evolutionary nature of the ABM approach. First of all, a certain degree of experimentation is required in order to fine-tune the individual parameters and to ensure that the model reflects the problem as accurately as possible. This implies that the resulting estimates are expressed as distributions instead of specific estimate points. Moreover, the results are also sensitive to the way the implementation is carried out (i.e. software development) since there are multiple ways to use the programming language to represent the agents and how they interact with each other. Another limitation of the ABM approach is that it is generally computationally demanding; however, the proposed implementation is relatively light, and the simulations carried out in this research have all required less than three minutes to complete on a laptop featuring a 2.26 GHz Intel Core 2 Duo processor and 4 GB of RAM. Nevertheless, an interesting topic for future work would be to investigate how the execution of the framework would scale when simulating very large populations (i.e. many agents) and whether or not the proposed framework could benefit from FPGA or GPU-based (e.g., Lysenko, D'Souza, 2008) parallel computing.

The second types of limitations are more specific to the model used in this work. A current limitation is that the results generated by the proposed framework have not been compared to other results generated by means of other approaches such as qualitative and quantitative marketing research, where some real surveys concerning insurance purchasing decision could be completed and processed using statistical methods of applied marketing analysis such as analysis of variance, correlation analysis, regression analysis, and factor analysis.

Another limitation is that until now the emphasis has been on individual insurance consumer-agent behavioural patterns, i.e. insurance product purchase decision is particularly analysed from the consumer's point of view. Thus, the possible future work includes designing a more complex system that would include agents modelling insurance companies and their interactions with the consumer-agents. Moreover, the analysis of insurance consumer behaviour could also include more detailed social imitation mechanisms such as the decoy/loc-in effect.

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