An updated conceptual framework for integrated modeling of human decision making: The Consumat II

Wander Jager & Marco Janssen

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Abstract

In this paper we propose an updated conceptual framework for developing agent rules to capture a number of main behavioural drivers and processes ensemble. We will sketch a perspective on the agents existence, social and personal needs, their satisfaction and ambition of agents, how they become uncertain and their tolerance for that, the behavioural options they can use, the abilities they need for using such options. This will culminate in four strategies in selecting a set of behavioural opportunities to compare: repetition, imitation, inquiring and optimizing. Combining these four strategies with variations in time discounting allows for modeling a continuum of simpler and more advanced decisional processes. We describe how these strategies impact the cognition of agents. We conclude with some testable expectations and a perspective on policy applications.

Keywords: agent based modeling, human behavior, decision making, needs

Introduction: the consumat approach from 2000, basic principles and problems

Since the introduction of the consumat in 2000 (Jager, 2000, Jager *et al,* 2000), the consumat approach is being used as a generic model of human behavior on the decisions people make in satisfying their basic needs in various settings. The consumat approach offers a simulation framework that captures some of the main behavioural principles as discussed in the literature on consumer behaviour. Whereas the model is not capable of simulating elaborate cognitive processes, logical reasoning or morality in agents, it does allow for simulating a number of key processes that ensemble capture human decision making in a variety of situations, such as consumers purchasing products, farmers deciding on a crop, citizens deciding where to live, and other situations where people select a behavior from a set of possibilities. Increasingly computer simulations are being used in policy context, and especially in such settings a framework that captures the main drivers and processes of behavior ensemble can be practical to include a reasonable representation of human behavior in such models.

The key concepts in the consumat approach of 2000 refer to needs, which can be satisfied by performing behavior. To perform behavior, an agent needs abilities. Decision-making on what behavior to perform can vary concerning the cognitive effort involved, and may be more individual or social oriented. Uncertainty and need satisfaction drive the type of decision making. A high satisfaction suggests you made good choices before and you are doing well, so there is no urge to engage in extensive decision making right now. Dissatisfaction however requires extensive scrutinizing for alternatives to increase one's satisfaction. Uncertainty is a psychological state influenced by insecurity concerning the results of behavior, and by deviating from the behavior of other people. With low uncertaintly and high satisfaction, agents engage in repetition, which is the mechanism behind habitual behavior. A high uncertainty combined with high satisfaction results in imitation. When satisfaction is low, the agents are more motivated to invest effort in improving their situation. Hence when they are certain but dissatisfied they will engage in deliberation, which is a form of optimizing or homo-economicus kind of behavior. Dissatisfaction combined with uncertainty results in social comparison, where the behavior of comparable others is evaluated and copied when expected satisfaction increases. Social decision-making is usually directed at more similar others, where similarity is related to abilities. Agents have a memory for behavioural opportunities and other agents behaviour and abilities, which is only updated if cognitive demanding strategies are being used.

The consumat approach is generic framework aimed at bringing together a number of processes that drive human behaviour. Obviously, using such an approach in modeling has its pitfalls. Most notably, the empirical validation and parameterization of a model using the consumat framework requires a lot of field work, and it is questionable if all parameters in the model can be empirically measured. Yet the alternative means the use of behavioural models that are validated very well, but are incomplete with respect to certain behavioural drivers for which we know they are very important. We adhere to the position that both approaches are valuable, and ultimately should grow towards each other. Integrated behavioural models such as the consumat indicate what types of models are required to address behavioural dynamics in many situations, and detailed empirically grounded models are required to build a solid argument for specific formalisations in behavioural models.

Whereas our aim is to develop a theoretical framework that is composed of submodels that have been empirically tested and validated, at this stage this definitely is not realistic. However, in recent years a number of developments took place that stimulated us to update the original consumat approach. In particular, the following problems were detected.

A first problem was that the four decisional strategies were too simple. In particular, the original consumat was not capable of making a distinction between agents concerning the different capabilities they have in estimating future outcomes. Yet it is obvious that people differ in this respect, which is important with respect to their evaluation of behaviours, and may have a critical role in the development of their expertise and role in the diffusion of new behaviours. This also implies that the decision strategies can be used differently by different agents. For example, in evaluating the behavior of others, one can simply look at the current outcomes, but also consider the long term outcomes of that behavior, e.g. the anticipated reward of imitating behavior (Bandura 1977).

A next problem is that the distinction between repetition on the one hand and deliberation on the other hand is creating too much of a gap. It is known that people use a variety of heuristics that vary concerning the cognitive effort they invest (e.g. Gigerenzer & Selten, 2002). Where repetition is based on simply repeating behaviour, and deliberation is focusing on optimizing behaviour (as in a homo economicus), an update of the consumat would have to include strategies that are satisficing.

The third problem is related to the use of the term "social comparison". Whereas in the consumat approach social comparison is being used for a social heuristic where the behaviour of comparable others is being evaluated, in the original Festinger approach is addresses more a motivation to be similar on opinions or slightly better on skills (Festinger, 1954). Because the Festinger approach relates to underlying social needs, we think it is more correct to use the term of "inquiring" as indicating a deliberate strategy to ask other people about their behaviour.

Concerning the implementation of the social strategies the consumat approach only focused at similarity as a key driver for interaction. Similarity, or homophily is an essential driver, as people want to belong to a group of similar others (social need), and behaviour performed by similar others usually is more likely to suit your needs as well instead of behaviour of rather different others. However, in the latter context the expertise of others is also important, and that is why the distinction between normative and informative influence can be used as a starting point (Cialdini & Goldstein, 2004), which has been applied in several ABM studies (Van Eck *et al*, 2011; Delre *et al*, 2010). Normative influence refers to the motive to associate with certain people (groups), and to avoid social expel. Increased similarity will translate in stronger attraction, and an increased dissimilarity in rejection of others behaviour. This process can be be formalized using the Social Judgment Theory (Sherif & Hovland, 1961), which has been used in an ABM context by e.g. Dykstra *et al*, (2010) and Jager & Amblard (2004). The informative influence is focused on exchanging experiences and opinions, where the quality of the information is important. Here the expertise of other agents plays a key role, where the more experienced another agent is, the stronger the informative influence and resulting change will be. If an agent has no (or limited) information stored about a certain behaviour or opinion, it is more likely to copy this information when interacting with an experienced agent (having much information stored). This strategy thus taps into the memory of the other agent.

A next issue that is relevant are the social networks between agents. In the last years social networks have gained a lot of attention in the study of social complex systems, most notably to publications on small-world and scale-free network properties (respectively Watts, 2004 and Barabasi & Bonabeau, 2003). Whereas the original consumat approach did not discuss social networks, they were implicitly present in the form of who is interacting with whom. However, the resulting network structures were not investigated, which is clearly a blind spot. In the current version of the consumat approach the position is taken that the network is not fixed,

but emerges from social interactions between the agents. This is important, and agents may change behaviour, and as a consequence of that also change their pattern of interaction, i.e. because they become more similar to other agents. The network as such is a dynamically changing structure, and it is important to observe how evolving network attributes such as clustering and path distance affect the behaviour in a system. For example, if a simulation repeatedly demonstrates that a negative development is anteded by an increased clustering and path distance, these network indicators serve as an important signaling variables that the system is about to change. This also expresses that a cultural change or transition is fueled by social interactions (e.g., Boyd & Richerson, 1985, Richerson & Boyd, 2005)

Finally, in the original consumat approach there were very strict thresholds determining the switching between different decision strategies. In the updated version it seems reasonable to make these switches smoother by using chances to engage in a certain strategy.

The problems that have been discussed above have been tackled in the conceptual description of the Consumat II, which is decribed in the following sections.

Conceptual description of the Consumat II

In this section we provide a very general description of the concepts used in the Consumat II. As the Consumat II is a generic model, it can be applied to different modeling issues where an integrated behavioural model is needed. However, in different domains different aspects may be more important, and as such the level of required detail in modeling may differ. In the following we will describe the generic conceptualizations, which serve as a guideline for formalizing the Consumat II in different settings.

Consumat needs

The most familiar needs theories are those formalized by Maslov (1954) and Max-Neef (1992). Max-Neef identified 9 different needs, respectively subsistence, protection, affection, understanding, participation, leisure, creation, identity and freedom. Using that many needs in a model is complicating the model too much. In reducing the number of needs we can look at the Goal Frame Theory (Lindenberg & Steg, 2007), which distinguishes between 3 leading behavioural motives: a hedonic, gain, and normative goal frame. In formalising the Consumat II we also use 3 main need forces: existence, social and personality. These needs are all relevant

concerning the need satisfying capacity of behavioural options. For example, in selecting a crop to grow, a particular crop will result in a harvest that can be used for food and/or be traded for other products or money, thus satisfying the need for existence. Next, a particular crop may be very common in a particular environment, and alternative crops may be socially be less desirable, e.g. hemp and nettle for the production of fiber. Finally, a farmer may have a personal preference for a crop, which addresses the personality need. The following conceptual descriptions can be given of these three needs:

Existence relates to having means of existence, food, income, housing and the like, and thus basically refers to economical dimensions of existence. In terms of Goal Frame Theory here the gain motive is dominating. For a farmer consumat deciding what crop to grow it depends very much if it can sell on a market or not. If no sales are possible, the consumat will grow crops that give the best nutritional yield. Else it is also possible to grow crops that are estimated to give good financial outcomes. The income is stored in a financial stock that can be invested later. Stocks can be stored and consumed over time, and hence serve as a buffer. Agents – in particular ones with a longer time perspective – will be more satisfied if they have stock levels that are also sufficient in bad times. Hence a farmer agent will be more satisfied with a stock that is sufficient to survive a bad harvest. Whereas some behavioural opportunities will generate financial stocks, most will cost money. For example, purchasing food, a house, a car, education and health care all require financial investment but do not generate income, except for a good education at later stages. Yet these opportunities will have a positive effect on the need for existence. Obviously it depends on the domain to be modelled how to formalize the stock of existence, and to what extent this stock is depleted or filled by engaging in certain behavior. An important choice here is if income is endogenous, and described as a more or less fixed influx, or if the agents have a choice in engaging in different income generating activities.

Social relates to having interaction with others, belonging to a group and having a social status. This need thus relates to the social dimension of existence, and in terms of Goal Frame Theory would be related to the normative goal frame. Important here is the definition of the peer group on which this social need is directed to. Whereas people can talk with many others, and obtain e.g. information from experts, the social need is coupled to the stong ties people have (e.g. Ryu

and Feick 2007). Here similarity (or homophily) is a key concept. Similarity can be linked to agent attributes (e.g., preferences as in the personal need, relative importance of needs describing a perspective on life), states (stock levels of existence need) and behavior (behavioural opportunities used). Also additional attributes can be used depending on the domain, e.g., gender, age, income, language, religion and residence. Hence similarity may have a fixed component and a dynamic component, the latter allowing for a restructuring of one's network. Instead of having a fixed network of peers, the similarity determines proportionally the chance of interacting with another agent.

Social is composed of two drives: being similar, and being superior (Festinger, 1954). On the one hand the consumat wants to be similar as it peers. Hence satisfaction is increased when it performs the same behavior as its peers. This is formalized as the proportion of peers performing the same behavior weighed by the similarity of these peers. Hence the more similar another agent is, and the more interaction takes place (strong tie), the more a similar behavior will result in the satisfaction of the social need. On the other hand the consumat wants to be superior to its peers. This implies that an agent is deriving satisfaction from e.g. earning more money, having a higher harvest or owning more products than its peers. This implies that agents are equipped with a weighting function in their social need, balancing the similarity and superiority drive. Competitive versus conforming agents can be modelled by introducing heterogeneity concerning this weighting function.

Personality relates to satisfying one's personal taste, engaging in activities one likes and being different from others. This need thus relates to the personal dimension of existence, which could be interpreted as addressing the hedonic dimension in the Goal Frame Theory. A behavioral option may more or less fit with the personal preferences of an agent, which can be addressed as taste. The more a behavioural option matches the taste of an agent, the more satisfied it will be. Hence the taste of an agent can be defined as an (multiple) ideal point, and the agent prefers to minimize the difference between its ideal points and the corresponding scores of the behavioural option. Using a multidimensional personality need allows for a fine grained modeling of preferences, as both the weight of a taste dimension and position on ideal point may vary. For example, in a car market one agent may find performance very important and value a high score on that. Another agent may also like a high performance, but does not evaluate that as very

important in comparison to fuel consumption. This approach of the personality need opens up the possibility of using conjoint analysis techniques in modeling the personality need.

Consumat satisfaction

Satisfaction implies the degree to which the three needs of the agents are satisfied by engaging in certain actions. These satisfactions are independent, and may have very distinct dynamics. For example, where the social need is susceptible to fashions, and may stimulate a person to follow the behavior of peers, the personality need will be more stable as it is based on relative fixed preferences.

The satisfaction of a need is based on the current utility derived from behavior, and the expectations of the future utilities derived. This implies that future outcomes can be relevant in the current satisfaction level. Also we have to realize that depending on the type of need and decision, the future outcomes can be more or less discounted. For example, for a farmer the satisfaction of the existence need is high if he expects good harvests and prices in the next years for the current behavior, especially when the stocks at this moment are high as well. On the contrary, for a consumer purchasing clothing it is not relevant to consider what his peers might do next year in estimating the social satisfaction.

A discount function describes the importance of outcomes over time in deriving a level of need satisfaction:

$$NyOxt = \Sigma\ t..t=n\ f(t) * (UyOxt)$$

In which:
- NyOxt = Need satisfaction of need y (one of the three) for using opportunity O at the current time step t
- t..t=n is the time frame considered
- f(t) describes the decay function if decreased weighting of utility over time
- UyOxt = Utility for need y of opportunity x at time t

Within the decay function f(t) a distinction will be made between the time discounting functions for the three needs and for different types of agents. It will depend on the type of behavior which

is being addressed how these time framing functions will be formalized. Empirical data on decision making of people will guideline this formalization. For example, it may show that farmers have a longer but differing time frame concerning the estimation the harvest/profits of a crop being grown (existence need), and a shorter time frame concerning the social need. Such data can be used in distinguishing between the time frames relevant for the different needs, and also indicate differences in the time orientation of the farmers, which is a reflection of their cognitive ability.

The consumat thus has three satisfactions: Ne for existence, Ns for social and Np for personal. When one of these satisfaction levels is decreasing, the agent will experience a motivation to improve the satisfaction level, which translates in different decisional strategies. This will depend on the ambition level of the agent. Whereas some agents will be satisfied with relative low levels of need satisfaction, other agents have a high ambition and strive for increased satisfaction. Hence the ratio (Aspiration level y/NyOxt) describes this motivation to increase satisfaction, which translates in the use of decisional strategies. Mind that agents may have different aspirational levels for the three needs, which indicates differences in a focus on existence, social and personal needs.

Consumat uncertainty

Uncertainty is coupled to the existence (Ne) and social need (Ns). For existence the uncertainty is expressed as the variability in the information obtained on the expected utility. In calculating future utilities (UyOxt), an agent may obtain different values from different sources. Whereas an average can be calculated, the more variance there is, the more uncertainty the agent experiences. Linking it to the time orientation of both the need as the agent, this variance may result in a higher uncertainty the closer in time it is, and the shorter the time perspective of the agent. This implies that a farmer with a long time perspective may be uncertain concerning the long term harvest, whereas a farmer with a short term perspective will experience less uncertainty on the existence need. The latter farmer may experience more uncertainty due to other farmers engaging in different behavior, as in a short time perspective the social uncertainty may become more important.

In formalizing this idea, for the existence need agents store information in their memory, and if different sources report different outcomes, variance increases. The more consistent

information a consumat already stores (an expression of expertise), the less uncertain it will get from dissonant information. For the social need uncertainty is coupled to the proportion of peers that perform the same behaviour. The more other agents that are considered to be peers engage in different behaviour, i.e. several similar farmer agents grow different crops, the more uncertainty will be experienced. The weighting of both uncertainties will be coupled to β_1 and β_3. Hence U (uncertainty) $= \beta_1 * (VAR\Sigma_{t+1..t = n} E) + \beta_3.* $ (share peers behaving different). Agents have an uncertainty tolerance UT, and the ratio U/UT determines the chance of using a more individual or social oriented decision strategy.

Behavioural options

To satisfy their needs, consumats engage in behaviour. As already mentioned above, the behaviours an agent can choose from are called behavioural options. Behavioural options may be numerous, and depend on the domain being modeled. In modeling farmer behaviour, behavioural options may address the decision to grow a variety of crops, the purchase of parcels of land, investments in tools and storage capacity. Behavioural options may address a time perspective, for example, in farming a crop rotation system may prevent soil depletion, and hence a particular schedule for rotating crops can be defined as a behavioural opportunity. Obviously a low time preference focus will emphasise the long term outcomes of such a rotation system. The decision to emigrate and to stop farming can be included. Also the choice of where to purchase a house addresses an array of behavioural options with different outcomes. The outcomes of behavioural options become manifest in the satisfaction of the needs. These can vary concerning their timescale and visibility. For example, draughts and floods can be very relevant concerning the outcomes of farming and locating a house close to a flooding-prone area, but it depends on the decision-making of the consumat to what extent such outcomes are included in the evaluation of the need satisfying capacity of behavioural opportunities. A consumat with a short time perspective is less likely to include the impact of a flood on its satisfaction of the existence needs than an agent that uses a long term time perspective.

As already discussed at the subsistence need, some behavioural opportunities will generate financial stocks, most will cost money. Hence in the description of behavioural opportunities it is necessary to describe how much money they cost or generate. Whereas for certain options this is quite clear, e.g. the costs of products, for other options this is less clear.

For example, in growing a crop, both weather conditions as developments on the market will affect the profit. This also opens the possibility to couple the consumat approach to e.g., market models.

Consumat abilities

The abilities of the consumat first relate to its capacity to actually use particular behavioural options. Hence they address the exchange between the demands of a behavioural opportunity to be implemented, en the related capacities the consumat has. For a farmer the climate zone and type of soil are typical abilities that relate to the feasibility of growing certain crops. For a house the income and working location are essential abilities that determine the feasibility of purchasing a particular house. In many domains budget is a key ability determining if an agent can afford an opportunity. If a certain behavioural opportunity requires more abilities than the agent has, the behavioural control is insufficient to perform the behavior. For example, an agent is not capable of purchasing a product when it has no budget available, and an agent cannot grow certain crops on certain soils.

Next abilities relate to the personal traits of the agent. First some agents have more capacity to elaborate about future outcomes than others. This is reflected in their time preference focus, where agents with a high time preference focus on short term outcomes and attach a low weight to long term outcomes. On the contrary, agents with a low time preference also focus on the long term outcomes. In the earlier described time discount function this agent ability can be formalised.

Another personality ability is the uncertainty tolerance (UT) of the agent. Some agents tolerate a higher level of uncertainty than other ones. This has an important effect on their decision making, as a low uncertainty tolerance implies that when an agent is confronted with variance in information (expected outcomes) is has a stronger tendency to engage in social processing (imitation, inquiring). Acquiring more consonant information may reduce uncertainty, however, when there is a lot of variance in the available information about opportunities, social processing may contribute to a further increase of uncertainty.

The final personality ability of the consumat is its ambition. Agents differ concerning how satisfied they are with a certain level of need satisfaction. If an agent is satisfied with a certain level, it is less likely to invest effort in finding better behavioural opportunities than when

an agent is dissatisfied with the current. Ambition thus has a relation with the decisional strategy an agent engages in.

Abilities play a key role in the determination of the similarity between consumats, and thus play a role in social interactions. Because some abilities are variable, such as income and budget, changes in abilities will have an impact on the chance of interacting with certain other agents (peers group). For example, an agent that suddenly becomes very successful financially may as a consequence increase the interaction with other rich agents, at the cost of interacting with older and poorer peers.

Consumat decision making

The consumat approach is based on the ideas that depending on their level of satisfaction and uncertainty, people engage in more or less extensive decision making, and focus more or less on the behaviour of other people to find suitable behavioural opportunities. The different decision strategies translate in the sets of opportunities that are taken into consideration. The key rules are (1) the lower satisfaction is, the more involved one is to process information on behavioural opportunities, and (2) the larger uncertainty is, the more the behaviour of other people is used to identify attractive behavioural opportunities. This also fits with the ideas of Laland (2004) on copying behavior in uncertainty and copying the behavior of the majority. The decision making of the consumat is captured by rules that describe for which sample of behaviours the expected utility is calculated. Key drivers of these rules are the ratio between ambition level/needs satisfaction, and the ratio between uncertainty/uncertainty tolerance.

The following four rules describe how different subsets of behavioural opportunities are used in the decision-making process. In evaluating different behavioural options within a subset, the agents use in principle the same time-discount function as for the determination of the current need satisfaction. Mind that agents differ concerning the time-horizon they use in evaluating opportunities, and hence the deepness of processing may differ considerably between agents, thus creating a continuum of decision strategies.

Repetition: consider only the behaviour that one is performing now. Mind that if an agent that has a long time perspective gets new information on long term negative outcomes, this will

decrease its satisfaction and thus may stimulate the agent to search for alternatives. Repetition of satisfactory behaviour is the main mechanisms behind habitual behaviour.

Imitation: consider all behavioral options performed by peers (strong links). Considering that the social need is driving behaviour as well, this strategy implies that successful behaviour that is performed by a majority of others is most likely to be copied. However, also the behaviour of a successful peer that deviates from the group can be imitated, which complies to the principles of imitative processes (Bandura, 1977).

Inquiring: consider all behaviour performed by all other agents. This opens the possibility to find out about interesting behavioural opportunities that are being used by more distant people (weak links).

Optimising: consider all possible behavioural options available. Here also opportunities are considered that are not yet used by other agents. Advertisements and other information may be provided on e.g. a new crop which can be considered when engaging in optimizing.

The lower the ratio of (Ambition level y/NyOxt) gets for any of the three needs, the larger the chance of an agent to engage in Inquiring or Optimising. These three chances can be considered to be additive. Similarly, the larger the ratio of Uncertainty/Uncertainty Tolerance, the larger the chance of the agent engaging in imitation and inquiring. Hence, given equal levels of satisfaction and uncertainty, an agent having a high uncertainty tolerance and a high ambition level has a higher chance engaging in optimization than an agent having a low ambition and low uncertainty tolerance. The proportional chance of engaging in the strategies implies that even an agent that is very satisfied and certain, and hence is likely to engage in repetition, occasionally uses another heuristic and thus is confronted with alternative behavioural opportunities.

Consumat cognition
The consumat has a memory in which it stores information on the behavioural opportunities, and on the behaviour, attributes and success of other agents.

Concerning the information on behavioural opportunities three types of information are available: own experience, experience of others and generic information (advertisement, media). Beliefs concerning an opportunity are the most firm when based on own experience, and the least firm when not based on experience at all. This implies for example that an advertisement that suggest different behavioural outcomes than the agent experienced itself will hardly result in a change of beliefs or an increase in uncertainty. Having no personal experience with an opportunity, and being confronted with conflicting experiences from other agents will result in uncertainty and a less firm opinion. If a new opportunity is introduced (news, advertisement), and nobody has experience with it, a weak opinion if formed, which is very susceptible for change when confronted later with experiences of other agents with this opportunity.

Concerning the behaviour of other agents the consumat stores what behavioural options the other agents use. This can for example be formalized as the similarity in distribution of different crops grown by a farming agent. Because the chance of interacting with another agent is partly determined by behavioural similarity, this implies that a change in behaviour also may have an impact on the social environment of the agent.

Concerning attributes the consumat stores the traits and preferences of the agents it interacts with. It stores the time-perspective of the other agent (a proxy of educational level), its ambition level, its relative importance of the three needs (a proxy of perspective on life) and the personal preferences (a proxy of taste). Because ambitious agents with a low time preference focus are more likely to be experts with a long term perspective, these traits can function as cues in estimating the expertise of another person. These traits together are essential in determining attributional similarity between agents, and capture the empirical findings that people generally compare themselves and interact with others having a same educational level, perspective on life and taste. Depending on the domain to be modeled, also attributes of other agents such as gender, age, income, language, religion and residence can be stored in memory. Hence the cognitive system of the agent is a memory which is being used to evaluate the similarity of other agents, their expertise, and the information it has on the expected outcomes of various behavioural opportunities. This cognition is updated depending on with what other agent an interaction takes place, and what kind of information is obtained.

Also the uncertainty as defined earlier is a cognitive construct. We propose that a forgetting function uses an asymptotical function (e.g. (Nembhard, 2000). This causes that old

information on a behavioural opportunity is slowly forgotten. If new information is obtained, the forget function helps to reduce the impact of old information, and also reduces uncertainty resulting from conflicting information.

Testing the Consumat II

Because the aforementioned conceptual model has not been formalized yet, we propose that first an abstract formalization will be done in testing the complete set of rules. In doing so, we want to test the framework by performing stylized experiments to explore if this relative simple combination of rules is capable of describing some empirical observations and theoretical notions as emergent phenomena. Examples of such phenomena are:

1: More ambition/involvement does not automatically result in better decisions, as a less smart agent (capacity to only look at short term outcomes) may invest a lot in acquiring information about alternative options, but only evaluate them on the short run.

2: Simple imitation and the force of the social need may help the less capable agents to adopt effective behaviour. Because using simple imitation they may free-ride on the cognitive capacity of other agents, this may be a more effective strategy than optimizing for these agents

3: Agents that are easier to satisfy will engage more in repetition, and their personal experiences will cause their opinions to be more firm. Hence satisfaction is related to conservatism and a low expertise.

4: It are not the most happy agents (combined need satisfaction) that are the most imitated, but the agents that are most successful concerning their existence need. This is because economic success is equal to all, whereas the social and personal need can be directed at different people and dimensions.

5: Agents that have a higher ambition will engage more in information processing, and acquire more information and thus more likely to become experts. Their opinion is more likely to have an effect on other people. This is an effective strategy in distributing experiences in a social system.

6: Agent that are smarter – i.e. have a longer time perspective – are more likely to be satisfied, and hence their behaviour is more likely to be copied. This is an effective strategy in distributing experiences in a social system

7: Some similarities between interacting agents are emergent properties. For example, if more ambitious agents are becoming more financially successful, a larger chance of interacting due to a similar financial budget brings together high ambitious agents. Due to their high ambition, they will have processed more information and are more likely to become experts. Hence we also expect clustering of agents in networks on dimensions that are not considered in the similarity expertise to cluster in networks.

Application of the Consumat II: towards gaming applications

Especially when simulations address a complex behaving system, many simulation runs provide a vast array of different outcomes that make it difficult to develop policy. Instead of basing policy on predictions, in turbulent behaving systems it appears to be more effective that policy makers are being trained in recognizing and managing these turbulences. Serious gaming has been identified by many scientists within the ABM community as a tool to explore and forecast developments in complex systems (e.g. Deguchi, Matsui, Arai, 2006; Guyot & Honiden, 2006). This increasing interest is currently visible in the emergence of networks on computer simulations supporting policy making, as for example in e eGovPolinet (http://www.policy-community.eu/). The essential difference between gaming and experimental designs is that in games the player has to respond to developments as they emerge, whereas in classical experiments the responses are usually defined as independent variables beforehand and have been organized in an experimental design. Leaving the implementation of strategies to real people interacting with the model thus has the advantage of creating a plausible managerial environment, as real people manage the system.

For the consumat II this would ultimately also be possible. Providing a conceptual framework the consumat approach is helpful in guiding empirical research in parameterizing a specific behavioural model. Next if the consumat is implemented in a simulation, it shows hod different relevant parameters might change over time, such as the existence, social en personal satisfaction levels, thus providing indicators of quality of life. Also indicators such as the Gini coefficient can be used as indicates of inequality in a simulated society. This shows how certain policies mau affect the quality of life and equality of distribution in a simulated society. Finally, the consumat approach allows for implementing policy measures, not only by changing the behavioural opportunities, but also by informational startegies directed at the population. Hence

it in principle offers a tool to implement policy aimed at behavioural change. Therefore we think that an approach such as the consumat II might be a valuable tool in the toolbox of integrative projects aimed at developing and testing policies involving human behavior in an environmental economical context.

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