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Surfing on the Net as a Source of Market Segmentation: a Self-Organization Approach

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■ Introduction

This paper studies the self-organizing properties of a system of agents ⁽¹⁾ interacting on the Internet. Those agents are consumers that purchase different types of commodities and are willing to gather some advice before choosing which brand to purchase for each commodity. More specifically, each agent has a utility function that reflects his preferences, but this function does determine choices only for a part. The other part is constituted with some collective or public information that the consumer gathers either by surfing on the Net or by using the popularity ranking that a conventional retailer establishes at some given interval of time for each commodity. Given that consumers do rely partially on some external information, what we want to test in this model is whether consumers do tend to self-organize in the forums that they explore while surfing on the Net or whether they tend to eventually give up surfing for relying only on the single and aggregate indicator that the conventional retailer gives for each commodity. Self-organization is said to exist when each consumer is able to find and adopt a forum that gives advice with which he is satisfied. On the

COMMUNICATIONS & STRATEGIES, no. 40, 4th quarter 2000, p. 125.

(1) For an introduction to self-organization in economics, see LESOURNE (1992).

contrary, self-organization is said not to occur when consumers do not eventually succeed, after a certain period of time, in finding the place where to gather the best and most suited information that is useful for them. In this case, either they keep moving from forum to forum or they remain apart of the Internet system, relying on the advice of the conventional retailer.

Understanding under which conditions consumers do self-organize on the Net is equivalent to understanding under which conditions forums do select consumers according to their consumption pattern. This ability to evaluate whether self-organization occurs is in particular very valuable for firms that search for more efficient commercial practices. Internet might help them to segment their markets more efficiently and more appropriately and, in this perspective, might make profitable the business of an "infomediary" that would propose bundles of products to sets of consumers that have the same overall characteristics in terms of consumption, rather than only the same social or sociological profile (on this topic see also WELLMAN & GULLIA, 1997). The value added of an infomediary for producers that want to reach their potential consumers immediately appears here. But, for this value added to become concrete, the infomediary has to understand the conditions under which self-organization occurs.

The latter issue has not received considerable attention in the literature up to now. Internet has motivated numerous authors - see KLOPFENSTEIN (1998) for a survey -, but their studies are most of the time focused on access pricing and congestion effects (HURLEY et al., 1999), price structure as compared to traditional markets (SMITH et al., 1999), or on the relationships between commercial sites and non commercial ones (GENSOLLEN, 2000; BAAKE & WICHMAN, 1999). The few models that have dealt with the issue of consumer choices and the influence of their gathering of advice on the Internet have rather focused on the problem of valuating the advice (MOUKAS et al., 1999; URBAN et al., 1999) or on the issue of Net surfing and the visiting of sites over time (OGUS et al, 1999). Those models generally show that the proliferation of information tends to generate a selection process from the internavts that reduce their visits to new sites over time or the number of sources of information they trust.

■ The Model

Consumption space and preferences

We consider N consumers $n = 1, 2, \dots, N$ and K goods $k = 1, 2, \dots, K$. Each good is available under L horizontally differentiated varieties (for instance, several brands of a given good). Time is represented as a discrete sequence $t = 1, 2, \dots, T$. In each period t , consumers randomly draw one of the K goods and choose to buy one of its L varieties.

The N individuals are divided into F families $f = 1, 2, \dots, F$, each of them being composed of N/F individuals. All the individuals belonging to the same family have homogenous preferences. However, these preferences differ from one family to another. For each good k , a given family f likes a single variety (utility equals + 1) and dislikes the others (utility equals -1). The preference structure of a family f is thus defined by a matrix $\{U_{kl}\}$ with dimension $K \times L$, the elements of which are + 1 or - 1.

Individuals don't know *ex ante* the values of their utilities. Only consumption reveals them. However, this revelation is imperfect since the quality of a purchased good is subject to randomness. With a probability π , close to one, *ex post* utility matches the deterministic value defined by the preferences structure. However, with a low probability $1 - \pi$, the inverse result is observed. Either the consumer benefits of a "good" specimen of a variety that was supposed not to satisfy him, or he suffers of the purchase of a "bad" specimen of a variety that he was supposed to appreciate.

When individual n chooses in period t among the several varieties of a good k , he uses as a relevant information the last variety he consumed of that good and the utility he derived. On the other hand, due to a continuous evolution of products characteristics, older purchases are not taken into account.

Consumption dynamics

Before the date $t = 0$, each individual is supposed to have "prehistorically" purchased a specific variety of each of the K goods. In the simulation runs, this preliminary variety is independently and randomly drawn for each individual n and each good k .

At $t = 0$, each individual n randomly draws a unique good k among the K goods. He then rationally selects (see below) the specific variety of the good k he will consume during period $[0, 1[$.

At the next date $t = 1$, each individual n draws again a type of good, different from that drawn at date $t = 0$, and decides the specific variety of this good he will consume during period $[1, 2[$. This process is repeated until date $t = K - 1$. At this date, individuals select the last good they have not purchased yet, and choose a specific variety which they consume during period $[K - 1, K[$. During this process, each individual has successively purchased a specific variety of each of the K goods $k = 1, 2, \dots, K$, at some date between $t = 0$ and $t = K - 1$.

Thus, the whole history $H = \{0, 1, \dots, T - 1\}$ of the purchasing dates is split up into $P = T/K$ successive phases H_p ($p = 1, 2, \dots, P$): during each phase $H_p = \{(p - 1)K, (p - 1)K + 1, \dots, pK - 1\}$, each individual n purchases a specific variety of each of the K goods.

Information structures

At the end of each phase H_p , a universal conventional retailer assesses the amount of sales (during H_p) of each of the $K \times L$ varieties and offers, for each good, a popularity ranking of the different varieties. Consequently, when making his decision during phase H_p , any individual n knows the amount of sales of each variety l for each good k during the previous phase H_{p-1} .

At any date $t \in H_p$, facing the choice of a particular variety of a good k , an individual n has two information. On the one hand, the memory of the utility provided by the consumption of a specific variety of good k during the previous phase H_{p-1} . On the other hand, a record of the sales of each variety of good k during H_{p-1} established by the conventional retailer. But by visiting forums on the Internet, the individual n has at his disposal a third source of information. Each forum provides, for any good k and at any date t , the average utility obtained by its members from the latest consumption of each variety l .

To sum up, the tripartite information structure is made up of a private information source (personal experience), a public information source (the conventional retailer) and a collective information source (forums).

The difference between forums and the conventional retailer lies in a quicker data updating process:

- during a phase H_p , the conventional retailer takes only into account information relative to the previous phase H_{p-1} . This information is "frozen" during H_p ;
- on the other hand, forums carry out a continuous "information refreshment" process by including immediately any information on the satisfaction obtained by an individual n with the variety l of a good k .

Consumption decisions

At $t = 0$, M forums $\Phi_0^m (m = 1, 2, \dots, M)$ do exist on the Internet and the N individuals are randomly and uniformly distributed among these forums. Thus, each forum is initially made up of N/M individuals. Of course the structure of forums will evolve according to an endogenous dynamics that will be later exposed.

At any date t , we label Φ_t^m the structure of the forum m . The forum Φ_t^m is deduced from Φ_{t-1}^m by withdrawing the individuals who decide to leave Φ_{t-1}^m at date t and by adding those who choose to join Φ_{t-1}^m at the same date. During history H , one or several among the initial forums Φ_0^m may disappear. We then observe $\Phi_t^m = \emptyset$ at any date t later than the extinction date. Moreover, at any date $t > 0$, some individuals may belong to none of the forums: they have left a forum and haven't joined another one (see below).

At any date t , each individual n draws (as described above) one of the K goods and chooses one of its L available varieties. However, the decision process differs according to the fact that n belongs or not to a forum at date t .

(i) if individual n does belong to a forum Φ_t^m , this forum indicates for each variety l of the drawn good k , the average utility obtained by members of Φ_t^m (except n) who have consumed variety l the last time they drew good k . Individual n uses this forum advice to build up an *ex ante* utility index of each of the varieties of good k . This index is equal to the advice of the forum for every variety of k , except for the latest variety purchased by n . In this case, the index is a linear combination of the forum advice and the utility derived from the personal experience of consumption. Parameter α ($0 \leq \alpha \leq 1$) denotes the weight attached to personal experience in this weighting. Conversely $1 - \alpha$ assesses the level of trust in the Internet.

Eventually, individual n selects in period t the variety of good k that maximizes his utility and, if several varieties do so, he randomly draws one of them.

(ii) if individual n does not belong to any forum, two cases have to be distinguished:

- either n has been satisfied by the specific variety of good k he consumed previously (utility equal to $+1$), then n repeats at date t the same purchase than previously (by construction the information provided by the conventional retailer is not in this case more relevant than his own experience);
- or n has been disappointed by his previous purchase of a variety of the good k (utility equal to -1), then n refers to the ranking of the conventional retailer (to the amount of sales of each variety l of good k during phase H_{p-1} preceding the current phase H_p); if the variety that exhibits the biggest sales is precisely the one n has previously experimented, he will choose the variety ranked in second position.

Forums dynamics

At date $t = 0$, individuals are "introduced" in the forums with the same level of loyalty $\underline{\varphi}$ ($\underline{\varphi}$ is an integer with $\underline{\varphi} \geq 0$). This level of loyalty will be later revised according to the consumption experiences of individuals. Hence, an individual n belonging to a forum Φ_t^m and who has drawn good k at date t , revises at date $t + 1$ his level of loyalty to Φ_t^m from φ_t^n to φ_{t+1}^n . For that purpose, n compares the sign ($+1$ or -1) of the utility of the variety he purchased at t with the sign of the forum advice at date t for the purchased variety:

- if signs are identical (relevant advice), the level of loyalty φ_t^n of individual n to forum Φ_t^m is increased ($+1$) at date $t + 1$. However, loyalty can not exceed a threshold value $\bar{\varphi}$ ($\bar{\varphi} \geq \underline{\varphi}$; $\bar{\varphi} \geq 1$) set exogenously;
- if signs are different (irrelevant advice), φ_t^n is decreased (-1) at date $t + 1$; as soon as his level of loyalty falls down to 0, an individual leaves his forum, either to join another one if he finds immediately a "better" forum (see below), or to stay out of any forum;
- eventually, if a forum has given in period t a neutral advice (equal to 0), the level of loyalty φ_t^n remains unchanged.

The role of parameters $\underline{\varphi}$ and $\overline{\varphi}$ is the following: $\underline{\varphi}$ represents the level of tolerance of an individual to consumption errors induced by a forum (a number $\underline{\varphi}$ of consecutive bad advice given to a new member of a forum leads this individual to leave it); $\overline{\varphi}$ is the maximal confidence an individual place in a forum. Then $\overline{\varphi} - \underline{\varphi}$ represents the maximum raise in tolerance with respect to bad advice that the endogenous dynamics can associate to any individual.

When individual n 's loyalty is already minimal and he experiences one more bad advice, n leaves forum Φ_t^m at date $t + 1$ and assesses his "distance" $\Delta_{t+1}^n(\Phi_t^m)$ to this forum. This distance is equal, for all goods $k = 1, 2, \dots, K$, to the sum of the gaps between the utility provided to n by his last consumption of good k and the average utility derived by other members of the forum by consuming the same variety.

Then, the "leaving" individual n randomly draws at date $t + 1$ a forum $\Phi_t^{m'} \neq \Phi_t^m$ and assesses his "distance" $\Delta_{t+1}^n(\Phi_t^{m'})$ to this new forum:

- if $\Delta_{t+1}^n(\Phi_t^{m'}) < \Delta_{t+1}^n(\Phi_t^m)$, n joins at $t + 1$ forum $\Phi_t^{m'}$ with an initial level of loyalty $\underline{\varphi}$. He then draws a good k and purchases a particular variety by weighting his own past experience with the advice of forum $\Phi_{t+1}^{m'}$ (see above);
- if $\Delta_{t+1}^n(\Phi_t^{m'}) \geq \Delta_{t+1}^n(\Phi_t^m)$, n remains out of the Internet. He draws a good k and purchases a variety of this good by referring either to the sales ranking of the previous phase H_{p-1} , or to his own last experience of consumption of good k if it was a positive one (see above); in next periods, n will draw again a new forum and will stay out of the Internet until he finds a forum closer to him than the last one he has left.

■ Simulation Runs and Results

Structure of the simulation runs

The model described in the previous section includes several exogenous parameters:

- the number N of individuals,
- the number K of goods (K is also equal to the length of the temporal sequence required to successively draw all the goods),

- the number L of varieties available for each good,
- the temporal horizon T ,
- the number F of families of individuals,
- matrixes $\{u_{kl}^f\}$ representing the preferences of the different families,
- the probability π for the utility derived from consumption not to be modified by hazard,
- the initial number M of forums,
- the trust α in personal experiences and the trust $1 - \alpha$ in forums advice,
- the initial level of loyalty $\underline{\varphi}$ to the Internet,
- the maximal level of loyalty $\bar{\varphi}$.

For given values of these parameters, the evolutionary dynamics depends on several sources of randomness:

- the initial distribution of individuals among forums,
- the draw, at each date and for each individual, of the good that will be purchased at this date,
- the hazard affecting the utility for a given variety,
- the possible draw among varieties that all maximize the utility index or that all have the same popularity ranking,
- the draw, at each date and for any individual who don't belong to any forum, of a possible new forum.

Simulations have been run for different values of the exogenous parameters, and, in a given configuration of parameters, for several random histories. Results presented in the next section have been obtained with the following values of parameters:

$$N = 4000, K = 10, L = 10, T = 4000, P = 400, F = 10, \pi = 0,99, M = 10.$$

Eventually, in our simulation runs the trust in personal experience is variable ($\alpha \in \{0,1; 0,2; \dots ; 0,9\}$), as well as initial and maximal levels of loyalty to forums ($\underline{\varphi} \in \{1, 2, \dots, 10\}$) and $0 \leq \underline{\varphi} \leq \bar{\varphi}$.

Attention is focused on two kinds of phenomena:

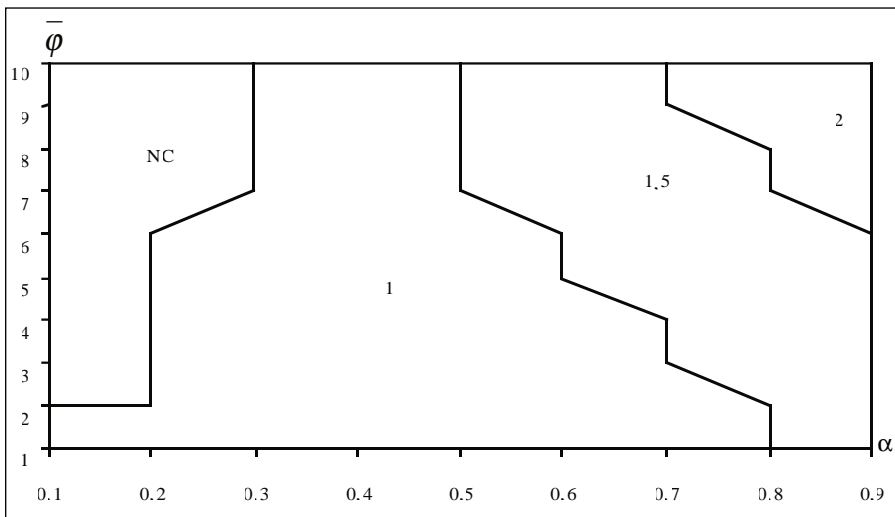
- *the degree of convergence*: this convergence is considered as well from the point of view of the stabilization of the number of individuals in forums as from the point of view of the lack (or the low number) of individuals remaining out of the Internet;

- *the degree of self-organization*: it is assessed by the number of varieties of each good purchased in each forum. The lower this number, the better the self-organization of consumers in forums that reflect their preferences homogeneity. Given the hypothesis of the model, a perfect self-organization refers to a situation in which only one variety of each good is purchased. An imperfect self-organization refers to a situation in which (on average) more than one variety of each good is purchased by the members of a forum. A chaotic structure refers to a situation in which almost all the varieties of each good are purchased in every forum.

Results analysis

In this subsection we study the influence of: parameter α (how much does the agent trusts his own experience); parameters $\bar{\varphi}$ and $\leq \bar{\varphi}$ (the initial and maximal loyalty); and the characteristics of consumer preferences.

Figure 1.a ($\bar{\varphi} = 0$)



The figure in each area indicates the average number of varieties of each good purchased in each forum
 NC = the system didn't converge

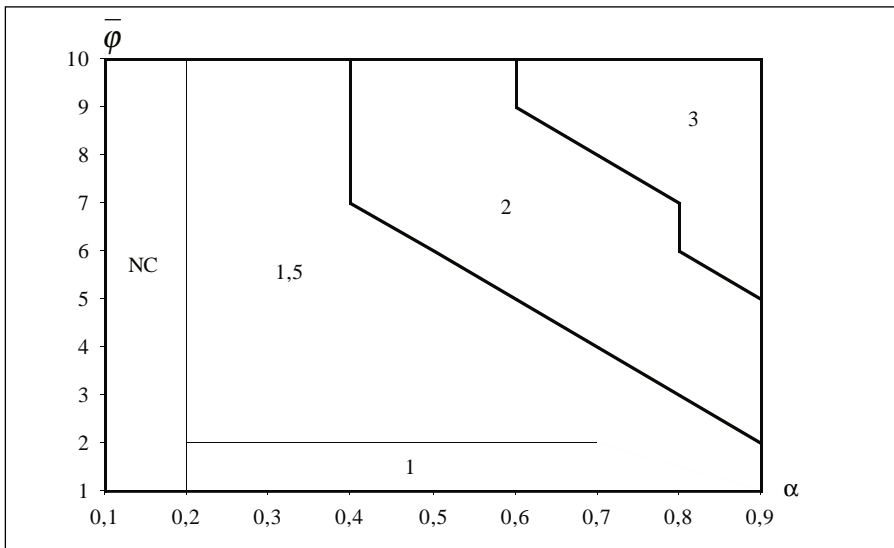
The combined influence of α and $\bar{\varphi}$ is shown in figure 1.a, with $\underline{\varphi}$ fixed to zero. In this case, the following results obtain:

- when α is high (therefore consumers rely mostly on their own experience and give little weight to external advice), the degree of self-organization is low. In other words, self-organization is imperfect. Moreover, the higher the value of $\bar{\varphi}$, the more imperfect the self-organization. This is due to the high inertia of consumers within forums that do not fit their expectations. While self-organization is rather weak, the system converges in the sense that the number of consumers outside the Net stabilizes and moves across forums do not longer occur;
- for intermediary values of α , self-organization is perfect or quasi-perfect, independently of the value of $\bar{\varphi}$. In this case, all the individuals that belong to a same family gather into the same forum and consume the same variety for each commodity;
- when α is low, self-organization doesn't occur and moves across forums and with the external world keep proceeding over time. Thus, consumers do not succeed finding acceptable forums because their respective weighting of personal and collective experiences is conducive to chaotic choices.

Then, there is a critical value of α , which draws a frontier between self-organization and disorganization. Self-organization occurs when the consumers attribute close weights to both their personal experience and the advice that they gather from the others. If they either rely too much on the others or conversely rely too much on their own judgement, disorganization becomes the rule. The explanation is straightforward: if there is no reliance on advice, the forums are not able to select the consumers over varieties because they make quasi random choices from which it is not possible to find a rational criteria according to which organizing; and if there is too much reliance on advice, the feedback between those advice and personal preferences is so weak that once again no rational criteria emerges.

Let's note that in the case when $\underline{\varphi}$ is set equal to $\bar{\varphi}$, that is to say when the consumers have a high tolerance level towards bad advice, the degree of self-organization substantially reduces for all levels of α (see figure 1.b).

Figure 1.b ($\underline{\varphi} = \bar{\varphi}$)



The figure in each area indicates the average number of varieties of each good purchased in each forum
 NC = the system didn't converge

■ Conclusion

What does this model teaches us about the self-organization properties of a system of interacting agents on the Internet and the ability of forums to select consumers according to some useful criteria? The following results obtain:

- forums help self-organization to emerge as a property of the system in the cases where consumers are not too radical in their trusting the others or rather themselves, but attribute some reasonable weight to both their personal preferences and the advice that they gather. In these cases in fact the feedback between individual experiences and collective experience ensures that selection operates according to an emergent criterion;
- self-organization has better properties when consumers have little loyalty to the forums that give them bad advice, or, put in other words, when consumers are demanding enough to forums.

An important complement is that the satisfaction of consumers is not a simple function of the perfectness of self-organization. The model shows that consumers may be satisfied by an imperfect self-organization as well.

For firms that would like to use the Internet as a way to innovate in commercial practices, as most of them do claim, the property of self-organization has a high value since it is the required condition for being able to segment markets in a better way. What this paper suggests is that an "infomediary" might create value added and price a service to firms by providing a commercial service that firms could not get by simply creating their own Web-site. The latter only attracts consumers that know the brand and are interested in it. Furthermore, analyzing information provided by a forum of consumers on a site is extremely labor intensive and requires specific skills (KALAKOTA & WHINSTON, 1996). An infomediary is able to enlarge the set of potential consumers by acting upon the parameters that our model has shown to be crucially important in the emergence of self-organization.

What the paper shows is that market segmentation by using the Internet can be improved by promoting self-organization. In this respect, a prediction of the model is that the stake is to provide devices that favor self-organization of consumers. Consumers might eventually be indifferent to the degree of organization, as we have shown, but their rationality is bounded by the sequential property of the system such that they are unable *ex ante* to assess the welfare that surfing on the Net will provide to them. Consequently, acting upon consumers fruitful participation to self-organization is possible by implementing devices that allow them to improve their efficient gathering of advice and their subsequent relative trust in the Web. Examples of devices that can reinforce the involvement of consumers in the Web include devices that improve the filtering of information, the notation of information or else the paying of consumers for surfing on the Net more actively or for assessing information more systematically. The conditions that allow an infomediary to effectively emerge, that is to say to create a valuable service, deserve attention. This issue will be investigated in a future work.

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