Slot allocation: A model of competition between firms when consumers are procedurally rational

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Abstract

We present a simple model of competition between firms who face boundedly rational consumers. The consumers cannot compare two consumption bundles; instead, they have some fundamental preferences and a selection procedure. In any Nash equilibrium of the slot allocation game, the firms choose the same allocation. There may be multiple equilibria, one of which is always to allocate according to the consumers’ tastes. Finally, as the number of firms increases, only the allocation preferred by the consumers remains as an equilibrium, which may not maximise the industry profit. © 1999 Elsevier Science B.V. All rights reserved.

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1. Introduction

Consumers in economic theory and decision makers in game theory are rational. Rubinstein (1998) lists some of the—often implicit—assumptions behind the rational man hypothesis. These are: knowledge of the problem (the rational man is fully aware of the set of alternatives), clear preferences (he has a complete preference ordering over the entire set of alternatives) and ability to optimise (he has the ability to find the optimal action by performing the necessary calculations, without any mistake). Observation of human behaviour does however suggest that these assumptions are not realistic in many
situations. Modelling bounded rationality becomes therefore important. However, it is probably premature to hope for a unified treatment of bounded rationality. The approach is likely to be rather piecemeal, with a variety of models each studying a different facet of bounded rationality, analogously to the variety of imperfect competition models that replace the paradigm of perfect competition. Here we present a simple model, where, we believe, bounded rationality arises very naturally. Our aim is to study the effects of elements of bounded rationality of some agents (the consumers) on the behaviour and interaction of fully rational profit-maximising firms.

We study a simple non-cooperative game where the firms are allocating services to slots. Consumers have an endowment of a scarce resource, available in discrete amounts, labelled slots, to which the consumption of competing goods or, more plausibly, services must be allocated. Only one service can be allocated to each slot. The consumption set, therefore, is the set of all allocations of services to slots which satisfy the property of allocating at most one service to each slot.

Our consumers do not have a complete preference relation over the consumption bundles. This is because, in general, the bundles are too difficult to compare. However, the consumers are not helpless: they have complete and transitive preference orderings over some sets of alternatives which are easy to compare. Moreover, in addition to these orderings, consumers have a procedure for decision making which enables them to select a consumption bundle from the available alternatives. Therefore, the consumers in our model are procedurally rational (Osborne and Rubinstein, in press; Simon, 1955) because they follow a rational procedure, which, however, falls short of outright optimality. Note that, given the offers, the procedure enables a consumer to choose which services to consume in which slot; she still does not have a complete preference over the whole consumption set. A consumer is fully described by her preferences and the selection procedure. Some examples in Section 2 illustrate the type of situations which fit this rather abstract description.

We keep the set-up as simple as possible, even at the cost of introducing strong assumptions. Our aim is not to provide a general model of bounded rationality, but, rather, to suggest one among many potentially possible ways of relaxing the rational man hypothesis. The results of the paper can be summarised as follows. Under the assumption of homogenous consumers, the allocation chosen by the monopolist is the one which maximises its profit; this need not be the one which would be chosen by the consumers. When more than one firm is present, all equilibria are such that all the firms choose the same allocation. Moreover, one of these equilibria is always that which the consumers would choose if they were free to select any allocation of services to slots. Finally, as the number of firms increases, the number of equilibria is reduced, and for a sufficiently large number of firms, only the allocation chosen by the consumers remains as an equilibrium; this allocation is not necessarily the allocation which maximises the industry profit. In this sense the firms must follow the consumers even though this has a detrimental effect on profits. This is an effect of the consumers’ bounded rationality; if they were fully rational, in equilibrium, the firms would still offer the same allocation but the allocation would maximise the industry profit.

The paper is organised as follows. We illustrate the problem with some examples in Section 2 and then present the model explicitly in Section 3. The results are in Section 4. Section 5 concludes.
2. Examples

Certain activities require allocation of a well defined unit of time (an hour, a day, a week). For example, the consumer could be a businesswoman who needs to organise her visits to a number of European cities: each city requires exactly one day, and she cannot allocate half a day twice in the week to the same city. A very similar situation is that of a team of auditors who need to make visits to different establishments of the company in different weeks. There are often natural slots in television programming: between 6 and 7, between 7 and 8 and so on. Consumers need to choose what to watch in each slot. Some newspapers have certain supplements in fixed days (Jobs, Houses for Sale, Weekly TV Guide, Book Review, Sports Review, Cars for Sale). It makes obvious sense to have each of these supplements fully in the same day, and practical reasons (such as having a similar number of pages in each weekday) suggest that the newspaper should allocate only one supplement to each day.2

We assume that the consumers are not able to perform a comparison between any two consumption bundles. The businesswoman who needs to spend a day in each of five different European cities cannot answer the following question: ‘Which combination do you prefer: {Milan on Monday, Trier on Tuesday, Warsaw on Wednesday, Tirana on Thursday, and Frankfurt on Friday}, or {Frankfurt on Monday, Warsaw on Tuesday, Milan on Wednesday, Trier on Thursday, and Tirana on Friday}?’ The reason why she cannot answer this question is that, although it is a sensible question to ask, it is too difficult for her to perform the necessary comparisons, and hence she cannot express preferences over bundles. She can, however, express preferences over the various available slots for a given service: our assumption on preferences implies that she can answer the following question: ‘Which day you prefer to spend in Milan?’. This, we think, is a minimum requirement of rationality.3

3. The model

3.1. The consumption set

There are \( H \) services, indexed by \( h, h = 1, \ldots, H \), to be allocated to \( S \) slots, indexed by \( s, s = 1, \ldots, S \). There are \( N \) firms, denoted by \( i, i = 1, \ldots, N \). There is a large number of consumers with identical preferences, that is, there is just one type of consumer, the

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2 Other examples can be given where slots are not time-slots: a multiproduct company may have purchased a number of different advertisement slots: TV slots at different times in different channels (hence with different audiences), newspaper pages or billboards. It then needs to allocate its products to the available slots. A further example, suggested by a referee, is the allocation of tasks within an organisation. If decision making is decentralised then service 1 (e.g. marketing) is decided by one person (or department), service 2 (e.g. distribution) by another and so on. The person at the top of the hierarchy decides the order in which these services are considered.

3A third type of questions, involving comparison between different services in different slots (such as ‘Do you prefer to spend Tuesday in Tirana or Friday in Frankfurt?’) is logically inconsistent because these are not mutually exclusive alternatives, and she cannot answer it either.
representative consumer. While this is undoubtedly restrictive, it constitutes a first step towards a more general analysis.

The consumption technology is such that the consumer can consume one service in each slot: the consumer has an allocation decision to make. We introduce an important restriction on the consumption set: the consumption set satisfies the satiation property: no service is consumed more than once in a consumption bundle; in other words, each service is consumed in at most one slot. The satiation hypothesis implies that a consumption bundle is characterised by an allocation of services to slots, which satisfies the constraint that each slot is occupied by one service, and no service appears more than once.

Note that the satiation property does not apply to any conceivable allocation problems: it could well be the case that consumers might be willing to consume the same service in more than one slot. In this case, the consumer is able to answer the question ‘Which is your favourite service in this slot?’, as the example in the footnote illustrates. The situation in which the satiation property does not hold is akin to the standard analysis with separable utility, and therefore it does not require a separate framework: the consumer in our model has an endowment of slots, and allocates these slots to the available services. In this case, the preferred allocation of services to one slot is not affected by the allocation of services to a different slot; this corresponds to the separability assumption that the preferred combination of goods within a group is not affected by the allocation of goods within a different group.

3.2. Preferences

The standard approach to consumers’ preferences takes the view that the consumer is able to form pairwise comparisons between any two consumption bundles. Our consumer, on the contrary, has bounded rationality: she is unable to compare two fully specified bundles of service–slot pairs. She can, however take a procedurally rational approach to choice, which we model as follows.

Given any service, the consumer has a complete strict ordering over the slots: for each service, she has a most preferred slot in which to consume the service, a second most preferred slot, and so on. Denote by $>^h$ the consumer’s preference relation over slots for consumption of service $h$: thus $s >^h s'$ means that, given the choice between consuming service $h$ in slot $s$ and consuming it in slot $s'$, the consumer prefers to consume it in slot $s$ rather than slot $s'$. For every $h$, $>^h$ is assumed to be complete and transitive. This specification of the preference relation implies a rather strong type of

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4 Our model bears a superficial resemblance with the marriage problem (Gale and Shapley, 1962) which is also an allocation problem but quite different in nature. The incompleteness of preferences in our model creates an asymmetry between slots and services which is not reflected in the symmetry between men and women in the marriage problem.

5 One of our colleagues has pointed out that all his sons want to watch on TV is football: having watched football between 7 and 8 they most definitely would not switch to opera if more football were available between 8 and 9.

6 The preferences can be extended naturally to the empty slot: empty slots, however, complicates the presentation of the analysis without providing any beneficial additional insight, and we rule them out.
separability: in a more general model, the preferred slot for a given service may depend on the service consumed in adjacent slots (one may not like to watch a slapstick comedy just after a tragic war film).

The consumer’s preferences are fully described by the $H$-dimensional vector $\succ^1, \succ^2, \ldots, \succ^h, \ldots, \succ^H$. For each service $h = 1, \ldots, H$, the consumer’s preference over the slots can be described by a permutation over $1, \ldots, S$, with the convention that 1 corresponds to the most preferred slot for this service, 2 to the second most preferred, and so on, with $S$ corresponding to the least preferred. For presentational simplicity, these can be put together in a matrix, with the rows corresponding to the slots and the columns corresponding to the services. See Table 1 (ignore the fact that some of the cells are bolded for the moment).

We have drawn a solid line separating the columns, and a dashed line separating the rows. This highlights the fact that the consumer can compare cells in the same column, but not cells in the same row across columns. In Table 1, the consumer’s favourite slots for service 1 is slot 1, followed by slot 2, slot $S$ is the 6th favourite. Slot $S$ is the preferred slot for service 2, and slot 1 the 5th preferred, and so on.

### 3.3. The selection procedure

The second element of consumers’ procedural rationality is the way they make their choices. If the consumer had a complete ordering over the available bundles, then it would be possible to construct a utility function over the set of bundles, and the consumer would simply choose the available bundle with the highest utility score. This is clearly not possible in our model: a selection procedure is necessary to determine what the consumer actually does in a specific situation. We assume the following.

**Assumption 1.** The consumer’s selection procedure is service-by-service:

Services are ranked according to an ordering: without loss of generality, let service 1 be the first in this order, service 2 the second and so on.

- Service 1: The consumer chooses to consume service 1 in the slot $s^1 \in C^1$ such that $s^1 \succ^1 \tilde{s}$ for every $\tilde{s} \in C^1 \setminus s^1$.
- Service $h > 1$: Let $\hat{C}^h = C^h \cup \bigcup_{k=1}^{h-1} \{ s^k \}$. The consumer chooses to consume service $h$ in the slot $s^h \in \hat{C}^h$ such that $s^h \succ^h \tilde{s}$ for every $\tilde{s} \in \hat{C}^h \setminus s^h$.

<table>
<thead>
<tr>
<th>Table 1</th>
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<td>An example of the consumer’s preferences</td>
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<table>
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<th>Slots</th>
<th>Services</th>
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<td>1</td>
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<td>$S$</td>
<td>6</td>
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</table>
According to Assumption 1, the consumer starts from service 1: she considers all the slots in which this service is offered and assigns it to the slot which is the preferred among them. Then she deletes this slot from the subsequent steps of this mechanism. The assignment procedure is then repeated for service 2, with the difference that the slots considered are those in which service 2 is offered except the slot assigned to service 1, and so on until the end of the services required or the slots available.\(^7\) To illustrate the selection procedure consider Table 1, and suppose that the services are available in the slots corresponding to the bolded cells only. The selection procedure determines that service 1 is consumed in slot 1, service 2 in slot \(S\) and service 3 in slot 2.

For a given selection process, the question remains what determines the ordering of the services: Which service is 1, which is 2, and so on? We do not address this question here: the ordering may be arbitrary,\(^8\) or it may be the result of some higher level preference ordering. In the latter case, consumers would be fully rational: as Rubinstein (Rubinstein, 1998, Chap. 1, Section 1.2) argues, even if the consumers do not behave in the manner described by the rational man process, it still may be the case that her behaviour can be described as if she followed such a process. Our model illustrates exactly the above comment. The unique outcome chosen by the consumer using the service-by-service procedure would be the same if the consumer had a complete lexicographic preference ordering over the service-slot matrix. Therefore, the observation of a certain outcome does not allow us to distinguish between the behaviour of our procedurally rational consumers and consumers with lexicographic (and therefore complete) preferences.

### 3.4. The firms

The firms’ behaviour is straightforward: they allocate various services to the different available slots; they are fully rational and they maximise profits. A pure strategy for firm \(i\), \(i = 1, \ldots, N\), is simply an allocation of services to slots, and is denoted by \(\sigma^i = (h^i_1, h^i_2, \ldots, h^i_H)\), where \(h^i_j \in \{1, \ldots, H\} \cup \{\emptyset\}\), and the \(s\)th element of the vector \(\sigma^i\) is the service offered in the \(s\)th slot.

The strategy set for firm \(i\) is the set of all possible vectors \(\sigma^i\). Note that we allow the firms not to offer anything in a slot; however, due to Assumption 2 below, firms only choose to do so in equilibrium in the trivial case where there are more slots than services.

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\(^7\) Suppose the selection order of the hypothetical businesswoman touring Europe corresponds to the alphabetical order of the cities. Then, when planning her schedule, she would choose her preferred day for the visit to Frankfurt, say Tuesday, as she can meet Herr Schmidt then, and then cross out Tuesday in her diary. ‘Milan next: What is the best day to go to Milan? Not Monday, they’ll all be talking about the day before’s football, Tuesday is Frankfurt, Wednesday afternoon shops are closed, Thursday? Thursday is probably better than Friday. Now Tirana. There is only a Monday flight to Tirana, so Tirana must be on Monday...’, and so on.

\(^8\) Obviously, our results may depend crucially on the order in which services are considered.
3.5. Payoffs

To complete the description of the game, we need to specify the payoff to a firm for a given strategy profile.

We assume that, for any service \( h \) and slot \( s \), \( h = 1, \ldots, H \), \( s = 1, \ldots, S \), there is a maximum net profit which can be obtained when service \( h \) is consumed in slot \( s \). We denote this profit by \( \pi_{s}^{h} > 0 \). For the present purpose, we do not need to specify how this net profit is calculated. We assume that the total profit is shared equally among the firms.

Assumption 2. (a) If service \( h \) is consumed in slot \( s \), and it is supplied by \( n_{h} \) firms, \( n_{h} \in \{1, \ldots, N\} \), the net profit of the industry is \( 0 < \pi_{s}^{h}(n_{h}) \leq \pi_{s}^{h} \) and the net profit obtained by each of the firms supplying service \( h \) in slot \( s \) is \( \pi_{s}^{h}(n_{h})/n_{h} \). (b) If service \( h \) is not consumed in slot \( s \), the net profit of the industry, and of each firm, is 0.

A firm’s payoff is simply given by the sum of its profits.

4. Results

Given the consumers’ selection procedure, consider the allocation which consumers would determine if each service were available in every slot. This is a strategy available to any firm; let it be denoted by \( \gamma \).

4.1. Monopoly

Consider the benchmark case of a single firm supplying the services. It is obvious that the profit maximising strategy is chosen (it always exists, as the strategy set is finite). Let it be denoted by \( \sigma^{M} \). Note that \( \sigma^{M} \) may differ from \( \gamma \), as in the example in Table 2. The small numbers in the cells denote the net profit obtained if the consumer chooses to consume the service corresponding to the column in the slot corresponding to the row.

<table>
<thead>
<tr>
<th>Slots</th>
<th>Services</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>2( \Box ) 4</td>
</tr>
<tr>
<td>2</td>
<td>1( \Box ) 6</td>
</tr>
<tr>
<td>3</td>
<td>3( \Box ) 4</td>
</tr>
</tbody>
</table>

Clearly, there are no prices in the model. Let us, for simplicity, assume that the net profits are exogeneously determined by some process.
monopolist would choose the allocation denoted by ■, which gives a profit of 20, whereas the consumers would select the allocation denoted by □, which only gives a profit of 16.

A noteworthy feature of this benchmark case can be obtained with the restriction implied in the following assumption.

Assumption 3. For any service \( h, h = 1, \ldots, H \), \( s > h's' \) if and only if \( \pi^h_s(1) > \pi^{h'}_{s'}(1) \).

In other words, if a slot is preferred by the consumers, then it also yields a higher net profit to the firms. This could be justified, for example, because the total surplus in each cell is divided equally between firms and consumers.

Proposition 1. Under Assumptions 1–3, in the allocation chosen by the monopolist, at least one service is supplied in the consumer’s most preferred slot for that service.

Proof. First consider the case \( H = S \). Consider the allocation chosen by the monopolist. Without loss of generality, relabel the slots in such a way that service 1 is allocated to slot 1, service 2 to slot 2, and so on. Suppose, by contradiction, that this chosen allocation is such that no service is supplied in the most preferred slot. Consider service 1. Let the best slot for this service be slot \( s_1 \) (\( s_1 \neq 1 \)). Consider service \( s_1 \). Suppose the best slot for service \( s_1 \) is slot \( s_2 \) (\( s_2 \neq s_1 \)). If \( s_2 = 1 \), then the monopolist can swap the slots for services 1 and \( s_1 \) and generate more profit. If \( s_2 \neq 1 \), consider service \( s_2 \). Suppose the best slot for service \( s_2 \) is slot \( s_3 \) (\( s_3 \neq s_2 \)). If \( s_3 = s_1 \), then the monopolist can swap the slots for services \( s_1 \) and \( s_2 \) and generate more profit. Similarly, if \( s_3 = 1 \), then the monopolist can just reallocate the services 1, \( s_1 \), and \( s_2 \) to generate more profit. If not, consider the service \( s_3 \). Suppose the best slot for service \( s_3 \) is slot \( s_4 \) (\( s_4 \neq s_3 \)). Now repeat the same argument as above till we find a profitable reallocation. As \( H \) is finite, a profitable reallocation exists. If \( H > S \), consider the services which are being offered and repeat the same argument for those services only. If \( S > H \), then consider the slots in which the services are allocated and relabel them so that service 1 is allocated in slot 1, service 2 in slot 2, and so on and then repeat the above argument. ■

4.2. Oligopoly

Consider now the case of an \( N \)-firm industry, \( N \geq 2 \). Note first of all that the strategy profile in which all firms offer the consumer’s choice, \( \gamma \), forms a Nash equilibrium. This is simply because no firm can gain by deviating while the other \( N - 1 \) firms are choosing \( \gamma \); it would simply lose its share of the market. This Nash equilibrium, however, need not be unique. For example, consider the consumer’s preferences shown in Table 3. Let there be two firms. As before, the number in the small font in a cell denotes the net industry profit for the cell. The equilibrium strategy profile \( \{ \gamma, \gamma \} \) is illustrated by the cells with the □’s. There is another equilibrium in which both firms choose the allocation marked by the ■’s. To see this, note that each firm has a profit of 48/2 = 24 in the ■-allocation, and the best possible deviation that one firm could make is the supply of the allocation preferred by the consumers, denoted by □ in the table. This gives the deviating firm a (single supplier) profit of 20 (= 10 + 5 + 5), which is less than 24.
We now state and prove the main characterisation result of the paper. In any Nash equilibrium of the game all the firms choose the same allocation.

**Proposition 2.** Let \( \{\sigma^i\}_{i=1}^N \) be a Nash equilibrium. Then \( \sigma^i = \sigma^1, i=2, \ldots, N. \)

**Proof.** Suppose not. That is, suppose there exists an equilibrium \( \{\sigma^i\}_{i=1}^N \) with \( \sigma^i \neq \sigma^1 \) for some \( j \). We consider the case \( S=H \) first. Relabel the slots in such a way that firm 1 occupies slot \( h \) with service \( h \), for \( h=1, \ldots, H \). Consider the subset \( D \) of \( \{1, \ldots, H\} \) such that \( \sigma^i_h \neq \sigma^1_h \), for \( h \in D \), that is, \( D \) is the set where firm \( j \) and firm 1 differ. Consider the service \( d_j \in D \). Without loss of generality, let \( d_j \) be supplied by firm 1, and let \( d_j \) be a service supplied by firm \( j \): such a service must exist in equilibrium, otherwise firm \( j \) would make a total profit of zero from the services in \( D \), and could duplicate firm 1’s allocation and gain a strictly positive profit for itself. Let \( d_k \) be the slot where firm \( j \) supplies service \( d_k \): it is \( d_k \neq d_j \) because firm 1 offers service \( d_j \) in slot \( d_j \). Firm 1, therefore, is not supplying service \( d_k \) either, because it offers it in slot \( d_k \), which is already occupied by firm \( j \): it follows that firm 1 is earning a zero total profit from services \( d_k \) and \( d_j \) together, which it supplies in slots \( d_k \) and \( d_j \), respectively. It could swap the slots in which these two services are supplied, and earn strictly positive profits, by sharing the market with whoever is supplying them (including firm \( j \)). This swap can be achieved without affecting any of the other slots, and it shows that firm 1 could increase its profit: the proposed allocation cannot therefore be an equilibrium for \( S=H \).

The extension to \( S \neq H \) is immediate, once it is noted that adding unused slots or unsupplied services (which must happen for \( S>H \) and \( S<H \), respectively) would not alter the argument given above.

The above result characterises the set of Nash equilibria of the slot allocation game. In any equilibrium, firms ‘fight’, that is, they all offer the same allocation. It is straightforward to see that, in general, if consumers are heterogeneous, it is possible to construct non-fighting equilibrium. Consider a simple two-firm, two-service, two-slot example. Suppose there are two types of consumers, one type prefers service 1 in slot 1 and service 2 in slot 2 and the other prefers the opposite. For some values of the profit numbers and the proportion of the types, in equilibrium one firm allocates service 1 in slot 1 and the other allocates service 2 in slot 1. However, Proposition 2 is robust to small perturbations: for any \( N \geq 2 \), there exists \( \varepsilon > 0 \), such that if at most a proportion \( \varepsilon \) of the consumers have different type then all equilibria are such that all firms offer the same allocation.

We next study how the set of equilibria depends on the number of firms.
Corollary 1. Let \( \{\sigma, \sigma\} \) be a Nash equilibrium for the two-firm game, with \( \sigma \neq \gamma \). Then there exists \( N_0 > 2 \) such that the \( N \)-dimensional vector \( \{\sigma, \ldots, \sigma\} \) is a Nash equilibrium for the \( N \)-firm game if and only if \( N < N_0 \).

Proof. Consider any equilibrium strategy profile for the two-firm game \( \{\sigma, \sigma\} \), with \( \sigma \neq \gamma \). If any firm deviates to strategy \( \gamma \), it obtains the whole profit from the allocation \( \gamma \), as \( \gamma \) will then be chosen by the consumers. Let \( I_{\sigma} \) (respectively \( I_{\gamma} \)) be the total profit with allocation \( \sigma \) (respectively \( \gamma \)). Next, simply notice that the per firm profit when \( N \) is the number of firms is bounded above by \( I_{\sigma} / N \), which decreases monotonically with \( N \), and becomes lower than \( I_{\gamma} > 0 \) for \( N \) sufficiently large.

Corollary 1 says that the equilibrium set shrinks as the number of firms increases, and that for \( N \) sufficiently large the only equilibrium allocation is the one which the consumers would choose. The following is an immediate consequence of Corollary 1.

Corollary 2. There exists \( N^* \geq 2 \) such that the \( N \)-dimensional vector \( \{\gamma, \ldots, \gamma\} \) is the unique Nash equilibrium of the \( N \)-firm game for \( N = N^* \).

We end the paper by comparing these corollaries with the outcome of the slot-allocation game where consumers have complete preferences over the possible allocations. The natural way to proceed is to assume that if an allocation is preferred by consumers, then it also yields a higher net profit to the firms (analogously to Assumption 3). Under such an assumption, almost tautologically, the consumers and the monopolist would choose the same allocation. Almost as immediate, if there are more than one firm, all the firms would choose the same profit maximising allocation. Thus, under complete preferences, the game has a unique equilibrium, which determines the allocation generating maximum profit.

5. Conclusions

In this paper we discuss a model of competition between firms when there is a representative consumer who has incomplete preferences and a rational selection procedure. In every equilibrium, all firms play the same strategy. If the number of firms is sufficiently large, there is a unique equilibrium of the game which is the allocation which the consumer would choose if every service were available in every slot. However, this outcome may not maximise the (total) profit: the equilibrium may be inefficient. This inefficiency is due to both competition between firms (the monopolist maximises profit) and incomplete preferences (when consumers have complete preferences, the equilibrium outcome maximises profit).

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References