# Pricing and Manipulation of Information in E-Marketplaces

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## 1 Introduction

Electronic marketplaces (E-markets) broaden the opportunities for humans to trade, for example by allowing them to visit stores that are not physically accessible. In addition, E-markets allow people to exchange pieces of information. Users can buy articles without being obliged to buy a whole journal, users can obtain news adapted to their personal interests without buying the whole newspaper. Managing information as a commodity opens up an entire area of relevant research. Pricing policies should be standardized to quantify basic pieces of information. New kinds of transactions can be developed that were not common with classical commodities. Operators can be applied on these pieces of information eventually creating new products based upon the buyers' requests or as new suggestions to them.

This paper focuses on information that can be dealt with in E-markets. In particular, we have developed the notion of InfoCenters, automatic agents that have wide accessibility to information products, as well as to manipulated data. Pieces of information are already being traded in existing systems (e.g., [4]) — tools to handle these pieces of information are becoming more necessary. Information management and commerce must deal with questions such as how different pieces of information will be handled, and how will their prices be calculated? Does the customer need to know which are all the information products that are available before he carries out a transaction? How can a software agent assist a user in building new information products out of the basic pieces existing in his data storage?

An InfoCenter is a software agent that interacts with information suppliers (i.e., sellers), information consumers (i.e., buyers) and Information Service Providers (InfoSPs) that can be automated agents or humans. Therefore, an InfoCenter agent can buy and sell information products, and moreover it can obtain manipulated information from the InfoSPs. The InfoSP agent enables services such as changing the presentation, fitting the presentation to different platforms, updating the information, summarizing it, or combining pieces of information. InfoCenters can reside, for example, in a library, at a portal Web site, or at a site that answers user questions.

The marketplace investigated in this paper contains InfoCenter agents, InfoSPs, information consumers (buyers) and information suppliers (sellers). Three models of trading interactions introduce the motivation for the implementation of InfoCenter agents. Then, results from simulations run with different settings of InfoCenter agents are presented. In this paper, we focus on the cooperative interactions between InfoCenters and the impact they have on the market. We have also started to study how InfoCenters can sell newer information products that are a result of applying operators on basic pieces of information. This study is part of a larger research project that aims at studying the effects of different AI techniques, such as planning and coordination, on the InfoCenter decision process.

# 2 The InfoCenter Agents

In this section, we motivate the implementation of InfoCenter agents in E-markets that trade with information. Even though the accessibility to information in the Internet is not constrained by physical distances as it is in the old economy, information intermediaries seem to be beneficial in this environment as well. An InfoCenter agent is useful in three scenarios as described below:

- When the InfoCenter agent already exists — Infrastructures are already built that include centers of information which can be handled by InfoCenter agents. One example consists of existing libraries, classical as well as digital ones (e.g., the Stanford Digital library Project [4]). The library buys information such as books, magazines and articles, and it serves its audience who pay for that information. Libraries already exist. Their services can be extended by attaching to them InfoCenter agents who will interact with different information suppliers and consumers.
- When buyers benefit from interacting with an InfoCenter agent — E-marketplaces may be interested in extending the services they provide to their buyers, by adding assistance services. For example, an InfoCenter agent can help a buyer by aggregating information (from different sources) that answers requests submitted by these buyers. In this example, the InfoCenter may need to interact with other software agents (e.g., agents who provide information services) to understand the question and for manipulating the different information elements to answer the person's question. The InfoCenter agent provides a service to the buyer, from which the buyer will benefit. The existence of such an InfoCenter agent should not conflict with the existence of the sellers. The sellers can benefit as well from delivering their information to the InfoCenters who will sell it on to the buyers. Pricing strategies are needed here to establish the relation between the InfoCenter agents and the sellers.
  Another example is when a buyer is only interested in one piece of information and it is not interested in a whole set of information (e.g., a buyer may be interested in acquiring a paper but not the complete journal). InfoCenter agents can handle the subscriptions

to information suppliers and provide the buyers with partial information.

- When the sellers benefit from interacting with an InfoCenter agent — There are cases when information suppliers will benefit from InfoCenter services. Different sellers can handle the information they sell, and an InfoCenter agent will handle the knowledge that is shared by all these sellers. For example, people that acquired different expertise would like to profit from sharing this knowledge with others who need it. Building a service that sells this kind of knowledge to interested people may be hard to perform. Implementing an InfoCenter for this purpose is one solution. A similar approach was taken by Kamoon [1]. The buyers post their information request to the InfoCenter. Each information expert can choose which information request he can handle. Then the buyer gets a list of potential experts that can give him the information that the buyer needs. The buyer can choose the expert he wants to approach and from whom he will be able to get the information requested. In that way, the InfoCenter provides a way to match between experts and people who need these experts' knowledge.

Figure 1 depicts an E-marketplace including buyers and sellers interacting with InfoCenter agents that can obtain manipulated information from InfoSP agents.

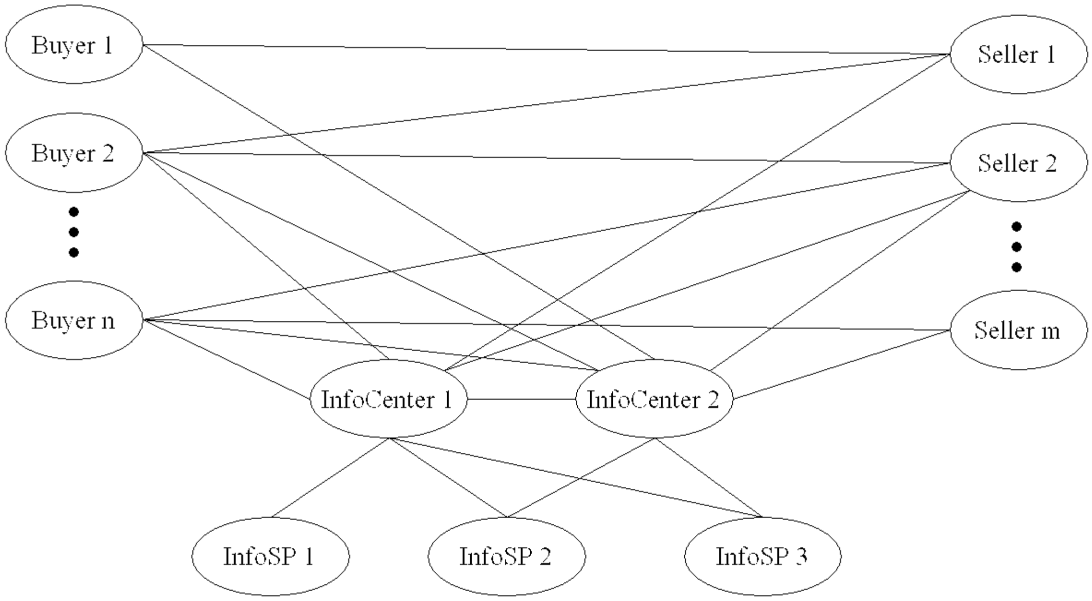


Figure 1: A basic E-marketplace including InfoCenter and InfoSP agents

# 3 The Model

Our study is based on the same marketplace model proposed by Kephart et al. [3, 2]. This marketplace contains commodities that are offered by $S$ sellers, and which may be bought by any of the $B$ buyers, assuming $B >> S$. Each buyer generates purchase orders at random times, at a rate of $\rho_b$, while each seller resets his price at random times, at a rate of $\rho_s$. The worth of a good to a buyer $b$ is represented by the value $V_b$. The cost of production for a seller $s$ is $C_s$.

Our framework extends the basic model [3] by including InfoCenter agents and Information Service Providers (i.e., InfoSP agents). The InfoSP agents are responsible for manipulating basic pieces of information. New commodities will eventually be built out of the existing commodities in the market. InfoCenters are added to the basic market as intermediaries of information. These agents interact with information suppliers and consumers by buying and selling information. We will use the terms sellers and buyers only for the information suppliers and consumers. Even though InfoCenter agents buy and sell as well, we will refer to these agents as InfoCenters to avoid confusion.

The goal of the InfoCenter is to profit by using the marketplace entities in a smart way. Unlike a seller, the InfoCenter can choose the commodities it wants to offer, and it can use the InfoSPs to create new commodities that are not available in the market. If a certain commodity has a low profit margin, the InfoCenter can stop offering it. InfoCenters can also track the history of the buyers' requests, and adapt their list of products accordingly (i.e., continue selling a newly created product that the buyers keep demanding, or stop selling it).

We have currently implemented an E-marketplace that includes three InfoCenter agents that can cooperate among themselves. These InfoCenter agents have three capabilities that give them advantages over classical sellers. First of of all, InfoCenters can offer new information products after having approached an InfoSP, and obtained a manipulated new piece of information. Second, InfoCenters may switch among the commodities they offer for sale. Since InfoCenters do not hold in stock the information they sell, these agents can decide upon the area in which they specialize in a more flexible manner. Third, we have implemented a mechanism for sharing information among the InfoCenters (i.e., a SharedCatalog), so that information remains distributed and its price is not necessarily handled by a monopolistic agent.

We tested two criteria for evaluating the effectiveness of the different configurations and algorithms. The first one is **InfoCenter profit**. This criterion compares the *gain* obtained by an InfoCenter when either the SharedCatalog is used or not, when the InfoCenter switches between commodities, or when the InfoSPs serve the InfoCenters. The second criterion is **stability of the marketplace**. A marketplace with frequent price changes can create unstable environments for the buyers. The reason is that a commodity bought now may cost, for example, half the price or twice the price if the buyer waits. A marketplace with (relatively) stable prices is desirable, although care should be taken to avoid a monopolistic market place, in which the prices will be set to their highest point. The desirable marketplace is one with stable prices that are competitive. We conclude this section by giving more details about the actions that can be performed by the InfoCenter and InfoSP agents.

## 3.1 Manipulated Information

The InfoCenters can approach the InfoSP agents in order to provide the buyers and sellers with new information products. The information manipulation methods that the InfoSP can offer include:

- Different presentation formats and resolutions — Resolution may depend on the connection speed available to the consumer. The buyer may wish to match the format of the information to the device he is using (e.g., the device can be a PC, a hand-held, a cellular phone, a fax-machine, or a printer). Currently, we have implemented a unary operator that enables the presentation of information either in PS or PDF formats.

- Information updates — The InfoSP can offer updates to existing pieces of information. This is relevant when the information in question may change over time, for example, information that refers to cost rates, stock values, news, reviews. This operator is left for future implementation.
- Combining and summarizing — The information requested by a consumer may require the combination of several pieces of information. In addition, the resulting information may consist of non-relevant information that should be removed. Currently, we have implemented a binary operator called collector that enables the combination of two pieces of information into a single unit.

For simplicity, the price paid by the InfoCenters to the InfoSPs for the services provided was fixed and did not change according to marketplace demands.[1] We assume that the time needed by the InfoSP to apply operators is very small. Therefore, the InfoCenters can offer information that was manipulated by various InfoSPs. If the buyers are interested in some new information that is not offered by any seller, then the InfoCenter will contact the relevant InfoSPs and will produce the information. Only then will the InfoCenter pay the InfoSPs. In that way, the InfoCenters and the InfoSPs can check the demand for different information commodities.

The InfoCenter agent can respond to a market request for an information commodity, and plan a way to make it available, using the information sources and the InfoSP's services that are available. It can replace information commodities with more profitable ones. The InfoCenter's ability to introduce new information commodities using the InfoSP should be used 'wisely'. Un-wise uses of the InfoSP's services can lead to lower profits. More details are given in the full version of the paper [5].

## 3.2 Switching between Information Commodities

InfoCenters can choose which information commodities they sell. An InfoCenter can stop offering a commodity he used to sell, and decide instead to sell another commodity for which there is a seller in the market. This action of switching information and contracting the sellers that offer that information will cost a certain fee. This fee is paid to the new sellers so they will hold a certain stock of information for the InfoCenter.

There is a trade-off between choosing which commodities to offer, and the profit from selling them. The following algorithms were tested to study this trade-off.

- MI (Moment Impulse) — an InfoCenter will switch between commodities and will pay a fee if the new commodity is more profitable than the commodities that are currently offered. The agent does not consider the past history of sales nor of demand.

[1] We plan to adapt the cost of the manipulated information to market demands, since this cost is affected by prices of the information commodities of which it consists, and these prices change according to market demands.

- HM (History Measure) — an InfoCenter will switch between commodities and will pay a fee if the new commodity is more profitable when taking into account past prices. It will give more weight to prices in the recent past and present, than to prices in the distant past, but it doesn't consider the demand for those commodities.
- MA (Market Analyze) — an InfoCenter will switch between commodities and will pay a fee if the new commodity is more profitable when considering the past and the demand for it. The current profit will be computed with a time discount factor. The weight given to profit is proportional to the time that has passed.

### 3.3 Cooperative InfoCenters

InfoCenters can share resources. That means that an InfoCenter $I_1$ can approach another InfoCenter $I_2$ in order to sell information products that are not accessible by $I_1$. In such cases, InfoCenters are not competing, but are rather helping one another to sell their products. Moreover, an InfoCenter doesn't need to have information on all areas, but can specialize in a certain niche and use other InfoCenters when other information is needed.

We implemented a SharedCatalog model to enable such cooperation among InfoCenters. The SharedCatalog enables the InfoCenters to share their commodities. When one InfoCenter wants to offer a commodity that it doesn't have, it can offer it to a buyer using the SharedCatalog. Then, assuming the commodity's price is P, and the buyer pays the InfoCenter a higher price $P'$, the profit to the InfoCenter will be given by $P' - P$. Buyers who approach an InfoCenter with a request for information will get the product with the lowest price offered. Even if there are several InfoCenters that offer the same commodity with different prices, buyers obtain, from the InfoCenter that they have approached, the offer with the lowest price (this process is transparent to the buyers). If there are several InfoCenters that offer the same commodity with the same lowest price, then one InfoCenter will be chosen randomly.

## 4 The Dynamics of the System

One simulation consists of a series of repeated encounters between finite sets of buyers, sellers and InfoCenters. A finite set of basic commodities are offered for sale by the sellers. New commodities can be created by the InfoSPs and can be sold by the InfoCenters.

Sellers and InfoCenters offer the information products that are for sale. Each product is initialized with a fixed price. Each seller holds an infinite amount of the products offered. The cost of producing a basic commodity was set to 0.[2] During the simulation, the price is updated according to the sellers' strategies at a given rate $\rho_s$. The buyers choose a seller, based on the products in which they are interested and based on their strategy (as explained below).[3] The buyers approach the sellers at a rate $\rho_b$. Once a buyer approaches a seller, the

[2] A commodity created after applying an operator by the InfoSP incurs an additional cost.

[3] There is a central agent that responds to each buyer's request with a list of all the sellers that sell the requested items. Each buyer applies the corresponding algorithm to choose which seller to approach from this list. Here, sellers refer to information suppliers as well as to InfoCenter agents. The specific model of interaction between sellers and InfoCenters will constrain whether the buyer can approach both

transaction is necessarily carried out between the two.

The normalized utility of a seller $S$ at time $t$, after he has sold $r$ products at a price $P(t)$ is given by $U(S,t) = (\Sigma_{i=1}^{r} P(t))/r$. The normalized utility of a buyer $B$ at time $t$, after he has bought $r$ products at a price $P(t)$ is $U(B,t) = v - (\Sigma_{i=1}^{r} P(t))/r$.[4] The normalized utility of an InfoCenter $I$ at time $t$, is given by $U(I,t) = (\Sigma_{i=1}^{r} P(t) - C_{f_j}(t))/r$, where $C_{f_j}(t)$ are the costs incurred by the InfoCenter from following each one of its behaviors given by its features. For example, $C_{f_1}$ is the cost of approaching an InfoSP. $C_{f_2}$ is the cost incurred from paying a broker fee for selling another InfoCenter's commodity, and $C_{f_3}$ is the cost for paying the sellers for holding a different stock after switching to it.

Kephart et al. [3] have implemented a market with buyers and sellers solely. The sellers have different pricing algorithms. The authors tested the dynamics of the prices and the dynamics of the agents' behaviors in the given market. Since the InfoCenters in our simulations act as sellers as well, we can compare the behavior of the agents and their gains to the corresponding results in Kephart et al. In addition, we show the added value of implementing such InfoCenter agents in the market, by enriching the information products that can be offered to buyers, and by making their capabilities more sophisticated through the addition of cooperative attributes. In the following section, we describe the strategies that could be followed by the participants of the E-market we have implemented.

## 4.1 Buyers', Sellers' and InfoCenters' Strategies

**InfoCenter-Sellers Interactions — Payment Strategies** Sellers are the basic information sources (i.e., we assume that the sellers already hold information products). InfoCenters are agents that can buy information products from the sellers and can sell it in a different form. In the more general model, InfoCenter agents can also buy information products from other InfoCenters. The InfoCenter agent can use any one of the following payment systems to pay for information sold by sellers:

- Full Price (FP) — The InfoCenter agents pay the list price for the information they buy from the sellers. This model of payment is reasonable if the InfoCenters can sell manipulated information. Otherwise buyers will not have any incentive to buy directly from an InfoCenter a product that they could buy at a cheaper price directly from the sellers.
- Wholesaler Price (WP) — The InfoCenter pays a reduced price, when it buys a large quantity of information.
- Subscription Payment (SP) — The InfoCenter pays a subscription payment for the right to sell a certain quantity of the information, and royalty payments for each information element that it sells.

**Buyers' strategies for choosing a seller** The buyers need to choose a seller from which they will buy the commodity of interest. We have examined three algorithms that were

the information suppliers and the InfoCenters, or whether they can only approach either the information suppliers or the InfoCenters. These models are described in section 4.1.

[4] $v$ denotes the value of one commodity for the buyer. In our implementation we assume all the commodities have the same value, and $v$ equals 1.

implemented by the information consumers (the number in parentheses represents the percentage of such buyers in the tested market):

1. Compare-All (70%) — Buyers compare all of the prices requested for the commodity of interest. Then, the buyers will choose the seller that asks for the lowest price. This algorithm is similar to the implementation of the ShopBot in [3].
2. Compare-None (10%) — Each buyer chooses randomly an information source that offers the requested commodity.
3. Compare-two (20%) — Each buyer chooses two information sources randomly and then it buys from the cheaper one.

**Pricing strategies for sellers and InfoCenters** Both sellers and InfoCenters sell information products. Sellers sell basic information commodities. InfoCenters may sell new, manipulated, information, and products purchased from a seller using the WP or SP payment systems.

Both sellers and InfoCenters will apply any of the following three algorithms to decide on a price for the commodity they sell (following Kephart et al.'s model [3, 2]):[5]

1. GT (Game Theory) — Kephart et al. have shown that there is not a single pure strategy that is in Nash equilibrium for the sellers to establish the price for a commodity. There is, instead, a mixed strategy that is in Nash equilibrium. This mixed strategy instructs each seller to choose prices randomly using the following function $p(F)$, where $F$ is a random value between the cost $c$ of the commodity and its value $v$ (in our case $F \in [0, 1]$). $S$ denotes the number of sellers in the market, and $w_i$ is the fraction of buyers that compare $i$ prices. $p(F) = c + \frac{w_1 * (v-c)}{\Sigma_{i=1}^{S} i * w_i * (1-F)^{i-1}}$ .
2. MY (MY optimal) — The seller sets the price of the commodity in the market to maximize his short-term profit (i.e., until another seller changes the price). This method requires knowledge about the buyers population $W$, the number of the competing sellers $S$, and all the sellers' prices.
3. DF (Deviate Follower) — the seller keeps increasing the price of a commodity as long as his profit increases. The seller will decrease the price when the profit drops off a certain level. The seller will continue decreasing the price as long as his profit decreases, and so forth.

# 5 Experiments

In this section, we report on the simulations performed to test the impact of adding InfoCenter agents and Information Service Providers to an E-market. As a preliminary step, we have implemented a market in which InfoCenter agents are attached to the information suppliers. That is, the InfoCenter agents do not pay any payment to the sellers (the InfoCenter and the sellers can be regarded as a single agent). In other words, the system we

[5]When the InfoCenter agents apply these algorithms, the function that denotes the cost considers the cost of the interaction between the InfoCenter and the sellers depending on the payment method implemented (i.e., FP, WP, or SP).

have implemented can be understood as a Full Price system in which the buyers necessarily approach the InfoCenters and cannot approach the sellers directly. We have motivated an FP system as one that includes InfoCenters that sell manipulated information. We have also tested all of the InfoCenter behaviors in such a case, i.e., even when the InfoCenter does not sell manipulated information but can cooperate with other InfoCenters.

In the simulations described below, we examined whether the addition of InfoCenter agents to E-markets is beneficial, i.e., whether they gain a positive profit. Since our results support this, we have also tested the impact the InfoCenters have on the market after implementing their possible behaviors as described in section 3. In all of the markets studied, there were two basic commodities, five InfoCenters and one hundred buyers. In order to analyze these resulting markets we distinguish between two main scenarios:

1. Homogeneous InfoCenter Agents — In this case, all of the InfoCenter agents were run with the same capabilities. We tested four different sub-cases:
   (a) Basic — When each InfoCenter offers his own commodities, the InfoCenter does not use the SharedCatalog, and the InfoCenter cannot switch among commodities.[6].
   (b) Cooperative — When the InfoCenters use the SharedCatalog, but cannot switch among commodities.
   (c) Switching — When the InfoCenters use the SharedCatalog, and also have the capability to switch among commodities (based on the MI, HM, and MA strategies described in Section 3. MI will cause the sellers to switch more often between commodities, and MA will induce the slowest rate of switching).
   (d) Manipulated Information — When the InfoCenters approach the InfoSPs' services in order to offer new information commodities.
2. Heterogeneous InfoCenter Agents — In this case, we simulated markets with two sets of InfoCenters, where each set applied one of the aforementioned capabilities.

The results obtained from running simulations implementing the algorithms described are summarized below in Section 5.1.

## 5.1 Results

We expected to obtain two results for all of the settings tested. First, the InfoCenters will specialize in niches of information when InfoCenters cooperate, and each one will become a monopolist. However, our simulations show that there is a continuous competition between the InfoCenters. InfoCenters are tempted to reduce prices below the monopolist price for a short time, in order to compete with the monopolists and to gain more buyers. Second, the InfoCenters were expected to increase their profit due to the introduction of new information commodities. In the simulations it was shown that unless the InfoCenters cooperate and do not sell the same new commodities all together, they will enter a price war in which the competition will lead to a reduction in the profit from the newer commodities.

We report on our results based on the settings described in Section 5.

[6] This case is similar to the one implemented in Kephart et al. [3]

**Homogeneous InfoCenter Agents** — In the short term, InfoCenters that trade manipulated information become monopolists over products that are not offered yet by other InfoCenters. Their average profit is larger than Cooperative and Switching InfoCenters. But, in the long term, while all the InfoCenters will become sellers of the same new products, their average profit decreases, and the Switching InfoCenters' utility gets larger. Switching InfoCenters are the most advantageous due to the periods of time when they can sell at the monopolist price. The Cooperative case (without switching) can be more beneficial than the basic one, if the commodities are distributed among the InfoCenters in a way that the InfoCenters become monopolists. Otherwise, the average gain obtained by Cooperative InfoCenters is equal to the Basic case.[7]

In the Basic case, a cyclic price war was detected (as was also shown by Kephart et al.). The price of each commodity changes between its lowest and highest possible price.

In the Cooperative case, there are fewer sellers that offer the same commodity (because the InfoCenters cooperate and can sell the commodities of other sellers). Therefore, the price changes at a slower rate than in the case when there is only one seller that offers a commodity and sets its price to the monopolist price.

In the Switching case, the InfoCenters switch to more profitable commodities. An InfoCenter will move away from a commodity offered by many InfoCenters at a low price to a commodity that can be sold at a higher price (i.e., because fewer InfoCenters offer it).

In the Manipulated information case, InfoCenters can offer new information commodities using the InfoSPs' services. The average profit depends on several parameters: the service cost, the number of commodities that an InfoCenter can offer and the value that the information has for the buyers (the $v$ parameter). The cost of the InfoSP services determines the profitability of the new information commodity. Higher service costs will cause lower profits for the InfoCenter. It is reasonable to limit the number of information elements that one InfoCenter can offer, because the number of all possible commodities that can be created is exponential in the number of basic commodities in the market. If there is no limitation imposed on the number of newly created commodities, then the Manipulated Information case yields results similar to the Basic case. If the number of new information products is indeed limited, then market behavior will be similar to the switching case market, when InfoCenters switch among commodities to gain higher profit.

Comparing our results to those obtained in Kephart et al. in [3], the InfoCenter model leads to a higher average profit for the InfoCenter agents. This happens due to the existence of a monopolist agent. At the individual level, the non-monopolist agents obtain the same profit as in Kephart et al.'s model. InfoCenter agents that were also allowed to switch among commodities obtain a larger profit on average as well as at the individual level. The possibility of changing the commodities offered to the information consumers led to higher prices in the market. Manipulated information was not handled by Kephart. Not only was this case shown to behave similarly to the Switching market when the amount of newly produced information is limited, and therefore the InfoCenters' average profit is the highest, but buyers also benefit from being able to acquire newer information products.

In our model, prices change at a rate that is slower than in [3].[8] On the one hand, buyers

[7] Details about the simulations that lead to these results will be presented in the full paper [5].

[8] In the Manipulated case, the rate of price change decreases as long as fewer InfoCenters sell new products.

can benefit from this fact, since they will be able to buy at the same price for a longer period. On the other hand, when InfoCenters switch among commodities, the price changes more slowly but does not arrive at the minimal price as in the model presented in [3], because the InfoCenters benefit more from switching to a more expensive commodity rather than from decreasing the price of the current commodity being offered.

**Heterogeneous InfoCenter Agents** — We have tested markets in which one InfoCenter follows any one of the Basic, Cooperative, Switching, or Manipulated Information behaviors and the other four InfoCenters follow a different behavior. We use the following notation to distinguish between these cases: $1X4Y$ where $X$ and $Y$ can be $B$ for the Basic case, $C$ for the cooperative case, $S$ for the switching case, and $M$ for the manipulated information case. When we explain a general result we will use the symbol | to denote or, for example, a market with one InfoCenter that obtains manipulated information while the other four can follow any other behavior will be denoted as $1M4B|C|S|$.

In the $1M4B|C|S$ case, the average profit of all the InfoCenters increases, in particular (and due to) the profit of the single Manipulated Information InfoCenter. This agent is the only one that can offer new information products and therefore it does not compete with any other seller in the market. In $4M1B|C|S$, the four InfoCenter agents compete with each other leading the market to a similar basic homogeneous market with at least four Manipulated Information InfoCenters and a larger set of information commodities including the newly created, that exist from the beginning. The average profit of the Manipulated Information InfoCenters will be lower than the average profit gained by the InfoCenters in the basic case, since the average cost of the commodities is higher.

The cases in which there is a single Cooperative or Switching InfoCenter are not relevant since this InfoCenter will not be able to cooperate. In a $1C4S$ market, the behaviors of the InfoCenters are similar to a homogeneous market with five Switching InfoCenters. When the four InfoCenters switch to more profitable commodities, the commodities' prices remain at higher prices. Then, the Cooperative InfoCenter takes advantage of this high price. In a $1S4C$ market, the result is similar to the case of five Cooperative InfoCenters. Although the Switching InfoCenter has the capability of switching between commodities, the four Cooperative InfoCenters will nevertheless enter a price war that will cause a reduction in the prices of the commodities.

A Basic InfoCenter in any heterogeneous market is never more profitable than a non-Basic InfoCenter. The capabilities added in all the non-Basic behaviors always increase the profit of the InfoCenters that follow them. Notice that this conclusion justifies the implementation of InfoCenters in E-markets.

Moreover, from all the simulations run, we can also advise the design of an InfoCenter with both Switching and Manipulate Information capabilities. We expect that these will result in the most profitable InfoCenters.

Trading with manipulated information enriches the market with newer information products and therefore improves the situation of InfoCenters as compared to regular sellers. Additionally, the buyers in this E-market benefit from being able to request richer and newer information products. If there are other InfoCenters implemented in the same E-market, we learned from our simulations in heterogeneous settings that a single Manipulated Information InfoCenter benefits the most, since it offers products that the others do not have, and can sell them at a monopolistic price.

Switching among commodities increases profit over Basic InfoCenters. Therefore, we expect that Switching will contribute to the Manipulated Information InfoCenters increasing their average profit as well, by avoiding entering price wars over products. If there are other InfoCenters in the E-market that are Manipulated Information as well, the Switching characteristic will enable the InfoCenters to specialize in niches and will be less influenced by price wars by switching to more profitable commodities.

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