THE EFFECTS OF MARKET-ENABLING INTERNET AGENTS ON COMPETITION AND PRICES[1]

Kevin Crowston
School of Information Studies
crowston@syr.edu

Ian MacInnes
Syracuse University
School of Information Studies
imacinne@syr.edu

ABSTRACT

The Internet offers a vision of ubiquitous electronic commerce. A particularly useful feature is the ability to automate the search for price or other information across multiple vendors by using an "agent" to retrieve relevant information. The use of agents has the potential to dramatically reduce buyers' search costs. We develop a framework that suggests that vendors who sell products with many differentiating factors beyond price will tend to accept agents, while vendors of commodities or branded goods will tend to resist them unless they have lower costs than their competitors. Empirically, we found that agents seem to be accepted for differentiated goods, but resisted for more commoditized goods, though not universally. An analysis of prices from one agent shows that 1) a small number of vendors tended to have the lowest prices and 2) while divergence in pricing remains, price dispersion declined over the period studied.

1. Introduction

Networks bridge geography, distance and culture, creating new opportunities for interaction and competition. Debate is increasing on how the on-going digital and communications revolution will change the nature of commerce. The growth of commerce on the Internet has attracted special interest. Being a public network and increasingly ubiquitous, the Internet neatly addresses the problem of connectivity between potential trading partners (Neches, Neches, Postel, Tenenbaum, & Frank, n.d.), extending even to consumers. The existence of multiple vendors for some goods leads to the possibility of a market for those items, in the specific sense of multiple vendors whose prices and offerings are compared for each sale.[2]

Clearly there are many potential obstacles to Internet commerce—the need for security, authentication and payment schemes are frequently mentioned, as are the lack of negotiation protocols or even commonly accepted business practices—but these are rapidly being addressed. Internet sales are expected to continue to increase, following the lead of catalogue and television sales. There are already numerous Internet vendors selling a variety of products, including music CDs, computer hardware and software and a host of others.

The basic argument of this paper is that one approach to developing an Internet marketplace is through the use of an "agent." An agent is a program, simple or intelligent, that operates autonomously to retrieve and process

[1] Parts of this work appeared earlier as Crowston, K. (1996). "Market-enabling Internet agents". In J. I. DeGross, S. Jarvenpaa and A. Srinivasan (Eds.), *Proceedings of the International Conference on Information Systems*, Columbus, OH and Crowston, K. (1997). "Price behaviour in an electronic market". (Research in progress paper, International Conference on Information Systems, Atlanta, GA). This paper has benefited from discussions with Martha Garcia-Murillo, Sunil Gupta, Robert Heckman, Junseok Hwang, Jian Qin, Dmitri Roussinov, Steve Sawyer, George Widmeyer, Rolf Wigand and Ping Zhang and from the assistance of Jackie Chang, Rajah Shah and Phillip Strnad. This work was partially supported by a grant from the i-Lab, London Business School.

[2] Note that we do not consider as markets a single merchant who stocks multiple products or a "mall" hosting multiple merchants but lacking features for making price or other comparisons across merchants. This definition excludes many self-described markets, such as Industry Net.

information on a user's behalf [Maes, 1994]. In this paper, we focus on the use of agents to support a potential purchase decision. The idea is that a computer program can retrieve [or even negotiate, e.g.,Chvez, Dreilinger, Guttman & Maes, 1997] price, availability, and other product information for a desired good and compare them to identify the vendor with the lowest-cost or best set of features, thus automating part of the purchase process and increasing market efficiency. For example, Andersen Consulting's Bargain Finder agent [Drulwich, 1996], now defunct, took the name and artist of a music CD and retrieved its price from several Internet CD stores with on-line searchable catalogues. This agent quickly identified which vendors carry the CD and facilitated easy price comparisons, key characteristics of an efficient market.

The remainder of the paper is presented in two parts. First, we discuss the function of market-search agents. The distinctive contribution of this paper is a framework for the role of such agents in electronic commerce. This framework is summarized in a payoff matrix showing the outcomes from decisions by vendors to cooperate or resist the use of agents. Analysis of the incentives for participation in an electronic market is a necessary precondition for their development. In this, our goals are similar to those of Reimers [1996] who analyzed the institutional and incentive structure pre-conditions for electronic markets. We use our framework to predict the kind of goods for which agents are likely to be successful.

In the second half of the paper, we compare the predictions of our framework with illustrative examples of buyer's agents for a range of products. We note a prominent counter-example to our predictions, shopper.com. To further explore the framework, we report on an analysis of price data gathered from shopper.com. We use this data to explore the fit between the framework's predictions and empirical observation. In particular, we test a crucial assumption of the framework, that the vendor that has the lowest prices for one product will be cheapest for many ("winner-take-all"). We also examine changes in prices over time to test a common prediction of the electronic commerce literature, that better information leads to convergence of prices [e.g., Bakos, 1991] .

2. Literature Review

Agents are software programs that operate autonomously to retrieve and process information on a user's behalf [Maes, 1994]. Many simple agents are already available to assist in navigation and information retrieval [e.g., O'Leary, 1996]. Deployed on the Internet, agents make searching for information easier. Guttman et al. [1998] note that agents can support different stages of a buyer's purchasing process: need identification, product and merchant brokering, negotiation, purchase and delivery, and service and evaluation. Similarly, Jonkheer [1999] provides a model of a transaction to show where agents can make provide assistance. Agents assist buyers because they can retrieve relevant information directly from on-line vendors and present it to a potential buyer in summary form [e.g., Chavez et al, 1997; Doorenbos, Etzioni & Weld, 1997; Yovovich, 1995]..

In this paper, we focus in particular on the use of agents to choose a vendor for a particular good, what Guttman et al. [1998] call merchant brokering. Greenwald and Kephart [1999] call such an agent a "shopbot". When such an agent operates across the range of vendors offering a product what [Yovovich 1995] referred to as a buy-side agent, rather than a sell-side agent), it essentially creates an electronic market comprising the offerings of these vendors. Viewing agents as market enablers has the advantage of bringing to bear the extensive literature on markets, electronic and otherwise.

Of course, electronic markets are nothing new. Formal electronic markets have developed for specific goods, such as airline reservation systems, stock markets, as well as electronic markets for electric power [Johnson, 1995], airliner parts [Choudhury, 1997; Malone, Yates, & Benjamin, 1989, p.167], truck capacity [Steimfield. Kraut & Plummer,1995] and even seeds [SeedQuest OnLine, http://www.seedquest.com/]. However, agent-enabled markets differ in at least two significant respects.

- First, the Internet is non-proprietary and public, so it is possible for an agent to access prices from a variety of vendors without special technical arrangements. As a result, an agent can create an effective electronic market from the diverse offerings of independent vendors (the "involuntary market" propery), at least in the sense of facilitating the contact between buyer and seller [Bailey & Bakos, 1997; Malone, Yates & Benjamin, 1987].
- Second, an agent can search vendors in parallel rather than sequentially, thus reducing search costs to zero at the margin (the "zero-marginal-search-cost" property). Of course, even a simple database of prices could have this effect, although creating such a database without the cooperation of the vendors basically requires creating an agent to gather the prices.

There is evidence that even simple agents reduce a buyer's search cost. For example, [Doorenbos et al. 1997] report on the use of an agent called ShopBot in a trial with seven users. They compared the performance of users using only ShopBot, those given a list of 12 vendor URLs and Internet search tools, and those using only the search tools. Users with ShopBot finished much more quickly (13 minutes vs. 112 and 59, respectively) and found generally

lower prices. The small sample size precludes conclusions of statistical significance, but the magnitude of the differences indicates the promise of this technology.

Since the use of agents significantly reduces buyers' search costs, their use has consequences on the market and for vendors. Many authors have noted that the existence of buyer search costs lead to differences in prices for standardized products [Pratt, Wise & Zechkauser, 1979]. Therefore, a system that provides better information should increase price competition [Alba et al, 1997; Bakos, 1991]. In a laboratory study, Lynch and Ariely [2000] found that increasing ease of comparison increased price sensitivity for common goods, but not for unique goods. As Stigler [1961] puts it, "price dispersion is a manifestation—and, indeed, it is the measure—of ignorance in the market" (p. 214). Conversely, in the absence of information prices should differ. Bakos [1997, p 19-20] shows that freely supplying product information, but not price, increases a vendor's profits by reducing buyers' motivation to keep searching once they have found the most appropriate product.

Price convergence, to the concern of vendors, is unlikely to happen upwards. Instead, agents are likely to put downward pressure on prices and therefore lead to similar low prices. Since agents summarize price information so buyers need only to look at the list and choose the lowest price, widespread adoption of agents means that the lowest-priced vendor will take the market in its entirety. In other words, easy comparison with agents creates a "winner takes all" market [Frank & Cook, 1995] for each product.

Vendors, possibly aware of their negative effects, have often resisted the introduction of electronic markets. [Bakos 1991, p. 299-2300] illustrated this with the example of bond traders. Numerous mechanisms can be used to block agents and thus avoid an involuntary market. Technically, a vendor's server might be programmed to reject all connections from the address of a known agent, as happened to Andersen Consulting's Bargain Finder. Vendors might also attempt to frustrate automated searches, e.g., by frequently change the user interface to be incompatible with the agent, limiting the number of price requests answered within a given time period to a level consistent with human rather than automated search or requiring that searchers logon and navigate through a succession of store pages rather than entering a search directly. Blocking might also be done institutionally, e.g., by refusing to pay commissions or legally restricting the use of price information. E-bay, for example, has sued the developers of an agent (auctionwatch) that searches their database. On the other hand, Bhargava et al. (in press) note that agents may be more successful if they can include all vendors, giving agent developers an incentive to attempt to work around blocks.

Products can also be designed to frustrate comparison. Zabih [1996] notes that manufacturers can protect vendors by developing different models to make comparison difficult, as is already done to differentiate mass-market and specialty stores. Airlines offer many different prices and rules to make comparison difficult [Bakos, 1991, p. 302]. On-line, Virtual Vineyards reportedly gave products unique names to frustrate comparison shopping [Heilmann, Kihanya, Light & Musembwa, 1995].

Finally, vendors might avoid comparison by not providing prices. Choudhury [1997], for example, noted that prices are rarely given on the Inventory Locator Service, an electronic market for aircraft parts. Another approach is having the buyers themselves decide on the price of any given product, i.e., an auction. An early example is the United Computer Exchange [Quelch & Klein, 1996] and OnSale auction computer equipment. Quelch and Klein [1996] point out that increasing the audience for auctions should increase prices, so such vendors have an incentive to have the largest audience possible. Finally, Greenwald and Kephart [1999] suggest that vendors might use agents themselves ("pricebots") to determine the appropriate price to charge given the circumstances.

If a vendor finds blocking difficult or is unable to develop a mechanism that limits the effectiveness of the agent, higher-cost vendors might decide to compete only in non-electronic commerce. Higher-priced vendors will have to lower their prices or exit the market, either to focus on goods for which they are competitive, or perhaps to compete only in non-electronic markets, serving the uninformed [Salop & Stiglitz, 1997] . As Bakos [1991] notes, the result of a market with customers with high and low search costs is a separating equilibrium.

In summary, the literature provides two important messages: first, that agents can lead to increased price competition, and second, that vendors can react by implementing strategies intended to make the use of agents difficult.

3. Analytical Framework

In this section, we present an analytical framework for a vendor's decision to accept or block an agent. We discuss first the assumptions behind the framework, then the framework, then possible limitations of the framework and its fit to the empirical situation of agents.

Assumptions of the Framework

This analysis assumes that there is more than one vendor for a good. We also assume that the good must be easily describable. Current agents and those likely to be available in the near future do not work well for products that are difficult to describe, since it is difficult to ensure that like products are being compared. However, electronic commerce does not work very well in this case either, because potential purchasers have the same problem in knowing what they are buying. In other words, unique non-comparable goods are difficult for both agents and human buyers to search.

We also assume that each vendor provides a way to search its offerings to determine availability and price and that these prices are available to any user on the Internet. This condition is not always true, as Zabih [1996] points out. However, availability and price must be provided if transactions are to be completed on the Web, i.e., without requiring off-line interactions. Furthermore, any individual vendor can benefit by being the first to offer more convenient fully-electronic transactions. Therefore, it seems likely that vendors will eventually make prices available, and this is the case for the vendors we studied.

Given such multiple vendors providing price information for identifiable products, a buyer interested in buying a particular product can comparison-shop to pick the lowest-cost provider. Therefore, there is a possible role for agents to speed up the search process as discussed above. Users looking for a particular product can use the agent to determine which vendors offer it and at what price and therefore choose the lowest-priced vendor.

The Framework

Our framework represents a vendor's choice of whether to block or accept an agent through a simple payoff matrix. If an agent is developed, vendors take some action in response. There are two basic actions that will affect profits: to either accept or block the agent.

- Vendors might accept the agent. Since the buyers using the agent will presumably choose the vendor with the lowest price, vendors with higher prices must either lower them to be competitive or exit the market. Either action leads to the common prediction that extensive use of agents should result in price convergence and lower prices in the market [Bakos, 1991]. This hypothesis will be tested in this paper.
- Vendors might try to block the agent in the various ways described above. Presumably, if the agent is owned or supported by the vendors, they will already have decided to participate, so this action should be restricted to cases where the buyer or third parties support the agent. Krulwich [1996] points out that blocking is a more difficult decision if many people are using the agent. This observation suggests that vendors who will not benefit from an agent should try to destroy its utility before it becomes popular.

An economically rational vendor will make the decision to accept or block an agent based on the predicted effect of the agent on profit. If the agent increases revenues more than costs, then there is no reason to block. If it decreases revenues, or increases costs more than revenues, then there is no reason to cooperate. While exact estimates of these costs will obviously depend on the particulars of the situation, there are some general effects:

- Costs go up because providing prices consumes some amount of resource on the vendor's server. All vendors pay this cost, although servers and agents might be more or less efficient. Costs will also increase if the vendors are supporting the agent, such as by paying a commission or paying to be listed.
- Revenues will go up if the use of the agent results in more sales. However, if buyers' choice of vendor are based entirely or mostly on price, then only the lowest-price vendor for a product will see an increase in sales for that product. Depending on how many buyers use the agents, higher-priced vendors might see some decline in their sales.

The payoffs in **Error! Reference source not found.** represents the net effect on profits of the decision as to whether to accept or block the agent. The initial analysis assumes that there are only two companies in the marketplace. If an agent is introduced and both parties block it, the profits of both firms remain the same as they were before. The respective payoffs for the low-price and the high-price company are (0, 0). If, on the other hand, both parties accept the agent, the payoffs could become (2, -3). The profit for the low-price company (company L) is higher because it has the lowest market price and will thus increase its total sales. As well, the agent includes all competitors and is thus likely to become recognized by consumers as valuable. The profit for the high-price company (company H) is lower, which represents its sales decline as customers using the agent switch to the low-price company. The overall change in industry profit is negative because the average sales price has declined. Logically, this situation is not likely to be sustained. Eventually company H will either reduce its price or leave the market. Regardless, prices seem likely to converge if both companies accept the agent. If company L accepts the agent and company H blocks it, the payoffs could become (1, -2). The agent will bring new business to company L while company H experiences a decline as some of its customers adopt the new agent. Since the agent does not encompass

the entire market not all customers will use it, so company L will earn lower profits and H fewer losses than under universal adoption. The payoffs to L blocking and H accepting follow a similar logic, though this cell seems unlikely to be attained over time, because a rational L could always gain through accepting the agent at any time. The relative payoffs imply that L will always accept the agent. Since H knows this, it receives a higher payoff if it blocks the agent. Figure 1, therefore, illustrates our expectation that high-price companies will block agents while low-price companies will not.

		High-price Company (H)	
		Accept Agent	Block Agent
Low-price Company (L)	Accept Agent	-3 2	-2 1
	Block Agent	2 -1	0 0

Figure 1. Payoff matrix for the decision to accept an agent.

From Products to Markets

Strictly speaking, the framework sketched above only applies to a single product, while vendors typically compete in markets comprising multiple products. In this section, we discuss the extension of our framework to the case of multiple products.

If vendors each offer a range of products with a unique mix of features, then there is no direct competition between them. In this situation, an agent would help by finding appropriate goods for given buyers (i.e., a product broker rather than a merchant broker, Guttman et al., 1998). If the agent is accepted, it effectively matches each company with its appropriate segment of customers given the features offered. This situation will likely hold when vendors produce their own range of products, as when manufacturers sell their products directly to end-users. Similarly, if products overlap slightly or vendors are cheapest for different kinds of products, then each vendor will be cheapest for some products and thus benefit from the agent for those products. In this case, vendors will have an incentive to block the agent for some but not all products. If blocking is an all-or-nothing decision, then vendors will have to balance the gain from the agent for the products on which they are cheapest to the loss from the agent on other products. For example, insurance policies, newspaper articles, mutual funds and airline tickets are somewhat differentiated goods, and different suppliers are likely to offer products that are competitive for certain market segments. Therefore, we predict that vendors of differentiated goods will also likely accept an agent.

On the other hand, if vendors offer identical goods that are directly comparable, we argue that it is likely that the agent will benefit only a small number of vendors, perhaps only one. Since the goods offered by different vendors are identical, buyers are likely to distinguish between vendors on price. The vendor with the lowest overhead and markup should be able to offer all products at the lowest price. As a result, this vendor should be able to capture all of the buyers (i.e., “winner-take-all” for a product extends to “winner-take-all” for the entire market). This situation will apply in particular to branded goods sold by retailers, since they are the same for all retailers and all retailers ultimately buy them from a single manufacturer at more-or-less the same price. There is some empirical evidence for this extension. For example, Brynjolfsson and Smith [2000] found that a single vendor had the lowest price for more than three-quarters of the books and CDs they examined. As a result, an agent for these kinds of goods will be perceived as a threat by most vendors.

In summary, agents should be useful and accepted markets for differentiated products where there is a range of goods and prices with a variety of features that must be traded-off. For commodity or branded good markets where there are similar or identical products that differ primarily on the price charged by different retailers, only a few vendors will benefit and other vendors will likely attempt to block the agent. In this case, the agent will likely cease to be useful or a feature war will ensue.

Limitations of the Framework

Our framework focuses on price and does not incorporate all of the factors relating to consumer choice of a particular vendor. Shipping charges and taxes, for example, vary depending on the location of the customer relative to the vendor. These factors increases the probability that different companies will have the lowest overall price for given customer segments. These factors also make it more complicated for agents to provide accurate pricing

customized for each buyer. As a result, if a company is lowest on price alone but not on price plus taxes, shipping and handling, it may still receive some of the business that might have gone to the low-price provider because some customers may not calculate shipping information for each competitive firm. (Indeed, some vendors seem to avoid providing shipping charges until near the end of the transaction.)

Furthermore, Alba et al. [1997] argue that agents need not have only a negative effect on price, because vendors can also provide information about quality that differentiates them. For example, some customers might want strong technical support, favourable return policies, or immediate availability with desired product options such as colours and sizes. Brynjolfsson and Smith [2000] suggest that well-known and trusted vendors can charge a price premium even without providing additional services. The more factors that can differentiate a product or vendor, the more likely that different customers will perceive different companies as the most appropriate for them. For example, a music CD vendor might specialize in a particular kind of music, making it more likely to be chosen if the request is for that style. Availability might also be an important attribute for products that are in short or varying supply [Choudhury, Hartzel & Konsynski, 1998]. The importance of these factors may lead to the acceptability of an agent.

4. Empirical Analysis

We now analyze empirical data to determine if there is evidence for our framework, specifically, evidence if there are cases of vendors blocking agents; if there is a winner-take-all phenomenon; and if there is price convergence. This section is divided into two sub-sections. The first subsection provides a brief survey of sites that offer searches using agents, divided by industries. This survey provides a quick check of the predictions of the framework, that vendors selling more commoditized products will be more reluctant to accept an agent. The second part of the empirical analysis tests the hypotheses of winner-take-all and price convergence. In this case, only products with commodity-like features were included. The purpose of this analysis is to determine if the fears that agents will cause lower convergent prices and winner-take-all are justified.

Vendor Behavior

As was explained in the analytical framework it is expected that vendors of products with differentiating features will be less likely to block agents, because for these products, price is only one of many important features. Commodities and branded products on the other hand are more susceptible to being compared only on price, so vendors selling them may be more reluctant to accept agents. As a quick check of this hypothesis—that vendors that sell commodities or branded goods actually block agents—we visited sites that enable buyers to use an agent to help find various products. Our initial survey was carried out in late 1996 and was updated with comparisons to the original findings in 2000. The following subsections present our observations for a range of industries, beginning with the most diversified and ending with those with a tendency toward commodity.

Information

In 1996 IBM offered a service called “InfoMarket” that allowed users to search the databases of numerous commercial information providers and pay only for the information they use, rather than a subscription fee for the service. For example, a search for “electronic markets on the Internet” returned numerous documents such as magazine articles or news releases, which could be purchased for between $0.25 and $3.50. As well, the search included Usenet news articles and Internet directories, which were provided free. According to Business Week [Tollbooth, 1996], IBM took 30 to 40% of each transaction, making this a supplier-supported agent. In 1998 IBM sold InfoMarket to Knowledge Link. Most recently it became available as Powerize.com as part of Hoover’s Online. The service now offers over 10,000 sources total, 2,400 free and the remainder on a pay-per-view or subscription basis. Northern Light provides a similar database with free and pay-per-view articles. In a sample search, documents ranged in price from $1 to $2.95. One thing that is striking about these services is that even though they provide some information for free, other publishers are still willing to participate. The framework predicts their rationale: since the goods are diversified, competition is based on availability or quality, not just price, making the search engine attractive to a range of vendors.

Insurance

In the insurance industry, several sites provided price comparison services at the beginning of the study. These include Coversure, 4 Insurance, and Insurance Shopping Network. Insurance Matters [now called Coversure, http://www.coversure.co.uk/main.htm], offers interactive quotations from a choice of several UK insurance companies. 4 Insurance [http://4insurance.com/] and the Insurance Shopping Network [http://www.800insureme.com/] similarly provide competing quotes. A purchaser fills out a form to request quotes for life, health, property, or auto insurance. Insurance agents pay to join the system and are sent leads in their geographic or coverage areas. However, in this case, the quote is returned by fax or telephone. Another site, Quicken Insurance [http://www.insuremarket.com], is now providing real time insurance quotes over the Internet from over

25 companies. The existence of these services and the ability of companies to provide customers lists of quotes from several companies indicate that this industry is embracing agents without much concern. In this case, the products being sold are diversified, so a company could expect to be the most attractive quote for some area of business. As well, customers may make decisions on attributes other than just price, again distributing purchases across the suppliers. Buyers of insurance have a range of different needs, so one product does not fit all.

Airline tickets and hotel rooms

One of the earliest electronic markets was developed for airline reservations. Numerous companies now provide access to airline reservations from a Web page. Furthermore, major airlines provide on-line reservations directly, such as Northwest Airlines [http://www.nwa.com/], British Airways [http://www.british-airways.com/], and American Airlines [http://www.aa.com/]. Although airline tickets have fewer features to choose from, there are elements that key them from being entirely commoditized, for example, choices between first and economy class; the time of day when the passenger is traveling; and the number of stops before reaching a destination. Since there are multiple airlines and multiple combinations for each of these factors, a traveler will find that under certain specifications some airlines will be cheaper while when using different specifications a different set can appear [Clemons, Hann & Hitt, 1998]. On-line travel agents such as Expedia and Travelocity continue to have strong brand recognition while discounters such as Cheap Tickets [cheaptickets.com] have become popular. It is interesting to note, however, that airlines will sometimes offer special incentives such as frequent flyer miles, for the use of their own web sites for booking reservations. Savvy buyers may choose to search an agent for the best price and then book directly with the airline.

Major hotel chains such as Marriott [www.marriott.com], Hilton [www.hilton.com], and Sheraton [www.sheraton.com] also offer on-line information and reservations. These are also available through general service travel agents such as those mentioned above. Online travel services typically list several dozen chains and independent hotels and provide a way to search them based on location, price, and features. Again, since hotel rooms are somewhat differentiated, an agent will likely be acceptable to owners of hotel. Furthermore, an intelligent agent might be useful to a potential customer by showing the trade-offs between location, price, and features in making a recommendation. Again, this example seems to support our general hypothesis.

Music CDs

In this category we visited two sites: Bargain Finder and ShopBot. Bargain Finder [http://bf.cstar.ac.com/] was the first widely known buyer's agent. It was developed as a research project at Andersen Consulting's Center for Strategic Technology Research [Krulwich, 1996] but never deployed commercially. Given an artist and the title of a music CD, this system retrieved price and shipping information from a number of on-line stores. Because the same manufacturers supply the CDs these stores stock, our framework suggests that most merchants will resist the development of the agent. In fact, the utility of the system was hampered by large-scale non-cooperation. Bakos [1997] reports that the system initially searched fourteen stores, but several dropped out immediately. When we tried it in 1996, it searched eight stores searched for an album, but retrieved only three prices. Three stores were listed as blocking the agent, while at the other two the agent "had trouble shopping". This search also demonstrates the potential utility of an agent, as the three prices retrieved varied from $9.97 to $11.66, not including shipping. In searching for the same album as Bargain Finder, ShopBot was able to find two prices, $11.05 and $13.98, but failed to find prices on two other sites that it searched. However, it did retrieve the appropriate pages, which could be examined manually.

From the point of view of an agent, music CDs are like a commodity, since if someone wants to buy a CD from a particular artist, the major factor distinguishing vendors is price. It is therefore not surprising that sellers are reluctant to accept the agent. Our research in 2000 showed that CD prices continue to be difficult to compare using agents. According to bargain shopping site eSmarts [http://www.esmarts.com/music/music_shopping_agents.html], shopping agents do not produce helpful results. For example, some agents, like Bottom Dollar and Junglee, give good results though for very few stores (consistent with our prediction that only a few vendors will accept an agent), while others, such as ShopFind, search many stores but do not succeed in identifying the lowest prices.

Computer hardware

In this category we initially visited Price Web, Shopper.com [http://www.shopper.com/] and ShopBot. We used each to search for prices for a Hewlett Packard DeskJet 660C printer. Price Web (no longer operational) took price and availability from published advertisements for computer peripherals (printers, CD-ROM drives, monitors, modems, scanners, and video cards) and published them on the Web [Zabih, 1996]. In other words, Price Web collected prices manually, rather than automatically. Prices varied: in our search, the advertised price for the same HP DeskJet 660C printer ranged from $339 to $489.

Shopper.com (originally called uVision and now part of c|Net), provides access to a database of prices supplied by merchants. Shopper.com appears to be supported by advertising on the site and some affiliate programs, but vendors apparently agree to list their goods and prices, rather than shopper.com collecting them without prior arrangement. On one search, prices ranged from $280 to $416 for the DeskJet 660C printer. A search conducted in 2000 for a later generation product, the Hewlett Packard DeskJet 880C, revealed similarly diverse prices, ranging from $153 to $249 from six vendors.

ShopBot is the only one of the three that actually obtained prices in real-time from vendors' websites. With ShopBot, the search for was somewhat less successful. Searching eight stores, it retrieved 30 product listings, of which only six were for the printer (25 of the 30 were from one store where the search retrieved all product descriptions including the word "HP"). Only four listings included a price; the other two were hot links to pages that included the price. Prices offered ranged from $365.95 to $619. Interestingly, the highest price was from a store located in Canada, which presumably quoted a price in Canadian dollars. As well, the agent "had trouble shopping" at three stores, although they could be searched manually, and one actually had a lower price ($289.99). A search conducted in 2000 for the DeskJet 880C found 29 listings of which none was the requested printer. All listings came from one vendor, Beyond.com. The difficulties ShopBot had with sites are indicative of the challenges facing agents.

When we updated this survey in 2000, we also examined Price Watch [www.pricewatch.com], a vendor-supported price database similar to shopper.com. A search in this system for the Hewlett Packard DeskJet 880C obtained prices from 5 vendors, two offering refurbished printers. The prices from the other three ranged from $169 to $228.

Computer hardware is an interesting segment because our framework predicts that the branded computer products market would cause suppliers to resist shopping agents. However, according to bargain shopping site eSmarts [http://www.esmarts.com/computers/], computing is the only category for which consumers can rely entirely on shopping agents to do the work. In particular, shopper.com and pricewatch seem to have been accepted by a number of vendors, counter to the predictions of our framework.

Books

More recently, we found another surprising case that did not exist in 1996: the market for books seems to have an effective agent to find prices, BestBookBuys.com. This agent searches across 23 vendors, including Amazon, Barnes and Noble, and Borders. The site makes money from the referral fees offered by the vendors and from selling advertising. Searches list each seller according to true cost to buyers, including shipping for a single title, from lowest to highest. BestBookBuys.com also provides information about the shipping carrier and amount of time it can take to receive the items. For example, a search for Amy Jo Kim's *Community Building on the Web* resulted in 18 hits from 16 vendors. One of the vendors listed twice had a club and regular price while the other had new and used versions. The search identified these special cases correctly. Prices including shipping ranged from $22.74 to $35.74. Only two sets of two vendors offered the same delivered price. The site also has a list of special promotions available to buyers. The cooperation of book vendors is surprising because we consider books a commoditized product similar to music CDs. Indeed, the success of the BestBookBuys.com is indicative of the ease of price comparison. Book publishers have agreed on a standard product number, the ISBN, with which books can be easily searched by an agent, ensuring accurate results.

Table 1. Predicted acceptability of agents to vendors of different goods.

Acceptance	Resistance
Information	Music CDs
Insurance	Book*
Airline tickets	Computer hardware*
Hotel rooms	

** There appear to be accepted agents for these goods, contrary to the predictions of our framework.*

Error! Reference source not found. summarizes our findings from an initial examination of vendor behaviour. These results are consistent with the analytical framework with the exception of the acceptance of shopper.com, pricewatch and BestBookBuys.com.

Price Data

In the remainder of this section, we will further explore the counter-example of shopper.com's success by examining price data from this agent. The analytical framework suggests that vendors will not have an incentive to cooperate with an on-line market for branded goods, yet shopper.com is apparently successful in attracting vendors to just such a market Note that our description of shopper.com's features captures its state at the beginning of our study in 1997. More recent changes to its features are described later in the paper.

Hypotheses

One possible explanation for the success of shopper.com is that buyers are choosing to purchase not just on price but are also considering factors such as the reputation of the vendors and after-sales support. In this case, higher-priced but higher-service vendors may choose to participate, expecting to win some business. Indeed, Brynjolfsson and Smith [2000] found that the on-line market for books and CDs was highly concentrated, and that the lowest-priced vendors did not in fact get most of the traffic, although they did not find that higher-priced vendors offered additional better services.

While these factors are undoubtedly important for some buyers, it seems unlikely that they were critical for shopper.com's users during the time of our data collection. While we do not formally investigate buyer behaviour in this paper, an examination of a typical shopper.com product screen from the time of our data collection (see **Error! Reference source not found.**) reveals that name, location, asking price (including shipping), availability and date of update are the only information presented for each vendor. (Again, shopper.com has evolved over time and added additional features, which we discuss below.) In other words, if buyers are deciding based on vendor characteristics, shopper.com offers little to help them do so. Furthermore, vendors can be listed in increasing order of price, again emphasizing the price comparison. The choice of vendor cannot be influenced by product features, since all of the vendors in **Error! Reference source not found.** are offering exactly the same product—just at different prices (in this case, from a low of $1,666 to a high of $2,186.96 from a vendor at the bottom of the page, which is not visible in the figure). In summary, shopper.com seems designed to help buyers choose vendors based on price, either alone or as an initial screen in an elimination-by-aspect strategy.

Another explanation for the disagreement between the framework and reality is that there is that the assumptions of the framework do not hold. Above we argued that a single vendor was likely to be cheapest across a wide range of products, as found by Brynjolfsson and Smith [2000]. However, the computer hardware market involves a variety of products from numerous manufacturers. If vendors pay different wholesale costs and mark up different products differently, it is possible that different vendors could have the lowest price for different goods. For example, a vendor might sell a lot of equipment from one manufacturer and receive a volume discount, yet pay relatively more for other brands.

If, in fact, different vendors are cheapest for different products, then many will have an incentive to cooperate with the agent. In particular, if a vendor is cheapest for only a few items, then entering an electronic market may be a good way to publicize this competitive advantage. In an ordinary market, most buyers will probably consider only a few vendors whom they have found in the past to have good prices, which makes it difficult for a niche player to be considered. In an agent market, all buyers of those items will find the niche player. In short, the seeming contradiction of the framework might be due to an over-simplified view of vendor pricing.

In this paper, we empirically test the extension of winner-take-all from individual products to the market. The following hypothesis is proposed:

H_1: prices are consistently lower at a small number of vendors across a range of products.

Second, we examine price dispersion. Since electronic markets make price comparisons essentially costless, if buyers are choosing to buy based mainly on price, vendors will be forced to have competitive prices in order to attract business. Consequently, price convergence is a common hypothesis from the electronic markets literature [Bakos, 1991]. However, previous support for this hypothesis is negative [Smith, Bailey & Brynjolfsson, 1999] . For example, Brynjolfsson and Smith [2000] found that on-line prices were lower, but that Internet prices were equally or more dispersed than prices in conventional stores. Similarly, Clemons et al. [1998] found more dispersion in the price for airline tickets than could be explained by product heterogeneity. We do not have data from conventional stores, so we can not tell if the price dispersion observed with agents is higher or lower, but we can look for on-going evidence of the effects of increased competition in the form of decreasing price dispersion. Specifically, we test the following hypothesis:

H_2: prices of vendors in an electronic market converge over time.

Seeing this change will be evidence of the effects of electronic markets on competition.

	Click for Prod Info	Click for Retailer Info	Phone #	State	Cash Price	Credit Card	Approx. Shipping	In Stock	Last Updated
1	Details	TruCost	800 892 9476	CA	$1666.00	$1666.00	Check	Yes	4-13-97
2	Details	Computer Market Place Express	610 690 6900	PA	$1679.07	$1679.07	$28.80	798	4- 7-97
3	Details	Iler Networking and Computing	970 485 1424	CO	$1680.32	Check	FREE	783	4-13-97
4	Details	Elek-Tek Inc	800 569 0565	IL	$1749.00	$1749.00	Check	6	4-12-97
5	Details	PCs Compleat Inc (CompUSA)	800 294 4727	MA	$1759.00	$1759.00	$19.95	Check	4- 4-97
6	Details	ABACUS America Inc.	619 455 7709	CA	$1764.00	$1764.00	Check	Check	3-27-97
7	Details	Computer Discount Warehouse	800 726 4239	IL	$1769.00	$1769.00	Check	Check	2-19-97
8	Details	Computer Quick	415 861 8330	CA	$1792.00	$1792.00	Check	Yes	4-8-97
9	Details	State Street Discount	800 222 4070	NH	$1795.53	$1795.53	Check	Yes	4- 9-97

Figure 2. Screen shot of a shopper.com product page, showing vendors and prices for a Compaq Deskpro computer. [URL: http://www.shopper.com.com/prdct/186/9.html; screen shot made 18 April 1997].

Data

To test these hypotheses, we collected price data for on-line vendors of computer equipment. Branded computer equipment was chosen because it is a homogeneous good, thus controlling for choices based on product differences [Brynjolfsson & Smith, 2000]. Prices were collected directly from shopper.com for the nine computer products shown in **Error! Reference source not found.**. These products were chosen to cover a range of prices (from $15 to $7,500) and types (e.g., accessories, supplies, computers, components, peripherals, and software). The analyses presented here are based on 560 days worth of data, collected between 31 January 1997 and 13 August 1998.

Table 2. Descriptions of products tracked.

Product	**Description**
Baystack 28115/Adv	Hardware—Networking hub
Deskpro 4000	Hardware—PC system
Internal 8x	Hardware component—Internal CD ROM drive
Laserjet 5M	Hardware—HP Printer
MDR-CD60 Digital	Accessory—Digital headset
Overhead Transparencies	Accessory—Supply
Transcend Enterprise	Training course
Corel WordPerfect	Software—Application (for Mac)
Windows NT	Software—Operating system

Because shopper.com is available on the Internet, an automated script was used to collect prices. However, a few nights worth of data were missed due to occasional problems in the download. Prices for the computer products were obtained from a total of 75 vendors over the course of the study. Some vendors offered prices consistently; others came and went (in fact, one offered prices for one day only). Depending on the day, there were between 1 and 37 vendors per product, with an average of 15.3 vendors per product. Reflecting the pace of innovation in this industry, several of the products (e.g., the PC, CD-ROM drive and laser printer) essentially stopped being offered during the period of the study, with only one or two vendors left offering the product at the end. The decreasing number of vendors created some problems for the analysis, as is discussed below.

Analysis

In this section, we discuss how we tested each hypothesis and the results of the analysis.

H_1: Winner-take-all. To test the hypothesis that only a few vendors have the lowest prices, we calculated an average price rank for each one. To create this measure, we first ranked the vendors for each product for each day in order of price, lowest to highest. We then averaged each vendor's ranks across days for each product, to determine each vendor's average rank for each product and then across products to determine an overall rank. A low value indicates that the vendor has consistently better prices than its competitors; a high rank, higher prices.

Ranks were used instead of average prices for several reasons. First, the computer products differed greatly in price, ranging from approximately $19 to more than $8,000 on average. Using ranks ensured that each product counted equally towards the overall rating of a vendor. More importantly, prices changed over the time of the study. A price that might have been good at the beginning of the study could become poor if other vendors lowered their prices (not uncommon for computer equipment). Calculating an average price for a vendor would make a vendor who was in the market from the start seem worse than it should. Using daily ranks instead of prices accounted for these changes. Finally, using ranks spread out vendors who might be quite close in actual price, thus emphasizing the competition between vendors[Davis, 1991]. In other words, it does not matter if a vendor is $1 higher or $100 higher than the lowest-priced competitor; it is still second.

Because there were a different number of vendors for different products and on different days, ranks were normalized to vary between 0 for the cheapest vendor and 100 for the most expensive vendor for each product on each day. For example, if there were 11 vendors for a good on a particular day, they would be assigned ranks 0, 10, 20, …, 100; if there were only 6, the ranks would be 0, 20, …, 100. Normalization ensures that a vendor does not get

a lower average rank simply because it happens to supply a product for which it has few competitors. Put alternately, normalization ensures that it is as bad to 10th out of 10 as 20th out of 20.

The results of this analysis are shown Table 3. Vendors are listed in order of increasing average normalized rank (that is, the leftmost column shows vendors from least to most expensive on average). For each vendor, the average rank is shown, as well as the number of products offered. Also indicated are the number of products for which the vendor has an average rank in the cheapest 3 (these ranks are shown in Table 3 in white on black) and the number for which it has an average above median rank (these ranks are shown on a grey background).

Table 3. Average price ranks of vendors, by product.

Vendor	Average	Number of goods	In cheapest 3	Above median price	BAYSTACK 28115/ADV	COREL WORDPERFECT	DESKPRO 4000	INTERNAL 8X	LASERJET 5M	MDR-CD60 DIGITAL	TRANSPARENCIES OVERHEAD	TRANSCEND ENTERPRISE	WINDOWS NT
3rd lowest rank	10				9	4	8	3	16	4	6	12	4
Median rank	51				48	40	47	51	50	40	50	43	50
Provantage Corp.	3	1	1										3
BuyComp	7	6	4		10	1		1	19	3	6		
Iler Networking and Computing	10	7	4		9		8	3	11	6	7		24
CMPExpress.com	10	7	4		23		12	3	5	4	2		19
Net Promenade	10	5	3		8	11				3	4	25	
4D Corp	15	5	1		32	11				11	8	12	
C.M.S.	17	6	1		11	4		18		23	35	12	
PC Save	18	1									18		
Delec	19	6	1	1	25	11	0		50		10		16
Software Street	21	5				6		16		14	27		41
Global Computing, Inc.	22	5	1			12		38	16		18		25
TruCost	23	9	2	1	21	4	30	9	21	39	51	2	33
Developer Shed	25	5			27	20				13	21	41	
Chili Pepper Computers	27	2								35	18		
NCBuy Computing Store	27	5			31	25				18	24	35	
Libi Industries, Inc.	27	1			27								
Hardware Street	28	3						46		17	21		
Neutron, Inc.	29	5	1	1	37				56	31	20		0
Wal-Mart	30	6		2	22	16		54		13	16		57
Shopping.com	31	7	2	1	0	17		93		29	35	0	40
Computer Discount Warehouse	31	5		1	19		34	35			56		11
PCs Compleat Inc	34	4	1	1	63		28	43					4
EJM Technologies	34	1								34			
Insight Direct	35	6		2	27	12		63		46	49		11
OMNA Digital	36	4		1	50					31	14		48
NECX	39	3		1	42						55		20
Elek-Tek	40	6		2	30		18	26		93	58		13

Vendor	Average	Number of goods	In cheapest 3	Above median price	BAYSTACK 28115/ADV	COREL WORDPERFECT	DESKPRO 4000	INTERNAL 8X	LASERJET 5M	MDR-CD60 DIGITAL	TRANSPARENCIES OVERHEAD	TRANSCEND ENTERPRISE	WINDOWS NT
Vektron International, Inc.	44	6		2	71		51	14	44		39		42
Anything, Inc.	44	6		2	38	28		78		48	43	28	
ComStar Co.	44	4		1	12					33	38		93
MC WORKS	46	2		1			73		19				
Systems Unlimited	47	9		4	54	38	44	48	64	25	27	61	65
GOTTAHAVEIT.COM	48	3		2						42	42	59	
McGlen Micro, Inc.	48	7		5	30	44		60		63	76	13	50
PC Zone.com	49	5	1	3	83	74	0				73		16
Access Micro	50	5		2	43	35				71	67	33	
PC Connection Inc	50	3		1				46			86		19
First Source International	51	8		5	68	47		20	39	34	64	76	60
#1 TechStore	51	3		2	30					72	52		
MacNet, Inc.	51	6		4	46	46			40	40	68	69	
32bit.com	52	6		3	73	49		42		31	35	82	
BuySoftware	52	9		4	16	34	100	100	91	42	23	14	50
Calico Software	53	8		4	80	40		7	43	36	83	100	36
CompUSA Inc	53	5		3	88		18	76			67		18
TechStore	54	4		3	55				45	64	50		
Computer Quick	54	9		5	41	34	60	31	42	80	93	45	65
Software.net	55	2		1		85							24
CDworld	55	1		1									55
RCSNet	55	9		7	48	60	48	66	21	68	67	42	77
Virtual Computer Super Store	56	4		2					81	33	30		81
Internet Shopping Network	59	7		6	69	30		59	54	57	72		73
Chumbo	62	1		1		62							
Sparco Communications	63	9		8	55	69	44	51	51	79	82	55	78
MaxComp Computers, Inc.	63	7		7	66	49		76		48	51	78	75
State Street Discount	64	7		5	86		47	89	53	59	43		72
Cyberian Outpost	65	4		4	75	56				77			50
Computer Discount Outlet	65	6		4	59			36	46	92	83		75
PC Universe	68	3		3				56			55		94
MicroWarehouse	70	4		3	80	89					97		12
Computer Stuff	73	7		6	99			64	93	71	73	28	82
Unicom-Sales	76	6		5	60		100		95	82	35		83
Internet Outlet	77	8		8	75	42	80	76	75	100	100		68
CompSource	78	6		6	80	78		61	61			100	90
Compulink Electronics, Inc	79	9		9	53	68	81	89	82	95	89	70	86
Bottom Line Distribution	80	2		2		98			62				

Vendor	Average	Number of goods	In cheapest 3	Above median price	BAYSTACK 28115/ADV	COREL WORDPERFECT	DESKPRO 4000	INTERNAL 8X	LASERJET 5M	MDR-CD60 DIGITAL	TRANSPARENCIES OVERHEAD	TRANSCEND ENTERPRISE	WINDOWS NT
Jentra	80	1	1										80
ABACUS America Inc.	86	9	9		85	91	82	97	90	90	79	64	98
Essential Data, Inc.	90	3	3					85		94		91	
Computer Bay of Kansas City	93	1	1								93		
Tenet Computer Group, Inc.	95	5	5		100	100	87	100			87		
Universal Listing Network	96	1	1								96		
Frontier Computer	100	3	3		100	100	100						
Onyx Computers	100	1	1				100						
Software Online Inc.	100	3	3		100						100		100

Average normalized rank of prices by vendor, overall and by product. Ranks of cheapest three vendors (on average) are in black with white text; ranks above median rank for product are in gray with black text. For each vendor, the total number of goods offered is shown, as well as the number for which the vendor is one of the cheapest 3 or above median. Note that 3 vendors are in the cheapest three for four of the products they offer, while another 18 are above median for all the goods they offer.

If our analysis is correct, then only a few firms should be cheapest across a range of products. Contrarily, if many firms are cheapest for a few items each, then these firms will have an incentive to participate in the agent-created electronic market so that their specialty can be discovered, thus explaining the contradiction between theory and reality.

The data in Table 3 seem to offer some support for the winner-take-all hypothesis. Three firms are in the cheapest three for 4 out of the 6 or 7 products they offered, another for 3 out of 5 products, while on the other hand, 18 vendors are in the top half of the price range for all the products they offer. Indeed, several were always the most expensive vendor for all the products they offered. A chi-squared test confirms that the distribution of vendors ranks is highly non-random ($p = 0.0000$).

Table 4 shows the actual average prices. Prices from the most expensive firms are hundreds or even thousands of dollars higher than from the least expensive. Given these price differences, it is hard to imagine that many users of this search agent choose to buy from the high-priced vendors and it is therefore unclear why these vendors choose to be listed in shopper.com.

The rank data also provides some insights into the behaviour of prices for the goods. For example, there are 3 vendors with an average rank of 0 for the Deskpro 4000. The 0 rank indicates that these vendors were cheapest during the time they offered that product. There are three such vendors because the times during which they offered the product did not overlap. In other words, for the Deskpro, vendors entered and dropped out of the market, and the cheapest vendor changed frequently. On the other hand, the lowest ranks for the LaserJet 5M are quite high, indicating that no vendor was able to be the lowest price vendor for this item consistently but the vendors remained in the market. There does seem to be some specialization of the firms: the vendors with the best price for Windows NT had relatively poor prices for other products or did not offer them at all.

Table 4. Actual average prices by product by vendor.

Vendor	BAYSTACK 28115/ADV	COREL WORDPERFECT	DESKPRO 4000	INTERNAL 8X	LASERJET 5M	MDR-CD60 DIGITAL	OVERHEAD TRANSPARENCIES	TRANSCEND ENTERPRISE	WINDOWS NT
Lowest price	7193	142	1269	159	1504	14	15	906	207
Median price	8429	158	1706	229	1622	20	19	1064	290
Provantage Corp.									269.56
BuyComp	8433.32	141.85		158.61	1505.49	15.83	15.35		
Iler Networking and Computing	7415.28		1517.66	219.63	1519.54	18.42	15.69		279.30
CMPExpress.com	8009.78		1499.36	198.88	1504.37	17.05	15.32		273.54
Net Promenade	8429.19	144.97				13.80	15.52	1081.08	
4D Corp	8712.82	145.78				18.01	15.17	1045.39	
C.M.S.	7193.40	152.01		231.62		20.28	17.62	906.07	
PC Save							16.10		
Delec	8629.16	152.86	1268.59		1539.49		16.26		273.31
Software Street		148.51		223.11		19.64	17.07		282.39
Global Computing, Inc.		154.65		242.11	1532.89		17.04		276.66
TruCost	7593.51	152.56	1620.90	211.36	1585.40	22.04	19.13	936.33	282.02
Developer Shed	8621.06	151.01				15.13	16.14	1115.15	
Chili Pepper Computers						14.93	16.11		
NCBuy Computing Store	8638.95	151.43				15.54	16.21	1117.59	
Libi Industries, Inc.	7489.95								
Hardware Street				189.03		17.57	16.71		
Neutron, Inc.	8627.26				1639.84	14.83	16.04		206.62
Wal-Mart	7407.37	154.68		238.08		19.23	16.49		289.97
Shopping.com	7725.94	157.45		226.63		20.28	18.14	955.57	289.59
Computer Discount Warehouse	8004.87		1603.00	211.28			19.14		273.44
PCs Compleat Inc	7793.60		1759.00	249.00					275.00
EJM Technologies						18.60			
Insight Direct	8544.99	145.65		177.99		17.73	18.73		273.08
OMNA Digital	7736.64					20.89	16.79		299.40
NECX	8338.92						19.54		278.14
Elek-Tek	8045.09		1475.13	192.76		29.00	19.99		264.59
Vektron International, Inc.	8265.80		1672.22	228.95	1608.43		18.51		286.46
Anything, Inc.	8712.57	151.35		179.15		17.54	18.04	1102.19	
ComStar Co.	7547.81					21.50	18.26		317.36
MC WORKS			1840.28		1547.19				
Systems Unlimited	8359.17	158.56	1699.59	232.02	1692.55	19.03	17.14	1074.06	301.53
GOTTAHAVEIT.COM						15.84	17.77	1133.63	

Vendor	BAYSTACK 28115/ADV	COREL WORDPERFECT	DESKPRO 4000	INTERNAL 8X	LASERJET 5M	MDR-CD60 DIGITAL	OVERHEAD TRANSPARENCIES	TRANSCEND ENTERPRISE	WINDOWS NT
McGlen Micro, Inc.	8230.78	159.13		219.06		21.25	20.63	1042.72	287.46
PC Zone.com	9099.00	159.98	1289.00				19.98		268.31
Access Micro	8795.88	152.10				19.04	20.14	1113.43	
PC Connection Inc				182.70			21.95		274.07
First Source International	8925.45	160.85		207.58	1590.29	20.13	19.76	1091.81	293.00
#1 TechStore	8476.76					17.58	18.97		
MacNet, Inc.	8749.00	153.73			1557.54	15.99	21.88	1135.16	
32bit.com	9111.31	158.19		170.41		20.42	17.80	1169.17	
BuySoftware	7955.30	150.93	1736.80	230.96	1824.76	17.72	16.60	1012.57	282.99
Calico Software	8151.00	161.00		228.00	1565.00	22.00	21.00	1202.00	279.88
CompUSA Inc	9471.78		1505.67	249.73			19.95		274.95
TechStore	8871.45				1551.90	17.79	19.00		
Computer Quick	8203.40	158.05	1735.65	218.91	1621.92	23.88	22.03	1062.03	299.69
Software.net		170.91							281.92
CDworld									292.44
RCSNet	8249.39	165.84	1681.48	233.59	1594.44	23.38	20.05	1046.11	312.03
Virtual Computer Super Store					1707.60	19.38	17.36		307.81
Internet Shopping Network	8388.93	157.19		217.73	1689.37	22.46	20.49		304.46
Chumbo		159.07							
Sparco Communications	8340.74	166.65	1738.79	226.49	1630.41	23.93	21.60	1077.51	306.55
MaxComp Computers, Inc.	7833.21	165.14		249.66		22.19	19.20	984.28	313.66
State Street Discount	8406.56		1586.51	254.72	1732.53	21.55	18.27		309.46
Cyberian Outpost	9131.09	159.95				23.95			289.95
Computer Discount Outlet	8594.69			233.21	1754.00	25.99	21.00		303.59
PC Universe				251.34			19.46		319.65
MicroWarehouse	9411.13	169.95					24.95		269.95
Computer Stuff	10283.53			239.87	1789.71	22.27	20.37	933.70	311.86
Unicom-Sales	8753.23		2895.65		1822.62	18.91	17.68		324.07
Internet Outlet	8252.52	166.95	1870.48	246.04	1716.92	29.07	26.05		307.95
CompSource	8668.80	167.89		248.40	1684.53			1059.65	318.24
Compulink Electronics, Inc	7752.80	168.27	1739.21	256.86	1753.62	26.59	23.68	983.50	317.13
Bottom Line Distribution		199.89			1599.59				
Jentra									317.08
ABACUS America Inc.	9022.34	182.75	1712.20	274.22	1781.21	26.25	21.01	1065.08	338.87
Essential Data, Inc.				260.01		27.00		998.00	
Computer Bay of Kansas City							26.23		
Tenet Computer Group, Inc.	11718.11	278.57	2044.83	305.56			24.12		
Universal Listing Network							24.69		

Vendor	BAYSTACK 28115/ADV	COREL WORDPERFECT	DESKPRO 4000	INTERNAL 8X	LASERJET 5M	MDR-CD60 DIGITAL	OVERHEAD TRANSPARENCIES	TRANSCEND ENTERPRISE	WINDOWS NT
Frontier Computer	10496.85	218.88	3357.90						
Onyx Computers			1733.64						
Software Online Inc.	11239.00						29.00		425.00

Note: Lowest price is in black with white text; prices at or above median price are in gray with black text.

H_2: Price convergence. To test the second hypothesis, that prices converge over time, we examined measures of dispersion for the prices for each product. Borenstein and Rose [1994] note that price dispersion can be measured in many ways, e.g., using the GINI coefficient, variance, standard deviation, coefficient of variation, relative interquintile range, or ratio of highest to lowest prices [1994, p. 656]. In their study, Borenstein and Rose used the GINI coefficient, but they stated that, "the results of our study are very similar when we instead measure dispersion by the coefficient of variation or the interquintile range" [p. 656, footnote 7]. For simplicity, we used the standard deviation and the inter-quartile range (IQR) of the prices. These measures were calculated for the prices for each product for each day. We then regressed these measures against time to determine the overall trend. If prices are in fact converging, then dispersion should be decreasing over time.

Several factors complicated this analysis. Firstly, as mentioned above, a few products essentially stopped being offered during the period of the study. Only one or two vendors offered these products at the end, making the dispersion measures for these products extremely volatile. To eliminate the biases caused by these data points, we eliminated data from days where fewer than seven vendors offered a price for a product (seven was chosen arbitrarily to eliminate approximately 15% of the data). The number of data points for each product before and after this process is shown in **Error! Reference source not found.**.

Table 5. Number of days of price data,
before and after eliminating days with fewer than 7 vendors.

Product	**Originally**	**After**
BAYSTACK 28115/A	554	554
COREL WORDPERFEC	553	553
DESKPRO 4000	485	241
INTERNAL 8X	494	367
LASERJET 5M	548	393
MDR-CD60 DIGITAL	554	554
OVERHEAD TRANSPA	555	555
TRANSCEND ENTERP	545	499
WINDOWS NT	552	404
Total	4840	4120

Secondly, we expected the price dispersions to be correlated with the prices of the products: products with higher prices are expected to have higher price dispersion. If prices decrease over time, as expected, this decrease could lead to a spurious conclusion that dispersion was also decreasing. Therefore, we controlled for the price of the products by entering mean price for the regression for standard deviation and median price for inter-quartile range.

Finally, because different products had different dispersions to begin with, a dummy variable was introduced for each product.[3] In summary, the regression equations were:

$$Stdev = \beta_{11} \cdot Mean + \beta_{12} \cdot Date + \sum_{i=1...9} \beta_{1Prod_i} \cdot Product_i$$

$$IQR = \beta_{21} \cdot Median + \beta_{22} \cdot Date + \sum_{i=1...9} \beta_{2Prod_i} \cdot Product_i$$

where $Product_i$ are the nine dummy variables for the products. H_2 is that $\beta_{21} < 0$ and $\beta_{22} < 0$. The results of the regressions are summarized in **Error! Reference source not found.**.

Table 6. Results of regression of the STDEV and IQR of prices against date, by product, controlling for product and for mean and median price, respectively.

Dispersion measure	**Mean price**			**Date**			**Adj-R^2**
	β	T	sig	β	T	sig	
Stdev	.03370	6.556	.000	-.02339	-3.212	.001	.904
IQR	-.02370	-4.188	.000	-.01213	-1.466	.143	.854

β is the reported regression coefficient; T, the value of the T statistic for that coefficient; sig, the reported significance of the coefficient; and Adj-R^2, the adjusted R^2 of the regression.

As shown in **Error! Reference source not found.**, the results of the analysis of the standard deviations of the prices support H_2. $\beta_{21} < 0$, meaning that the standard deviations of the prices do appear to be decreasing over time (by just over 2 cents per day). As expected, $\beta_{11} > 0$, meaning that when the mean price of the products is higher, the dispersion is greater. On the other hand, analysis of the inter-quartile range does not provide support for H_2. The coefficient for date has the expected sign, but is not significant. On the whole though, it appears that H_2 is supported.

5. Discussion

In this paper, we analyzed the competitive effects of buyers' agents. Our framework suggests that agents will be accepted for diversified goods but resisted for commodities and branded goods from retailers. To test our framework, we examined price data from an on-line database of computer prices, shopper.com. The data from this system offers some support for the assumptions behind the framework. A few vendors seem to be consistently cheaper for the products they offer, while many others are consistently more expensive. As well, price dispersion for the products does appear to be slowly decreasing over time, suggesting that vendors are feeling the effects of this competition.

The results do not contradict our framework, but they do not help us understand why higher-priced vendors are in the market in the first place. Indeed, they deepen the mystery. While it seems logical to assume that firms would not choose to participate in a market where their prices can be easily and immediately compared to their competition and consistently found to be higher, our data suggests that this is the case.

There are several possible explanations for this apparent discrepancy. First, the nine products chosen might have missed products on which the apparently high-priced vendors are competitive. Even though a broad range of goods was included, with only nine products at most nine of the vendors could possibly claim to be cheapest for something; it is not even possible for every vendor to offer one of the three best prices for a product. It may be that there are

[3] The analysis was actually performed using SPSS's General Factorial ANOVA procedure, entering product as a factor and date and mean price as covariates.

more products like Windows NT for which a specialist firm can be cheapest. However, the odds that two vendors would by chance be in the cheapest three for 4 out of the 9 products are low, suggesting that the apparent division between high and low-priced vendors is more than just chance. A possible future study could retrieve prices for all products offered by a selection of low and high-priced vendors to directly determine the set of products for which they are competitive, thus directly testing this possibility.

Second, as we discussed above, it may be that buyers are making purchase decisions based on a variety of factors beyond price, on which the higher-priced vendors are competitive. Indeed, since the time we collected our price data, shopper.com has added Bizrate rankings and status as a "CNET Certified Merchant" for some vendors, as shown in **Error! Reference source not found.**. Brynjolfsson and Smith [2000] have argued that consumers accept higher prices because of their greater trust of the suppliers, which they argue accounts for the high market concentration they observed in the on-line market for books and music CDs. However, while these factors may make a difference, they probably do not make the highest priced vendors listed in shopper.com sufficiently attractive, especially considering the high rankings of some of the lower-priced vendors.

Finally, it may just be that electronic markets are still immature. Less charitably, vendors may not yet be aware of how harsh competition will likely be in these electronic markets. It may be that vendors are still learning about Internet commerce and view shopper.com as a simple way to get started or to gain some exposure. Non-competitive vendors seem still to be figuring out that they need to adapt (or to stick to markets where they can compete). It will be interesting to follow firms that currently have higher-prices for a longer period to see how they adapt to the competition. Recent developments suggest that vendors' strategies are starting to consider agents. For example, one recent entrant, ecost.com, advertises very low prices for items, but then adds both a shipping and a handling fee. As a result, the vendor typically appears as the lowest-price vendor on an agent's list, although the actual total price may well be higher than other competitors. Other vendors advertise free shipping, perhaps in an attempt to capture buyers put off by the first vendor's pricing model. However, our casual observations of shopper.com since our data was collected suggest there are still a surprising number of high-priced vendors participating in the market.

Finally, shopper.com now lists prices directly from a manufacturer for at least a few products. This development is consistent with our framework, which suggests that manufacturers (rather than retailers) of branded goods are likely to accept an agent. We have not explored this phenomenon in detail, but in at least one case, the price offered is lower than that from any retailer, consistent with the hypothesis of disintermediation [Benjamin & Wigand, 1995] . Of course, a manufacturer faces substantial risks in undercutting its usual marketing channels. It would be interesting to track the price of products offered by a manufacturer to determine how their prices compare to those of retailers.

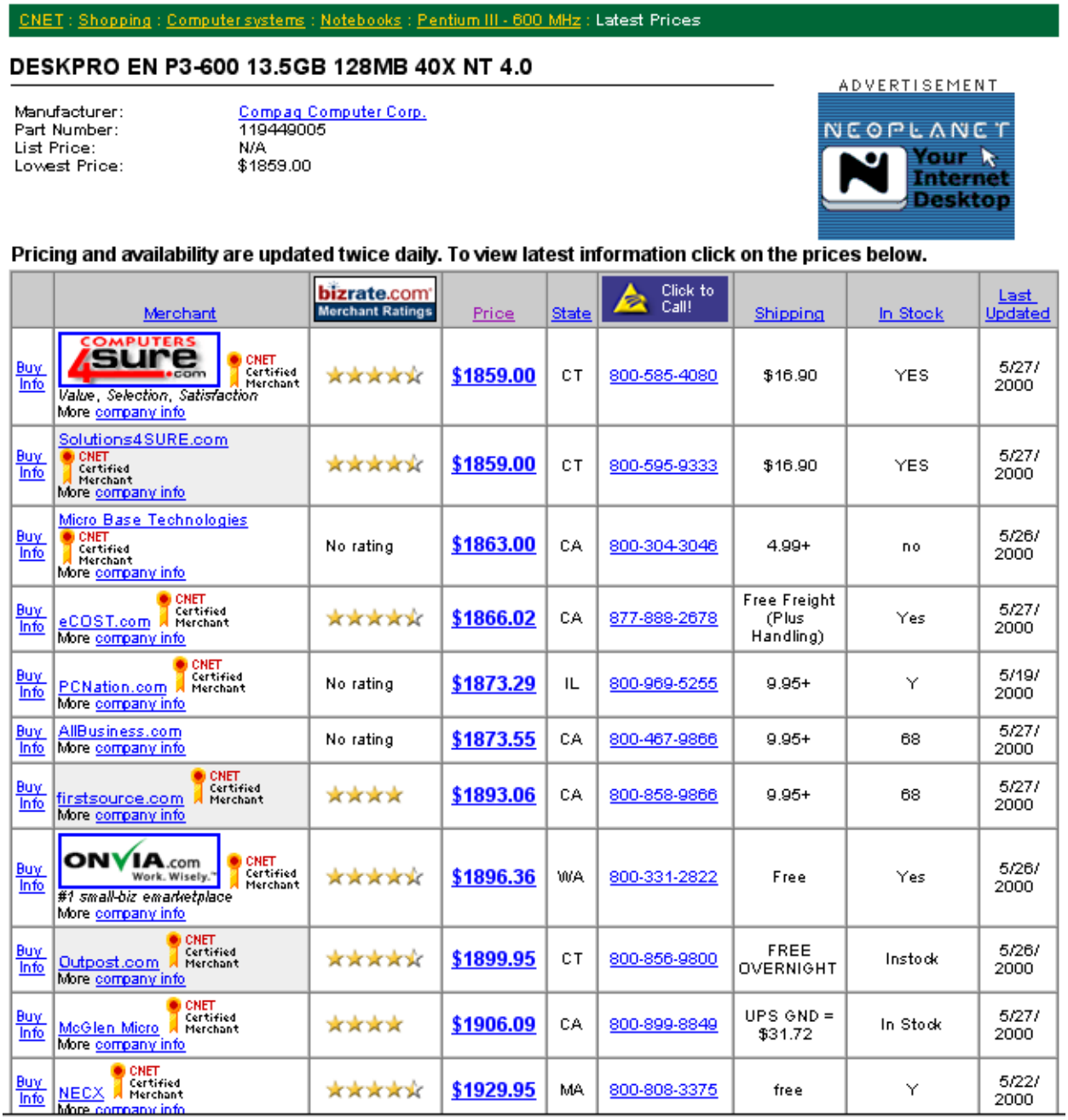

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Figure 3. Screen shot of part of a more recent shopper.com product page, showing vendors and prices for a new model of Compaq Deskpro computer. Note the addition of bizrate rankings and "CNET Certified Vendor". [URL: http://shopper.cnet.com/shopping/resellers/1,10231,0-1613426-311-1456362-3,00.html; screen shot taken 28 May 2000].

6. Conclusion

In this paper, we presented a simple framework for the decision of a vendor to block or accept a buyer's agent and provided empirical evidence to support the framework. While our framework seems to rule out many agents, blocking makes sense only in winner-take-all markets. In these markets, consumers can search only occasionally or rely on referrals to identify the lowest-cost provider and then revisit that vendor in the future. Agents are most beneficial when the lowest-cost vendors cannot be predicted, and vendors should welcome them in these cases. In

fact, vendors in these markets often introduce agents themselves. For example, airline tickets and hotel rooms differ on several dimensions, and the airlines themselves developed the reservations systems for searching these products. These systems can now be accessed via the Internet, and interestingly, different systems seem to make different tradeoffs among attributes [Clemons et al, 1998]. .

One limitation of our work is that our analysis incorporates only the merchant-brokering phase of a purchase [Guttman et al, 1998]. We assume that users have already decided what they want before using the agent. Agents can also play a role in determining which goods are appropriate, as in the case of Firefly [Maes, 1998] . In commodity or branded markets, however, the competitive forces seem to provide a negative incentive for a merchant to increase costs by providing additional information in their system. Therefore, this role might shift to manufacturers or wholesalers, while retailers focus on moving products from manufacturers to customers as cheaply as possible. Indeed, many low-cost vendors seem to offer only repackaged data about their products.

The research outlined in this paper can spawn follow-ups in several areas. First, while the evidence from our quick survey of agents seemed to support our hypotheses, it is clearly not conclusive. A more thorough survey should be done of agents to properly assess their acceptance. Second, we can apply the same methodology to collect data from Shopper.com for a wider range of products or from agents for different goods, such as books, financial instruments (mortgages, CDs) or music CDs. With some extensions, the approach might be applied as well to products with varied features, such as airline tickets and hotel rooms [Clemons et al, 1998]. The book market is interesting because it appears to contradict our predictions, while the music CD market is interesting because several CD vendors have resisted the introduction of agents, consistent with our predictions. Indeed, we have already collected some price data for CDs. Because there is no central agent with the coverage of Shopper.com, it has been necessary to implement data collections for each vendor separately. This data collection technique introduced a great deal of noise in the data, as scripts broke when a vendor changed some detail of its site, a not-infrequent occurrence. These difficulties highlight the problem inherent in developing a buyer's agent. Third, as mentioned above, we could collect prices for all goods offered by particular vendors to directly assess how competitive their prices are.

Finally, we have identified at least two cases where agents seemed to be accepted contrary to our expectations. Clearly, more research is needed to determine the cause for these seeming anomalies. Unfortunately, it will be difficult to address this issue working only with price data. To truly understand the strategy of these vendors will probably require some other methodology, such as interviews with their key decision makers. Fortunately, numerous agents have recently been introduced, so there should be many opportunities for future research to clarify the value and limitations of Internet shopping agents.

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