

Understanding the Impact of Costly Search on Market Equilibria: A Comprehensive Review

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Abstract—When consumers lack the necessary knowledge on product characteristics, in order to conclude on a purchase decision, they may need to gather information first. Collecting information is a costly process, enveloped by a degree of personalization that depends on each person's idiosyncrasy. The amount of time spent searching to reveal information depends on individual expectations and preferences, while the way this amount of time should be spent is also a matter subject to personal interpretation. Understanding the interaction between the existing competitive forces and consumer search behavior can provide useful insights and further enhance our knowledge of markets with partial information and costly searchers.

Keywords—costly search; ordered search; reservation values; telecommunications;

I. INTRODUCTION

An abundance of options available for purchase is considered to have a positive impact on consumers and the economy in general even though the existence of said options can potentially burden shoppers with the often-tedious task of searching and comparing. When facing a decision, consumers scan through products and firms looking for the best match in value and price. It is then safe to suggest that search behavior can have an impact on market structure and equilibrium, although its effect is not necessarily straightforward.

As behavior varies from one person to another, a consumer's decision-making process can also vary producing discrepancies in the way search is being conducted. A typical and familiar to most people example is the following. Imagine a three-store shopping center and a consumer looking to buy a new pair of jeans. Different levels of commitment and personal preference can vastly influence the procedure of purchasing under such circumstances. Some consumers might enjoy the process and go on to visit every relevant shop, collecting information on value and prices. Instead, others that get easily tired will consider a smaller amount of shops missing out on some of the available information. But there are also those who visit only their favorite store without partaking in any of the searching.

Two obvious and fundamental issues that arise in situations as the one described above have to do with the order and the intensity of search. In the context of the jeans example, search intensity describes the number of shops visited before a consumer decides she has seen enough to make a final decision while search order dictates which shop is visited first, which one second, third etc. Searching demands time and effort and not every consumer is bound to keep incurring search costs until every single firm has been visited. Even in an e-commerce setup aided by the use of search engines, a consumer is not expected to examine every product available as the sheer number of shops can be daunting. Apart from the number of options, the order with which consumers go through those options can vary drastically depending not only on preference, but on store location too. Although search order can be predetermined, it can also rely entirely upon the individual. Looking for a gas station, while driving in an unfamiliar region, is a classic case of a predetermined order that cannot be altered by the consumer.

On the other hand, purchasing over the internet allows consumers to perfectly determine the search order based on their needs, even though that is often not the case. An important factor that can affect a shopper's strategy is her perception of the market and, in particular, expectations regarding prices and quality. Expecting one firm to be cheaper or providing higher quality from the others could very likely alter search order but also search intensity. It would be reasonable to look into the most reputable firm first, but also to stop searching if after gathering information on a number of products, the remaining options are not expected to be up to standard.

Understanding intuitively the non-streamlined nature of a buyer's search strategy can predispose us of the impact that costly search can have on a market. Consumers search when there is imperfect information regarding the characteristics of firms and the products they supply. Obviously a fully informed agent does not need to browse through her options since she will instantly select the product that best matches her needs and competing firms have no reason to advertise or try to entice the omniscient consumer. That is rarely the case and as a result the need to search and gather information, at some cost, becomes a

necessity which in return affects the state of the competition allowing firms to take advantage.

The rest of the paper is organized as follows. In Section II, a walkthrough on the economic background of costly search models and the ideas that set the foundation for future research to come. In Section III, the most recent and relevant publications are presented along with an in-depth discussion on the research approaches taken. In Section IV, follows a brief analysis on the most notable differences among referenced publications and a market specific description of costly search issues relating to the Telecommunications Industry. Finally, some concluding remarks on the importance of studying costly search models, the current literature and potential future research.

II. ECONOMIC BACKGROUND

One of the earliest examples that study the importance of search costs appear in [1], a seminal paper on markets with uninformed consumers. Examining a model where shoppers search costly through the potential sellers in order to strike the better deal, provides a way to explain price dispersion and the reasons why prices vary even for homogeneous goods, in violation of the “law of one price”. Looking solely into this insight is enough to understand the importance of costly search as it can affect a market in a very straightforward manner.

As the significance of bending the competitive characteristics of symmetric markets became known, researchers looked towards the broadening of the initial findings. For example, [2] and [3] consider a market that consists of identical firms but incorporate product differentiation into the model. Consumers search for the best match value instead of the lowest price in a context similar to the circular product space of [4]. The main difference is that consumers are not assumed to have perfect information, allowing for their lack of knowledge to possibly alter the equilibrium. This observation is something to keep in perspective as future research would show that not even the help of the internet and its search engines is enough to provide sufficient levels of information to consumers. As search still needs to be conducted, firms employ strategies to mitigate the value that the internet provides [5], keeping the study of imperfect information models relevant.

While modeling uninformed consumers who rely on their expectations to devise utility maximizing strategies, a relevant and important challenge is to understand the optimal search strategy when ambiguity is part of the process. Should someone prefer to search sequentially or non-sequentially? Sequential search is a step-by-step process until satisfactory results appear and non-sequential occurs when the number of searches is predefined, e.g. a firm that decides to interview 10 candidates for a job position. For the purposes of this paper sequential search is examined. In this case, how should a consumer decide which firm to sample next and also for how long should the search continue? Obviously for different types of consumers, different answers might arise, so a general rule of thumb would be invaluable in order to provide robust mathematical ways to interpret consumer behavior.

Therefore, the need to propose rational and, if possible, optimal solutions to search problems becomes apparent, especially when dealing with uncertainty. If a consumer has

complete knowledge of firms’ prices and quality then searching becomes redundant. Otherwise, the best way to approach a selection problem, as seen in parts of economic literature that employ search theory, follows almost to no fault one specific rule for optimal selection as shown in [6]–[8]. In general, the decision depends on the information that the searcher collects in comparison to the expected results of not stopping.

An agent keeps on searching if the expected marginal benefit derived from her next search is greater than the maximum value she has already revealed. The maximum revealed value has substantial meaning since more often than not researchers study models in which search is conducted with perfect recall, meaning that a consumer can go back costlessly and accept any previous offer discovered. Assuming perfect recall provides some welcome simplicity without sacrificing modeling reliability as consumers are often able to keep looking for a better price without the risk of losing a deal. Purchasing on the internet is an obvious example where consumers are not equally punished for taking time to search. A well-known counter example is the job market where offers come with an expiration date. Thus, once an offer with value higher than the expected value of every remaining option is found, then the searching stops since consumers don’t expect to find something better along the way, leaving them with no incentive to continue incurring search costs to no avail.

Under a symmetric market scenario which describes firms that charge the same price or supply a homogeneous product, the difficulties of conducting an optimal search are less serious than in an asymmetric market. Intuitively, a searcher that has identical expectations regarding price and quality between his options could just as well search randomly without losing any efficiency. In the context discussed, identical might mean that their distinguishing characteristics are identically but independently distributed across a common support. What happens when expected benefits differ for each possible choice is another fundamental question that encompasses the aspect of search order in itself.

Using reservation values as a defining aspect of costly search [9] shows what the optimal search order is, without violating the already accepted rule of optimal stopping. In particular, based on the same concept of expected marginal benefit of the next search, a reservation value is calculated. Said reservation value is equivalent to the expected benefit that a search must incur in order for the consumer to be indifferent between searching or not, granted search costs and maximum revealed value. Understandably, in a symmetric situation with non-fluctuating search costs each option has the same reservation value. But when options are not symmetric, reservation values are stochastically dominated and as a result the search order becomes relevant. An important effect of the existent stochastic dominance is that riskier distributions imply higher reservation values. Therefore, it is optimal to sample spread out distributions first, hoping to come across a bargain and terminate the search process early.

III. RECENT DEVELOPMENTS

The significance of studying costly consumer search, is supported by the ongoing debate regarding the effects of search

order and intensity on markets. Prices, quality of competition, consumer and producer welfare are all being equally analyzed with researchers reaching conflicting conclusion at times. The initial assumptions made are enough to lead to different results as the nature of a market is heavily defined by vital theoretical components.

One of those components deals with the way search order is defined. Reference [10] studies an ordered search model that consists of identical firms producing a homogeneous product and consumers with constant and positive heterogeneous search costs. The major defining aspect of the model is that consumers having observed the firms' prices search sequentially in a predetermined and known to the firms order while each consumer's length of search varies. Under such circumstances prices are found to be declining in the order of search for active firms, as is intuitive. No firm has the incentive to charge higher prices than its predecessor knowing that no consumer will have the motivation to keep searching when there is no expected benefit to it. Apart from a clear departure from the traditional randomly ordered search, an exogenously predetermined order mimics some real-life situations — the gas station example mentioned earlier being one — proving useful despite its somewhat simple foundation.

Using a similar approach and an exogenously defined order, [11] derives opposite results, suggesting that consumers may keep on searching even if they expect prices to get higher. In this model, products are differentiated and the way consumers evaluate them is idiosyncratic. Also, they are not fully informed about prices, but retain rational expectations. As consumers search incurring identical costs, they reveal prices and product quality allowing for a stopping rule similar to [9] with the distinction that unlike earlier models both price and personal preference are included as deciding factors. In the concluding remarks [11] underlines possible routes to strengthen the modelling approach by allowing consumers to have varying search costs and an endogenously determined search order.

As observed, in markets with varying characteristics, expected equilibrium prices can differ significantly, an observation that engulfs the initial research goals of search theoretic models, meaning the understanding of erratic price behaviors [12]. [13] uses [14] to model consumers with identical search costs which are divided into two groups depending on desire to shop, a now classic way to include heterogeneity in a model without the complexity of a personalized search cost. Also, the order of search is naturally random as firms do not have systematic differences between them while symmetric equilibria are examined. Results show that prices increase if search costs decrease, revealing the impact of costly searching on prices in addition to the order of search. A similar outcome is derived in [15], in a study that includes unobserved by consumers double marginalization, showing that retail prices can situationally be a decreasing function of search costs, as well as in [16] that concludes that reduced search costs can occasionally lead to higher equilibrium prices in a model that allows some consumers to only search once.

Interestingly, [17] provides conditions under which prices can move both ways when search costs decrease. In this case, consumers' search costs are independently drawn from a

common distribution function. A price-symmetric case with horizontally differentiated products is studied where consumers have idiosyncratic valuations which are identically distributed across all firms. As a result of the described symmetry, search order is random without loss in effectiveness. The fact that consumers are characterized by their own cost of search is what diversifies this model. A reduction of such costs should expectedly increase the elasticity of demand and consequently reduce prices. But at the same time, lower search costs could allow for consumers with inherently higher search costs that were previously not searching to enter the market resulting in an altered consumer population with decreased elasticity of demand.

What becomes clear is that the effect of search costs on prices is ambiguous and relies heavily on assumptions made and modeling decisions. Despite its importance, the distribution of search costs across consumers is not the parameter to affect the order of search, but merely the intensity of search. The previously mentioned articles assume either an exogenously defined order or a symmetric market environment. For the order of search to be endogenously decided there needs to be a differentiating parameter between firms. Heterogeneous and idiosyncratic quality/price valuations but also firm specific search costs provide consumers with an incentive to follow a personalized search order. Sometimes it is far more enticing to go to the local grocery store than driving 30' minutes to visit one's favorite superstore. Effects of firm specific search costs apply even in the context of an internet search where time is needed to fully understand prices and multi-attribute products.

This approach is examined by [18] in an asymmetric duopoly where firms employ obfuscating tactics and decide not only on price strategies but also on the search costs that consumers incur in order to reveal product characteristics. Then clients select which firm to search first comparing reservation prices and expected benefits to optimize the procedure. The incentive for a firm to obfuscate comes with the ability to guide high-cost consumers to search first its rival firm while at the same time softening the competition for the remaining consumer population. This paper is focusing predominantly on the obfuscating behavior of firms, more so than the expected issues resulting from costly search in partially informed markets. Nonetheless, the most important observation is that consumers are allowed to select not only the number of firms they search but also the order in which to do it, something that is not the case in the vast majority of the related literature.

Towards the relaxation of search order assumptions also work a series of articles that discuss inter-firm competition for prominence, i.e. being the first option for consumers. Such a case is examined in [19] where all consumers sample the prominent firm first. The nature of the rational consumer does not change apart from the initial assumption. If the prominent firm's product is not proven to be satisfactory enough then the search continues randomly among the remaining identical firms. Various cases are then discussed, such as heterogeneity in firm quality or in consumer search costs. Each one provides the firms with different incentives to compete for prominence and charge accordingly thereafter. The way firms become prominent is also touched by [20] as the importance of being an early bird in

consumers' considerations is underlined time and again, as also shown in [21]–[25].

IV. DISCUSSION

Based on Section I, it is safe to deduce that there is no universally accepted way to describe the defining parameters of a search cost model. Arguably, it is not even needed as different perspectives provide potential answers to different questions. As a result, one can observe publications that model identical and symmetric firms that supply a homogeneous product but, as expected, distinguishable firms and product differentiation are discussed just as well. Similarly, consumer behavior is subject to the same degree of specialization.

Search costs can be identical for each consumer but also heterogeneous and independently drawn from well-behaved distributions, allowing part of the consumer base to search longer than others. A similarly heterogeneous but more standardized approach distinguishes fractions of populations, e.g. λ consumers search every firm or μ consumers search only the most popular firm, providing greater specialization.

The order of search is exogenously defined in static models but also completely random in symmetric cases with identical firms. When decisions rely on price and quality expectations the randomness no longer applies and rational consumers follow rules of optimality to maximize their welfare. Simply put, keep searching in descending order of expected benefit until no remaining choice surpasses the best yet disclosed option.

Subsequently, price distributions and product fitness take on a deciding role in determining length and order of search. Both, if modeled accordingly, are stochastically dominated by price or quality distributions. A firm more likely to be cheaper is a better choice to look into first. If said firm proves to be better than what the competition is expected to be, then the search stops.

Thus, the way products are described also becomes a vital decision. Assumptions range from firms that are completely identical and understood as such by the entirety of the population to completely differentiated both by firm decision and consumer perception alike. Obviously, instances where firms are homogeneous but its products are horizontally differentiated with consumers showing some sort of predetermined preference are also in the literature mix.

The multi-faceted perspective of search theoretic models is valuable for every market that is characterized by lack of information. The Telecommunication Industry cannot be an exception whilst the nature of this particular market might render the costly search approach even more valuable. Rationality and optimal behavior are not bound to follow the previously established rules when, for example, network externalities are present. Relevant literature has shown that externalities can have direct impact on product fitness and consumers will indeed show a degree of preference to the firm that has a strong presence in their social surroundings and also take size network into consideration, *ceteris paribus* [26]–[28].

As a result, it becomes interesting and worthwhile to discuss telecommunications under the scope of costly search theoretic models. In particular, the market specific characteristics can

create a vulnerable environment and encourage deviations from rationality. As discussed previously, preference towards a specific firm is a pivotal factor in establishing optimality in the order of search, something that comes in hand with firm efforts to establish loyalty amongst its client base. Studying consumer tendencies could then become even more important for telecommunication markets, especially when talking about 12-month contract commitments or even longer. The recurring nature of consumer decision when dealing with telecom products or services should not be overlooked. Bundling lengthy contracts along with the purchase of expensive smartphone devices adds another layer of complexity for consumers. The simplicity of this type of examples does not retract from the need of theoretical understanding.

Additionally, as price remains the most crucial attribute to decide an optimal strategy of search, telecom firms have the ability to employ various pricing schemes of their own which naturally adds even more intricacies to a costly search market approach. Tariff-mediated network externalities are powerful and at times even more so than information contagion [29]. Imagine a consumer that has to compare firms and take into consideration specialized tariffs, switching costs, length of contract etc. Considering the influence that incumbents may exert, along with the knowledge that firms have regarding clients' usage rate and contract characteristics, it is understandable that the ever-important parameters of length and search order are not impervious to firm behavior. Obviously, if a firm can effectively use its power to better its position and competitive prowess, then regulatory and competition issues can potentially arise, demanding possibly for intervention and antitrust policies.

V. CONCLUSIONS

The importance of studying markets characterized by partial information can be argued solely on the basis of its trustworthy realism. Consumers do indeed search, deciphering the riddle of "best buy", as abundance of options and competition prove to be essential economic factors. Prices, competition quality and welfare are all being influenced by consumer behavior which ultimately means that consumers collectively, play a crucial part in defining equilibria solely by striving for maximization under the scope of costly searching. Depending on the initially assumed market characteristics the direction of the equilibrium varies, enhancing even further the significance of consumer search behavior. Even using rules of optimality following a strict mathematical perspective, ambiguity persists still stands as parameterization leads to diversity in scientific results. Different types of consumer behaviors lead organically to different equilibrium outcomes.

The existent literature provides insights on a wide array of situations but as expected there appear some gaps that would need further examination. The most apparent dealing with ordered search that is endogenously decided by the consumer base. Potentially, every single consumer can have her very own preferred order of search, an approach that is very lightly touched in the literature. Modeling a single prominent firm or letting an endogenously defined order between two firms is only a foundation for what could be a far more generalized case. Also, considerations on the way order personalization is built could

also prove to be an interesting issue to examine. For example, firm size and reputation can be touted to be a defining factor as suggested in [30], or even clustering preferences influenced by friendly or family bonds. Both these examples should impact our understanding on the Telecommunications Industry where significant market power and network externalities are at least influential.

Another possible debate could be dealing with issues of bounded rationality among consumers. The question being, to what point can optimal search behavior be assumed and when should researchers begin mitigating the earlier findings on optimal stopping in order to build behavioral costly search models? But then, can early stopping be deemed as irrational when a consumer with high search costs decides to stop prematurely or does an early stop come as an expression of sensitivity to search costs, thus, a rational reaction? These are some of the main questions this paper looks to build upon for future research with the parallel goal of setting the tone and promoting further arguments and ideas on the literature of costly search.

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