Measuring the Effects of Search Costs on Equilibrium Prices and Profits *

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Abstract

This paper assesses the effects of marginal search costs on equilibrium prices and profits. My empirical strategy uses data on purchases of liquid laundry detergent and combines a "front-end" estimation of the demand and cost parameters with a "back-end" analysis to evaluate the equilibrium prices and profits with respect to marginal search costs. I find that the profits of some firms initially rise and then fall for larger marginal search costs. The magnitude and direction of the effects of marginal search costs on equilibrium prices and profits are heterogeneous, because marginal search costs create different incentives that may work in opposite directions. My results show that the effects of search costs on prices and profits are sensitive to the relation between actual prices and consumers' prices beliefs.

1 Introduction

Empirical evidence suggests that consumers often have incomplete information about the prices and characteristics of the available alternatives, and thus need to engage in costly search before making their choices (Wildenbeest, 2011; De los Santos, Hortacsu, and Wildenbeest, 2012; Seiler, 2013). These search frictions have important implications for firms, because they affect the competitive behavior and firms' incentives (Baye, Morgan, and Scholten, 2007). In particular, from a firm perspective, marginal search costs create two incentives that work in opposite directions. On the one hand, marginal search costs create an "investment" incentive for a firm to decrease prices: firms "invest" to push a product into the consumer consideration set[1], which causes a competitive

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[1]I refer to a consideration set as the optimal subset of products searched by a consumer and within which the consumer makes an explicit utility comparison before choosing the product to purchase.

pressure to lower prices. On the other hand, marginal search costs create a "harvesting" incentive for a firm to raise prices: the number of products that consumers search fall for larger marginal search costs, thus reducing the competition within the consideration set and allowing a firm to extract rents from consumers who have a greater preference for its product[2].

Even without an "investment" incentive, the effect of larger marginal search costs on profits can be either positive or negative. On the one hand, price competition is lower with higher marginal search costs, because the number of searched products is lower and a firm can extract larger rents from consumers who prefer its product. On the other hand, the probability of searching falls for larger marginal search costs, thereby reducing the customer base of a firm.

The direction of the effect of marginal search costs on prices and profits is therefore an empirical question, whose answer may depend on the magnitude of search costs. In this paper I address this question and evaluate the effects of larger marginal search costs on equilibrium prices and profits.

Identification of the direction and magnitude of the effects of marginal search costs on equilibrium prices and profits is economically important. Firms can employ strategies and choose actions to influence marginal search costs. Firms therefore want to know the level of marginal search costs for which their profits are the highest, so that they can take the necessary actions to achieve that level of marginal search costs. Even if firms cannot choose an exact level of marginal search costs, they can often choose actions that yield different marginal search costs and thus knowing the profits in each situation allows them to choose the best alternative. Regulators also have advantages of knowing the effect of marginal search costs on equilibrium prices and profits. If regulators can either take actions to influence marginal search costs or enforce firms to take such actions, then they need to know the effects of marginal search costs on equilibrium prices and profits so that they can choose the best policy. For instance, regulators want to know whether a decrease in marginal search costs lowers prices and whether such decrease in marginal search costs leads to a large fall in firms profits or can indeed rise them.

In order to find the equilibrium prices and respective profits for different levels of marginal search costs, I consider a methodology that combines a "front-end" estimation of the demand and cost parameters with a "back-end" analysis to evaluate the equilibrium prices and profits for different marginal search costs. The general strategy is as follows. First, I estimate demand and search costs. I then use the demand and search cost estimates jointly with pricing rules implied by a Nash-Bertrand pricing game with single-product firms to recover marginal costs from the profit maximization first order conditions. Finally, I use the estimates to evaluate numerically the equilibrium prices for different values of search costs and then calculate the profits associated with each of these values. I perform the analysis using household panel data on shopping trips and purchases of liquid laundry detergent. The data are drawn from two behavior scan markets

[2]There are similarities between the incentives created by search costs and the incentives created by switching costs. I therefore adopted the terminology proposed by some of the literature on switching costs (Dube, Hitsch and Rossi, 2009; Cabral, 2009; Cabral, 2013).

and cover six years, beginning January 1, 2001.

One of the challenges of this analysis is that the effects of search costs on firms incentives depend on how consumers form their price beliefs but those price beliefs are not observed. Although consumers do not observe actual prices before searching, it is possible that they receive some signal about those prices before the search process starts and this signal affects the formation of their price beliefs. The existence or not of this signal and how it informs about actual prices have important implications on firms' incentives. For instance, if there is not a signal and consumers' price beliefs do not depend on actual prices, then search costs only create a "harvesting" incentive for firms. In contrast, the "investment" incentive may be stronger than the "harvesting" incentive if there is a signal that provides complete information. I address this issue by evaluating what happens for different assumptions regarding the relation between actual prices and consumers' price beliefs.

I find that the effects of marginal search costs on profits differ across products: for some products the profits are an inverted U-shaped function of search costs, whereas for other products the profits always fall for larger marginal search costs. The inverted U-shaped relation between profits and search costs for some products occurs both when consumers' price beliefs do not depend on actual prices and when consumers have some or full information about actual prices. Yet the number of products for which profits can rise with marginal search costs and the magnitude of this rise is larger when consumers' price beliefs and actual prices are less correlated.

I show that the "investment" incentive for firms tends to be less important than the "harvesting" incentive, unless the correlation between consumers' price beliefs and actual prices is large. Hence, the equilibrium prices of almost all products increase with marginal search costs for low levels of information provided by the price signal, even though the magnitude of these increases is heterogeneous. The direction of the effect of marginal search costs on equilibrium prices differs across products and can depend on the level of search costs when the level of information received by consumers is more precise.

I explore the implications of different marginal search costs by evaluating the effects of the marginal search costs of one product on prices and profits of all products. Larger marginal search costs of a product lower the profits of that product and increase the profits of products that are not searched together with the product with higher marginal search costs. A larger marginal search cost of a product may reduce the profits of other products that are usually searched together with that product. I find that total profits can rise with larger marginal search costs of a product when actual prices are not correlated with consumers' price beliefs. Hence, limited information and costly search can create market power and yield larger profits. The effects on prices of higher marginal search costs of a product are heterogeneous and depend on the level of correlation between actual prices and consumers' price beliefs.

My findings have important implications for firms decisions. The inverted U-shape relation between profits and marginal search costs for some products suggests that some products prefer intermediate levels of marginal search costs. Firm producing these products therefore have incentives to take actions to ensure that marginal search costs do not drop to zero. Nonetheless, all firms are worse off when marginal search costs are large and thus have gains from avoiding high levels of marginal search costs.

My work is closely related to the literature on search costs. In particular, with the work that evaluates and quantifies the effects of search costs on prices and profits. Mehta , Rajiv and Srinivasan (2003) show that the size of the optimal consideration set increases with the price variance if all prices have a type I EV distribution with the same variance. Furthermore, the size of the optimal consideration set is larger in product categories with greater price variability. Wildenbeest (2011) proposes a model with product differentiation and search frictions in which vertically differentiated firms mix prices over different supports. The structure of the equilibrium model is used to estimate search costs using only price data and then to evaluate the effects of a change in search costs. Wildenbeest (2011) finds that increasing the share of consumers with very low search costs results in higher prices. Ellison and Ellison (2009) show that internet retailers often engage in obfuscation–practices that frustrate consumer search or make it less damaging for firms–which lowers price sensitive on some other products. Ellison and Wolitzky (2012) formalize the observation in Ellison and Ellison (2009) that improvements in search technology need not make search more efficient. They propose a search-based model in which firms have incentives to raise consumer search costs.

My research further relates to work that models and analyzes the importance of imperfect information and search costs on pricing strategies (e.g., Varian, 1980; Salop and Stiglitz, 1982; Pancras, 2010). Those papers show that imperfect information and search costs create different levels of consideration that firms can use to price discriminate consumers. In two seminal papers Varian (1980) and Salop and Stiglitz (1982) examine the rational of temporal price dispersion by means of sales. Varian (1980) proposes a store choice model with informed and uninformed consumers. In equilibrium, stores engage in sales behavior in order to price discriminate between informed and uninformed consumers. The decision of becoming informed or uninformed is made endogenous by assuming that consumers get fully informed if they pay search costs. Coexistence of informed and uninformed consumers is explained by heterogeneous search costs. Salop and Stiglitz (1982) consider a model with identical consumers who have imperfect information about the prices (or qualities). Consumers live for two periods and can store the good with a storage cost. Salop and Stiglitz show that, in their model, there is a two-price equilibrium where some firms charge high prices and others charge low prices.

My paper also relates to work that evaluates how consumers form their expectations about prices. Fevrier and Wilner (2013) evaluate whether consumers are fully rational and have perfect expectations given their information set or consumer rationality is bounded because of limited memory or capacity. Their results suggest that consumers hold simple expectations and behave as if they did not revise their beliefs.

Finally, my work and results relate to the literature on switching costs. Dube, Hitsch and Rossi (2009) show that switching costs can decrease equilibrium prices in a dynamic model of price competition. They point out that switching costs have two effects that work in opposite directions: (1) a "harvesting" effect that creates incentives for a firm to raise its price to "harvest" the existing consumer base, and (2) an "investment" effect that increases the incentives of a firm for decreasing its prices to raise a loyal customer base and prevent consumers from switching. Dube, Hitsch and Rossi (2009) find that the magnitude of the "investment" effect is larger than the magnitude of the "harvesting" effect for intermediate values of switching costs. Cabral (2013) shows that this result can be generalized for a broader class of situations. Arie and Grieco (2012) show that small switching costs may lead to a decrease in prices even without forward-looking firms, because firms have an incentive to lower prices to compensate consumers by the cost incurred to switch into the firm. Chen (2011) points out that the existing literature shows that switching costs usually lead larger firms to choose higher prices to explore locked-in consumers, which leads to a transfer of consumers from larger to small firms. So, there is a trade-off between the incentives to exploit current consumers and to increase market share.

The paper proceeds as follows. Section 2 presents the demand and supply model. Section 3 describes the estimation strategy and the data. Section 4 presents the results and discusses their implications for consumers and firms. Section 5 evaluates the effects of varying the marginal search costs only for one product. Section 6 concludes the paper.

2 Model

2.1 Demand

I consider a static version of the demand model proposed in Pires (2014). The modeling assumptions are as follows. When a consumer enters a store, she knows the products available but does not know the price or the realization of the random shocks associated with each product. To buy and obtain the information about the price and realization of the random shocks for a specific brand j of size x the consumer needs to pay a cost sc_{jxt}. Consumer pays a fixed cost $\bar{S}$ if she searches at least one product.

Choice is modelled as a two-stage process. In the first-stage, after entering a store, the consumer decides whether to search. If the consumer does not search, she does not have to make another decision in the current time period. If the consumer searches, she will choose the set of products to search. In the second stage, after observing the price and the random shocks for the searched products, the consumer chooses whether to buy one of the searched options. I will refer to the first stage as the "search stage" and the second stage as the "purchase stage". I assume the timing and incidence of shopping trips are exogenous.

The model considers a fixed sample size search process where consumers commit to a fixed number of searches before the beginning of the actual search. In this process the search only finishes after the consumer searched the number of products she committed to, even if she gets a good search outcome early on.[3] A justification for assuming a fixed sample size search process can be found in Pires (2013), where I find empirical evidence in favor of a fixed sample search strategy over a sequential search strategy for the data used in this paper. I show that (1) the prices of brands that are not the favorite brand affect the likelihood of purchasing the favorite brand even when the favorite brand is on sale, (2) the likelihood of buying the favorite brand falls with an exogenous and unexpected decrease in the prices of all brands when the magnitude of the price discount of brands that are not the favorite is larger, (3) the effect of the prices of the favorite brand on the incentives to continue searching after observing the price of the favorite brand is not significant, and (4) there is a negative correlation between price dispersion and search costs both within and across stores. All these patterns are expected when consumers follow a fixed sample size search strategy but usually cannot be explained by a sequential search strategy.

I define a product as a brand/pack-size combination. Let Ω_{sxt} be the set of brands of size x available in store s at period t and let Λ_{sxt} be the powerset of Ω_{sxt} excluding the empty set (the choice of not searching). Define $\Lambda_{st} \equiv \cup_x \Lambda_{sxt}$. In each purchase occasion a consumer can buy at most one product. The value obtained by consumer i in period t from purchasing brand j with size x is given by

$$U_{ijxt} = \alpha_i p_{jxt} + \eta_i I_{it} + \xi_{ijx} + \epsilon_{ijxt}$$

where p_{jxt} is the price of brand j of size x at shopping occasion t, I_{it} is inventory of consumer i at period t,[4] ξ_{ijx} is a brand-size specific effect on utility that could vary across households, and ϵ_{ijxt} is a random shock to consumer brand-size choice[5]. The value of purchasing nothing is

$$U_{i0t} = \epsilon_{i0t}$$

I assume consumers are myopic and thus they do not take into account the effect of their current choices in the future value of inventory, even though the value of inventory affects the

[3]See Honka (2010) and De los Santos, Hortacsu and Wildenbeest (2012) for a discussion about the sequential and fixed sample size search processes.

[4]The inclusion of inventory in the utility specification captures the effects of storage costs and potential effects of inventory on consumption.

[5]The prices and the nonprice attributes are store specific. The idiosyncratic tastes and the random shocks can also be store specific. I only omit the store subscript from those variables to simplify the notation. Likewise, in the specification for search costs, display and feature ads are store specific but the subscript for the store is omitted.

current utility. The evolution of inventory is described by:

$$I_{it} = I_{it-1} + x_{it} - C_{it}$$

where I_{it-1} is the current inventory, x_{it} is the quantity purchased at period t, and C_{it} is the consumption at period t.

The expected net benefit of searching the set K, denoted by V_{iK}, is the difference between the expected maximum utility of searching the brands in the set K and the cost of searching these brands. That is,

$$V_{iK} = E\left[\max_{j \in K}\{U_{ijt}\}\right] - SC_{Kt}$$

where SC_{Kt} is the cost of searching consideration set K at shopping occasion t. The search costs include a fixed component $\bar{S}$ and a specific cost sc of searching each product in the consideration set. That is,

$$SC_{Kt} = \bar{S} + \sum_{l \in K} sc_l$$

The proposed model does not allow me to identify the baseline search cost separately from the intrinsic quality of the products for an additive specification. I take that into account in the choice of the functional forms for the search costs. I assume that the fixed search cost $\bar{S}$ is

$$\bar{S} = \tilde{S} \cdot \exp\left(z^{s\prime}\beta^{s}\right)$$

where z^s are the covariates that affect the fixed search cost and $\tilde{S}$ and β^s are parameters to be estimated. For sc I assume that

$$sc = \tilde{s} \cdot \exp\left(z^{g\prime}\beta^{g}\right)$$

where z^g are the covariates that affect marginal search costs and $\tilde{s}$ and β^g are parameters to be estimated. I assume that the fixed cost of searching $\bar{S}$ is a function of non-detergent expenditure and the specific cost sc of searching a product is a function of product display and feature ads.

In the search stage consumers face uncertainty about the actual prices and the random shocks to consumer choices. Although consumers do not observe actual prices before searching, it is possible that they receive some signal about those prices before the search process starts and this signal can affect the formation of their price beliefs. For instance, if there is a positive correlation between prices and the marketing activities associated with a product, then consumers will update their price beliefs according to the level of marketing activity that they observe. Suppose firms advertise more their products during a price promotion, then consumers will believe that it is more likely a lower price when they observe advertisement, thus creating a positive correlation between consumers price beliefs and actual prices. It is important to distinguish the aforementioned effect from the effect of marketing activities on search costs. In the aforementioned situation marketing activities do not reduce search costs because their content neither provides information about what consumers are going to find after search nor reduces the searching effort. The effect of marketing activities is through the effects on beliefs that can be correct or wrong (for instance, in some situations consumers find that a product is not on sale even though it was advertised).

I do not observe how consumers form their price beliefs and thus I do not know the relation between actual prices and consumers' price beliefs. It is indeed possible that price beliefs do not depend on actual prices, but it is also possible that consumers have full information about prices. In order to evaluate what happens under different situations I assume that consumers price beliefs in period t are characterized by a distribution with all mass in $(1-\lambda)\,\bar{p}+\lambda p_t$ where $\bar{p}$ is the sample mean of prices and $\lambda \in [0,1]$. I estimate and recover the structural parameters for different situations by varying the value of λ, which allows me to consider several hypothesis about consumers' expectations.

As for the random shocks to consumers' choices, I assume they are independent and identically distributed extreme value type I. I further assume prices are independent of the random shocks to consumers' choices.

Finally, I add a mean-zero stochastic noise term ς_{iK} to V_{iK} to smooth the choice set probabilities[6]. I assume ς are independent and identically distributed extreme value type I.

2.2 Supply

For the supply side I assume each product is produced by a different single-product firm. The subscript j is used to denote both the product and the firm that produces it. The profits of firm j are:

$$\pi_j = (p_j - c_j)\, M \cdot s_j\,(p) - C_j$$

where $s_j\,(p)$ is the market share of product j, which is a function of the vector of prices p, M is the size of the market, p_j is the price of product j, c_j is the marginal cost of product j, and C_j is the fixed cost of production. I assume that (1) firms play according to a Nash-Bertrand equilibrium, (2) there exists a pure-strategy Nash-Bertrand equilibrium in prices, and (3) the prices that support it are strictly positive.

Although demand depends on the inventory hold by consumers, I assume that firms do not observe consumers' inventory and make their choices assuming that the inventory of each consumer is equal to the median inventory. I further assume that firms do not take into consideration the evolution of inventory level when choosing prices and therefore solve a static problem. One potential interpretation of this assumption is that firms receive a new group of households every week. These assumptions are consistent with some anecdotal evidence that firms are not aware of consumers' current inventory and thus their decisions are not based on this variable.

[6] See De Los Santos, Hortacsu and Wildenbeest (2012) for a discussion of this assumption.

3 Estimation and Data

My empirical strategy consists on a "front-end" estimation of demand and cost parameters and a "back-end" analysis to evaluate the equilibrium prices and calculate the profits for different search costs (see Nevo, 2000; and Nevo, 2001). I first estimate the demand and search cost parameters by maximizing the likelihood of choices implied by the proposed demand model. I then recover marginal costs from the profit maximization first order conditions using the demand and search cost estimates jointly with pricing rules implied by a Nash-Bertrand pricing game. Finally, I use the demand and cost estimates to evaluate numerically the equilibrium prices of all products for different values of marginal search costs. I then calculate the profits associated with these equilibrium prices.

One of the estimation challenges is that I do not observe the products searched by households and therefore need to integrate over all possible consideration sets. This strategy creates a complex combinatorial problem with a large number of products. To make the problem tractable, I make the following assumptions. First, products can be aggregated into ten brands: Tide, Xtra, Dynamo, Purex, All, Arm&Hammer, Era, Wisk, a Private Label, and a composite brand that includes all the other brands. Second, each product can be assigned to one of three sizes: small, medium, and large[7]. Finally, consideration sets only include products of the same size.

Other estimation challenge is that I do not observe inventory or consumption decisions. The estimation of inventory holdings follows Hendel and Nevo (2006). For each household, I start with an initial guess for inventories and then calculate the inventory in each week using the observed purchases and the estimated consumption. To reduce the impact of the initial guess, the first 8 visits of each household are used to simulate the distribution of inventories, but are not used in the estimation. To simplify the estimation, I assume that households are consuming detergent at a constant rate until they run out of inventory. I calculate the rate of consumption of each household as the ratio of the total amount purchased to the overall time in the sample. One of the flaws of this procedure is to ignore stock-outs. I, however, believe the measurement error is not large, since I observe several purchases for each household and the consumption rate is consumer-specific.

I estimate demand and cost parameters using household panel data for shopping trips and purchases of liquid laundry detergent collected by Information Resources Inc. (IRI). The data are drawn from two behavior scan markets (Eau Claire, Wisconsin; and Pittsfield, Massachusetts) and cover six years (313 weeks), beginning January 1, 2001. I supplement the panel data with aggregate store level data, which include the average price charged, the aggregate quantity sold, and the promotional activities (product display and feature ads) for each product at each store

[7]Products with size greater than 0 and lower than 4lb were assigned to the small size, products with size greater than 4lb and lower than 8lb were assigned to the medium size, and products with size greater than 8lb were assigned to the large size.

during each week. The store level data are also collected by IRI.

The raw data were cleaned to guarantee a suitable sample for the estimation. An observation in the final sample is a shopping trip. The final sample consists of 225,597 observations. It contains 704 households, 23 stores, and 366 upc's, aggregated into 37 brands from 17 different manufacturers. In the estimation I restrict the sample to the first 36 shopping trips of each households. The estimation is therefore performed using the information from 19,531 shopping trips. A detailed description of the data and the procedures to clean the raw data are provided in Pires (2013).

The identification of the utility and search cost parameters follows the same arguments discussed in Pires (2014)

4 Results

4.1 Demand

Table 1 reports the demand and search cost estimates for a static demand model with consideration sets. Each column reports estimates for specifications that differ with respect to the effect of actual prices on consumers' price beliefs. Specifications are ordered according to the level of correlation between consumers' price beliefs and actual prices. Hence, the first specification assumes actual prices do not affect consumers' price beliefs, whereas the last specification assumes full information about prices.

The results show that marginal search costs are statistical and economically significant for all specifications. The monetary value of marginal search costs seems to be higher for specifications that assume higher level of correlation between consumers' price beliefs and actual prices. The intuition for this result is that with more information about prices, the model requires higher estimates of search costs to fit the presence in the data of shopping trips where consumers miss price promotions and do not purchase the good.

Product display and feature ads reduce considerably the cost of searching a product. For instance, the cost of searching a product that is displayed and featured is less than two thirds of the cost of searching a product that is neither displayed nor featured. My goal in this paper is to evaluate the effects of marginal search costs on equilibrium prices and profits. These results therefore reveal that this evaluation allows us to understand the importance of product display and feature ads for profits and prices.

The fixed search costs and the price-coefficient constant are significant and have the expected direction. The magnitude of the price coefficient falls with respect to the level of correlation between consumers' price beliefs and actual prices. Table 2 reports the demand elasticities obtained from the estimates in table 1. Demand elasticities[8] fall with the level of price information for almost all products, but they increase in some cases for the three top products (i.e., medium packages of Tide, Xtra, and Purex), particularly for low levels of correlation between actual prices and consumers' price beliefs. The fall in elasticities for most of the products is explained by the fall in the price coefficient parameter. However, more information about prices can reduce the market power associated with the limited information, which explains the raise in elasticities for the three top products for low levels of λ.

The demand and search cost estimates presented in table 1 are used to recover the marginal costs in each shopping trip. The estimates for the marginal costs are reported in table 3. Assuming that actual prices do not affect consumers' price beliefs yields some unrealistic marginal costs[9] for 3 products–medium packages of Xtra and Purex, and the large size of the composite brand. The unrealistic values for the large size of the composite brand are partly explained by aggregation, but the negative values for some of the marginal costs of the other products are necessary for the model explaining the low prices of these products when they have a large market power due to consideration sets. The other specifications yield reasonable patterns and values for marginal costs. These results suggest that consumers may have some information about actual prices and thus the assumption that actual prices do not affect consumers' price beliefs is not the best one.

4.2 Supply

In this section I evaluate the effect of search costs on equilibrium prices and profits. The demand estimates reveal that firms can employ marketing instruments to affect search costs and consequently consumer welfare. Therefore, the identification of the direction and magnitude of the effects of marginal search costs on equilibrium prices and profits is an important economic question. It is also an empirical question, because marginal search costs create incentives that work in opposite directions. On the one hand, marginal search costs create an "investment" incentive for a firm to lower prices. Marginal search costs increase the competitive pressure to push a product into consumers' consideration sets, because consumers search less products when marginal search costs are higher. So, a firm employs actions to reduce consumers' beliefs about its prices to prevent consumers from not searching its product. On the other hand, marginal search costs create a "harvesting" incentive for a firm to raise prices. Marginal search costs reduce the number of products that consumers search, thereby reducing the competition within the consideration set and allowing each firm to extract rents from consumers who have a greater preference for its product. In summary, search costs increase the competition to be present in consumers' consideration

[8] Interpretation of the demand elasticities considers the absolute value of the estimates

[9] Peters (2006) points out that "it may be more appropriate to refer to [the value recovered from the first-order condition] as the supply-side residual rather than as marginal cost", because its value may reflect prediction errors due to misspecified conduct.

sets, but they reduce the competition within the consideration set (i.e., after the products were searched).

The aforementioned "investment" incentive depends on whether and how actual prices affect consumers' price beliefs. For instance, if actual prices do not affect consumers' price beliefs, then larger marginal search costs will not create an "investment" incentive, because firms cannot use a reduction in their prices to lower consumers' price beliefs. In this case, the direction of the effect of marginal search costs on prices is only an empirical question if, as pointed out by Cabral (2009)[10], the "harvesting" incentive is negative for some firms due to the lower demand created by marginal search costs. In contrast, if there is a signal correlated with actual prices, then there is an "investment" incentive, which can indeed be stronger than the "harvesting" incentive.

The effect of marginal search costs on profits is an empirical question, even without an "investment" incentive or a fall in prices. On the one hand, larger marginal search costs reduce price competition by lowering the number of products in each consideration set, which increases the rents that a firm can extract from consumers who prefer its product. On the other hand, larger marginal search costs decrease the probability of searching, thereby reducing the customer base of a firm.

There is an analogy between the effects of search costs in my model and the effects of switching costs identified by the extant literature (see for example, Dube, Hitsch and Rossi, 2009; Cabral, 2013). For instance, Dube, Hitsch and Rossi (2009) point out that switching costs create two incentives that work in opposite directions: an incentive "for a firm to lower its price and 'invest' in customer acquisition", and an incentive "for a firm to raise its price and 'harvest' its existing customers". There is, however, some differences between the effects of search costs and switching costs. First, in my framework firms do not solve a dynamic problem and thus the "investment" incentive occurs through price beliefs and their effects on consideration-set formation rather than through the dynamic gains from raising the loyal customer base. Hence, in a model with search costs the benefit of reducing the price is only for the current shopping trip and the magnitude of the effect may therefore be lower than in a switching cost model. Second, in a search model there is not an existing customer base and thus the "harvesting" incentive refers to consumers with stronger preferences for the brand. Finally, switching costs create a vertical differentiation among products, whereas in my model search costs do not create vertical differentiation. The only differentiation created by search costs is against the outside option, because the value of the outside option increases with search costs.

In the next subsections I evaluate the effect of search costs on equilibrium prices and profits for different levels of information regarding actual prices. I start by considering a situation where actual prices do not affect consumers' price beliefs, which allows me to evaluate what happens when firms do not have an "investment" incentive. I next consider the other extreme case in which

[10]Cabral (2009) considers a different framework, but his intuition can be used in my model.

consumers have full information about actual prices. One expects the "investment" incentive to be larger in this situation. Finally, I summarize the results for some situations where consumers receive some signal about actual price but the signal is not completely informative.

4.2.1 Equilibrium prices and profits when actual prices do not affect consumers' price beliefs

In this subsection I evaluate the equilibrium prices and profits for different marginal search costs when actual prices do not affect consumers' price beliefs. In this case, a firm does not have an "investment" incentive to lower the price, because actual prices do not affect the search probability. Therefore, an increase in marginal search costs should often create only an incentive for a firm to raise prices and extract rents from consumers. It is, however, possible that a firm lowers its prices with an increase in marginal search costs if this increase reshuffled the preferred consideration sets of consumers such that the probability of including a product in the new consideration set was higher. Since the fall in marginal search costs is equal for all products, the previous scenario is unlikely.

Figures 1a and 2a plot, respectively, the equilibrium prices and the equilibrium price indices of 6 products with respect to marginal search cost. The figures also plot the equilibrium average price and the respective index with respect to marginal search costs. These figures confirm the aforementioned intuition: in my empirical application larger marginal search costs increase prices when actual prices do not affect consumers' price beliefs.

Although larger marginal search costs increase the prices of all products, there is a large heterogeneity across products regarding the magnitude of this effect. For products with low market shares the effects of marginal search costs on prices are small. In contrast, for products with high market shares the effects of search costs on prices can be very large. For instance, the price of the medium-package Purex with a search cost parameter equal to 6 is nearly twice the price with a zero marginal search cost. The intuition for these results is as follows. High-market-share products tend to be the preferred products and thus are the last products that consumers stop search when they need to reduce the number of searched products. High marginal search costs therefore create consideration sets in which a product with a high market share is the only product or one of the few products in the consideration set. The probability of choosing these products conditional on searching rises and becomes less sensitive when marginal search costs increase. Hence, the market power and prices of these products substantially rise for larger marginal search costs. In contrast, products with low market share are searched less often and lose market power with larger marginal search costs. Moreover, these products have higher price elasticities. The lower harvesting incentives for these products are therefore explained by a smaller customer base and higher price elasticities. This numerical result has similarities with the analytical result in Arie and Grieco (2012) that the "harvesting" incentive of larger switching costs is stronger for high-market-share firms.

In my setting there is other explanation for the smaller increase in prices of low-market-share products. The proposed search model assumes that consumers can only search products of the same size in each shopping trip. In the specific empirical application, consumers attribute higher valuations to medium-size products and thus usually search products of this size. Medium-size products have higher market shares and hence their prices are more sensitive to marginal search costs variations. Some consumers move their search efforts from medium-size products to small- and large-size products for larger marginal search costs. The probability of searching small- or large-size products can therefore increase with search costs. In fact, in my empirical application the probability of searching a small-size product increases with marginal search costs when their level is low or moderate. Hence, the smaller increases in prices for small packages is partly explained by an incentive for lowering prices with a rise in marginal search costs to induce a purchase from the new consumers searching the product. This example shows that for products that are usually searched together, a lower price of one of them can create a positive externality in the other products by making consumers choose consideration sets with those products.

Figure 3a and 4a plot, respectively, the profit and the profit indices of 6 products for different values of the marginal search costs. Total profits are also plotted. The figures show that total profits initially rise and then fall for larger marginal search costs. This pattern is also observed for the other products plotted, but it is possible that the profits of some products always fall for larger marginal search costs.

Marginal search costs affect profits through prices and demand. The equilibrium price of a product always rises for larger marginal search costs, but the effect of larger marginal search costs on demand can be positive or negative. Demand can increase with larger marginal search costs due to a higher probability of being searched, or a higher probability of choosing a product after searching it, or both. In my specific application, the increase in the probability of searching a product only occurs for small- and large-size products and as a result of consumers switching their search from medium to small- and large-size products due to the larger rise of prices for medium-size products.

The increase in the search probability is not sufficient to guarantee a rise in demand. It is also necessary that there is not a fall in the probability of choosing a product after searching it, or the increase in the probability of searching a product outweighs the fall in the probability of choosing a product conditional on searching. The increase in the probability of searching a product is also not necessary to guarantee a rise in its demand for larger marginal search costs. The demand of a product can increase with larger marginal search costs, because the number of searched products is lower with larger marginal search costs and thus there is a higher probability of choosing a product after searching it.

In summary, the profits of a product can rise for larger marginal search costs because the price and the demand increase or the gains with the rise of prices outweighs the losses from a fall in demand. In the latter case, the larger marginal search costs allow firms to extract rents from consumers and these gains are higher than the losses created by the smaller consumer base from consumers who do not search the product and from consumers who search but decide not to buy due to the high price.

The previous reasons explain why the profits of some products rise with larger marginal search costs for low and moderate levels of marginal search costs. I next explain why the profits of all products fall with larger marginal search costs for high levels of marginal search costs. The intuition is as follows. The "harvesting" gains from larger marginal search costs have an upper bound because consideration sets include at most one product after a certain level of marginal search costs. Hence, the competition faced by a product does not fall with larger marginal search costs for high levels of those and thus the incentives of raising prices and the potential for increasing demand with larger marginal search costs disappears. For high marginal search costs levels, larger marginal search costs only reduce the probability of consumers search, which decreases profits.

Table 1 shows that in my application the marginal search cost is 3.91 when actual prices do not affect consumers' price beliefs and products are neither displayed nor featured and 2.19 when products are displayed and featured. Figures 3a and 4a show that total profits and the profits of the other 6 products are higher when products are displayed and featured. In particular, total profits with all products displayed and featured are more than three times higher than the total profits when products are neither displayed nor featured. Nonetheless, some products–for instance, the small packages of Tide and All–would have higher profits if search costs were slightly above the value of search costs with product display and feature ads. Employing displays and feature ads would also be beneficial for consumers due to a fall in prices, in addition to the lower search costs. For instance, the price of Purex would drop from \$4.30 to nearly \$3.61 when all products are displayed and featured.

4.2.2 Equilibrium prices and profits with full information about prices

In this subsection I evaluate the equilibrium prices and profits for different marginal search costs when consumers know the actual prices. Although consumers have complete information about actual prices, I still assume that consumers do not know the realization of the random shocks associated with each product and collecting that information is costly.

Figures 1e and 2e plot, respectively, the equilibrium prices and the equilibrium price indices of 6 products and the average price for different values of the marginal search costs. The figures reveal heterogenous effects across products. For some products–such as the small packages of Tide and All–the equilibrium prices initially rise and then fall for larger marginal search costs. In contrast, for other products–such as the medium packages of Tide and Purex–the equilibrium prices always fall for larger marginal search costs. For the average price we observe the latter pattern.

The figures further show that the effects of larger marginal search costs on prices are small for most of the products. A firm faces two incentives that work in opposite directions when marginal search costs increase: (1) an "investment" incentive to reduce its price, and (2) an "harvesting" incentive to raise its price. The coexistence of these two incentives explains the aforementioned results. My results indeed suggest that these two incentives have similar magnitudes and thus cancel each other out for most of the products, which explains the small effects of larger marginal search costs.

Figures 1e and 2e suggest that the effects of marginal search costs on equilibrium prices are higher for products with larger market shares[11]. Although the "harvesting" incentive tends to be stronger for high-market-share products by the reasons mentioned in the previous subsection, the "investment" is also larger for these products with complete information about prices. Products with larger market shares tend to have higher expected utility, are more likely to be in the consideration set, and have a higher choice probability conditional on consumers search them. Hence, the gains of being included in the consideration set are higher for these products and they therefore have more incentives to reduce prices.

Figures 3e and 4e plot, respectively, the profit and the profit indices of 6 products and the total profits with respect to marginal search costs. As in the previous subsection, the relation between profits and marginal search costs is characterized by an inverted U-shaped function for some products, whereas for other products profits always fall for larger marginal search costs. Yet the potential increase in profits with larger marginal search costs is smaller with complete information about prices and thus the number of products with an increase in profits and the magnitude of that increase is smaller. In contrast with the previous subsection, larger marginal search costs increase products competition to be part of consumers' consideration sets, which partly explains the larger negative effects of search costs on profits. Some products have nonetheless substantial increases in profits with a rise in marginal search costs. For instance, profits of the small packages of Tide and All increase by nearly 25% when marginal search costs rise from 0 to 1.2 utils.

The fall or lower rise in the prices of some products with marginal search costs when consumers have complete information about prices may positively affect other products because of the complementarity existent during the consideration set formation among products that are usually searched together. For instance, the fall in prices of the medium packages of Tide and Purex can lead some consumers to start searching medium-size products rather than small- or large-size products. Hence, some medium-size products can have a higher probability of being searched, even though search costs are higher.

Table 1 and the results of this subsection suggest that firms have higher profits when products

[11]The medium packages of Tide and Purex are the two products among the 6 in the figure with the larger market shares and they are also the products with the larger effects.

are displayed and featured (ignoring the cost of displays and feature ads). In contrast, displays and feature ads can be bad for some consumers, because the prices of some products are higher with displays and feature ads. For instance, the price of Purex is nearly $0.10 higher with displays and feature ads. The average price is indeed $0.02 higher with displays and feature ads. If this negative effect of higher prices for some products is higher than the savings in search costs, then the welfare of some consumers can decrease with displays and feature ads.

Figure 5 reports the expected net utility[12] with respect to marginal search costs. The figure shows that the expected net utility always falls for larger marginal search cost. Thus, the fall in the prices of some products is not enough to compensate the losses due to the larger search costs and the larger prices of some products. The suggested measure for the expected net utility integrates over all consumers. Hence, the results in figure 5 are reconcilable with the possibility that the expected net utility of some groups of consumers rises for larger marginal search costs.

4.2.3 Equilibrium prices and profits with partial information about prices

This subsection evaluates the effects of marginal search costs when consumers receive some signal about actual prices before searching but they do not have complete information about those prices. In particular, I assess how the level of information provided by the signal affects the results.

Figures 1 and 2 suggest that a rise in the information provided by the signal increases the magnitude of the "investment" incentive, which reduces the rise in prices with marginal search costs. Panel (d) in both figures indeed reveals that a rise in marginal search costs reduces the prices of some products with $\lambda = 0.75$ and high levels of marginal search costs. That is, the investment incentive can be stronger than the harvesting incentive when the signal received by consumers about prices is sufficiently informative.

Figures 3 and 4 show that for different values of the signal the relation between profits and marginal search costs is characterized by an inverted U-shaped function for some products, whereas for other products profits always fall. The figures, however, suggest that the positive effects of marginal search costs on profits fall with the level of information that consumers have about actual prices. A rise in the information about prices induces firms to compete more fiercely during the consideration-set formation stage, which has negative effects on profits.

The results show that the effects of search costs on prices and profits are sensitive to the level of information provided by a signal about actual prices.

[12] The expected net utility is defined as $EU = \int \max_k \{V_{ik} + \varsigma_{ik}\} \, dF(\varsigma) di$

5 Extensions

In this section I evaluate the effects on equilibrium prices and profits of variations in the marginal search costs of one product. In particular, I evaluate the effects of larger marginal search costs of the medium-package Tide while holding constant the marginal search costs of the other products.

Figures 6 and 7 report, respectively, the equilibrium price indexes and the equilibrium profit indexes with respect to the medium-package-Tide marginal search cost for different values of λ. The results in these figures assume that all products, except the medium-package Tide, have a zero marginal search cost.

Figure 6 shows that the price of the medium-package Tide rises with its marginal search costs when actual prices do not affect consumers' price beliefs, but it falls for all the remaining cases. If actual prices do not affect consumers' price beliefs, then the medium-package Tide can only use its price to "harvest" the consumers who still search it despite the higher search costs. In contrast, the medium-package Tide can use the price to induce consumers to search it if consumers receive some signal that creates a correlation between actual prices and their price beliefs. That is, there is an incentive to reduce prices in order to compensate consumers for the cost of searching. Our results reveal that this incentive is larger than the "harvest" incentive and thus the prices of the medium-package Tide fall with larger marginal search costs. The magnitude of this fall increases with the level of information about actual prices, because a reduction in prices to attract consumers is more effective when there is more information.

Figure 6 further reveals that a larger marginal search cost of the medium-package Tide affects mostly the other medium-size products, particularly when the values of λ are small (i.e., consumers have less information about prices). The prices of small- and large-size products always rise with larger marginal search costs of the medium-package Tide, but the prices of the medium packages of Purex and Arm fall when consumers have complete information about prices. The prices of these two products nonetheless rise with larger marginal search costs of the medium-package Tide in the remaining cases that are plotted in figure 6.

A larger marginal search cost of the medium-package Tide creates incentives for searching other products instead of Tide, thereby increasing the likelihood of searching other products and lowering the likelihood of including the medium-package Tide in the consideration set. Since consumers only search products of the same size, it is, however, possible that a large marginal search cost of the medium-package Tide makes consumers move their search efforts from medium-size products to small- or large-size products. It is further possible that a larger marginal search cost of the medium-package Tide makes consumers not search at all, but that is unlikely. Hence, for small- and large-size products a larger marginal costs of the medium-package Tide increases the number of potential consumers, but does not affect the competition within the consideration sets in which they are present. The prices of these products therefore tend to increase with larger marginal search costs of the medium-package Tide. The rise in the price of these products is higher for larger values of λ, because the fall in the prices of medium-size products moves consumers who are more price sensitive from small- and large-sizes to medium-sizes. Since consumers who search small- and large-sizes with higher marginal search costs are less price sensitive, then small- and large-package products have other incentive to rise prices.

Medium-size products other than Tide compete with the medium-size of Tide within the consideration set. So, these products have incentives to reduce their prices when the price of the medium-package Tide falls. Moreover, these products may have incentives to reduce their prices when the marginal search cost of the medium-package Tide increases in order to provide incentives for searching medium-size products and preventing consumers from not searching or searching products of other sizes. These incentives are higher for higher levels of correlation between actual prices and consumers' price beliefs. Our results indeed suggest that the incentives to reduce prices may be higher than the incentive to rise prices–because of the lower competition of Tide–when consumers have full information about prices.

Figure 7 shows that larger marginal search cost of the medium-package Tide lead to (i) a fall in the profits of the medium-package Tide, and (ii) a rise in the profits of small- and large-size products. These results hold for all values of λ, even though the rise in the profits of small- and large-size products is larger for low values of λ. In contrast, the effects of the marginal search costs of the medium-package Tide on the total profits of the other medium-size products depend on the value of λ: total profits and the profits of the other medium-size products rise with medium-package-Tide marginal search costs for low values of λ, but they fall when λ is high. These effects are nonetheless small.

The rise in the marginal search costs of the medium-package Tide reduces the likelihood of searching and purchasing this product, thus lowering its profits. Furthermore, in the situations described in panels (b) to (e) a larger marginal search cost of the medium-package Tide is associated with lowers prices of this product, which also lowers profits. In panel (a) the price of the medium-package Tide rises with its marginal search costs, but the losses from the lower demand are higher than the gains from raising prices.

The effects of the marginal search costs of the medium-package Tide on the demand of medium-size products other than Tide can be either positive or negative. On the one hand, there is a reduction in the competition within the consideration set. On the other hand, some consumers move their search efforts from medium-size products to small- and large-size products. Furthermore, the prices of these products rise with the marginal search costs of the medium-package Tide in panels (a) to (d), but they fall when consumers have full information about prices.

The rise in the profits of small- and large-size products with larger search costs of the medium-package Tide is explained by the increase in their prices and demand associated with some consumers moving their search efforts from medium-size products to small- and large-size products.

Figure 7 further shows that total profits can rise with larger marginal search costs when consumers have little or no information about actual prices. Hence, limited information and costly search can create market power and yield larger profits.

Finally, this exercise suggests that the medium-package Tide would have large incentives to employ displays and feature ads in the described situation: its profits with displays and feature ads are more than twice the profits without displays and feature ads.

6 Conclusions and Future Research

In this paper I evaluate the effects of marginal search costs on equilibrium prices and profits using a structural model of demand and supply. I find that the profits of some products initially rise and then fall for larger marginal search costs. This effect of marginal search costs on profits implies that for some products it is optimal to have an intermediate level of marginal search costs rather than zero marginal search costs (or high marginal search costs). Firms may therefore create marginal search costs or avoid engaging in activities that reduce marginal search costs to zero. My results further suggest that the positive effects of marginal search costs on the profits of some products are lower when consumers have more information about actual prices.

I find that the effects of marginal search costs on equilibrium prices depend on whether a firm has an "investment" incentive for reducing the price of its product to induce consumers to search it. If actual prices do not affect consumers' price beliefs, prices will always rise with larger marginal search costs. In contrast, if consumers receive a signal sufficiently informative about prices, then the "investment" incentive can be stronger than the "harvesting" incentive and a rise in marginal search costs reduces the prices of some products. These results therefore provide important insights for regulators. They show the importance of knowing the magnitude of search costs and the level of information regarding prices to design welfare maximizing policies.

In my analysis I assume that firms only produce and sell one product. Multi-product firms have different incentives and thus it is important to extend the model and the empirical strategy to analyze the effects of marginal search costs on equilibrium prices and profits of multiproduct firms. Likewise, the comparison of the incentives of manufacturers and retailers is an important question that should be answered in future research.

My work does not consider strategic interactions during the choice of actions with effects on marginal search costs (e.g., product display and feature ads). If products can have different marginal search costs and can employ instruments to affect marginal search costs, they have incentives to have lower marginal search costs than the rivals. This situation can lead to equilibria where profits are lower than the profits without strategic interactions. Future research should explore the characteristics of the equilibrium when marginal search costs can differ across products and firms can employ instruments to affect marginal search costs. This will help researchers to understand how a firm can use promotional activities to achieve higher profits when there are search frictions.

Mehta et al. (2003) show that consumers who are more price sensitive search more under certain circumstances. This suggests that firms may use search frictions to discriminate consumers and thus extract larger rents from them. For instance, firms may use price promotions as a mechanism to sell their products to price sensitive consumers who search more. In this case, the regular price is higher than the price without price promotions, because it is used to extract rents from price insensitive consumers. The study of the strategies that firms can employ in these situations is an important extension of the work developed in this paper.

In this paper I do not estimate how consumers form their price beliefs. My results however illustrate that the relation between actual prices and consumers' price beliefs has important implications in the effects of marginal search costs on prices and profits. Future research should explore the mechanisms through which consumers form their price beliefs and evaluate the effects of these mechanisms for firms.

This paper considers a static demand model, ignoring the dynamic effects of consumer inventory and stockpiling. Hendel and Nevo (2006) and Pires (2014) show that these effects can be important and thus future research should explore the dynamic effects created by consumer inventory. Likewise, it would be important to evaluate the potential dynamic effects associated with learning about prices.

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8 Appendix

Table 1: Demand Estimates

	Specifications for different values of λ									
	λ =0		λ =0.25		λ =0.5		λ =0.75		λ =1	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Price Coefficient										
Constant	-1.164	0.139	-1.076	0.101	-0.710	0.053	-0.539	0.036	-0.442	0.030
Income	0.006	0.004	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Family Size	0.027	0.007	0.024	0.006	0.024	0.006	0.024	0.006	0.024	0.006
Income * Family Size	-0.003	0.001	-0.002	0.001	-0.002	0.001	-0.002	0.001	-0.002	0.001
Search Cost										
Fixed Search Cost										
Constant	3.848	0.155	3.604	0.128	3.689	0.158	3.756	0.195	3.745	0.234
Non-detergent Expenditure	-0.131	0.012	-0.141	0.012	-0.139	0.012	-0.138	0.013	-0.139	0.013
Marginal Search Cost										
Constant	3.913	0.267	4.734	0.355	4.465	0.426	4.284	0.500	4.347	0.656
Display	-0.279	0.030	-0.200	0.025	-0.210	0.032	-0.222	0.039	-0.219	0.048
Feature	-0.300	0.029	-0.216	0.025	-0.226	0.033	-0.240	0.041	-0.237	0.051
Inventory	-0.003	0.001	-0.003	0.001	-0.003	0.001	-0.003	0.001	-0.003	0.001
Log-likelihood	13753.31		13749.49		13761.25		13771.34		13778.96	
N	19,531		19,531		19,531		19,531		19,531	

Note: Estimation is performed using a nested fixed point algorithm where the solution of the dynamic problem is nested within the parameter search. All specifications include brand-size fixed effects. The rate of consumption of each household is the ratio of the total amount purchased to the overall time in the sample. The simulation of inventory starts with an initial guess and then updates inventory in each week using the observed purchases and the estimated consumption. Asymptotic standard errors are reported. Specifications vary with respect to the value of λ

Table 2: Own-Price Elasticities

	λ =0.000	λ =0.250	λ =0.500	λ =0.750	λ =1.000
TIDE Small	-2.376	-2.293	-2.021	-1.859	-1.763
DYNAMO Small	-4.092	-3.653	-2.459	-1.890	-1.570
PUREX Small	-2.739	-2.449	-1.682	-1.296	-1.071
ARM Small	-3.047	-2.745	-1.843	-1.401	-1.148
ALL Small	-2.831	-2.529	-1.954	-1.637	-1.446
ERA Small	-3.523	-3.167	-2.143	-1.640	-1.350
WISK Small	-5.588	-4.937	-3.452	-2.710	-2.283
Private Small	-2.083	-1.846	-1.395	-1.154	-1.011
Other Small	-3.041	-2.824	-2.179	-1.853	-1.665
TIDE Medium	-2.299	-2.971	-2.952	-2.912	-2.886
XTRA Medium	-0.772	-1.013	-1.073	-1.078	-1.078
DYNAMO Medium	-2.757	-2.767	-2.388	-2.164	-2.023
PUREX Medium	-1.316	-1.610	-1.622	-1.599	-1.580
ARM Medium	-2.728	-2.510	-2.152	-1.933	-1.794
ALL Medium	-2.126	-2.271	-2.177	-2.085	-2.021
ERA Medium	-2.398	-2.495	-2.275	-2.131	-2.038
WISK Medium	-3.578	-3.588	-3.134	-2.807	-2.585
Private Medium	-2.072	-1.924	-1.649	-1.473	-1.359
Other Medium	-2.442	-2.612	-2.350	-2.199	-2.106
TIDE Large	-9.372	-9.486	-7.474	-6.457	-5.874
XTRA Large	-4.346	-3.997	-3.056	-2.538	-2.227
DYNAMO Large	-10.151	-9.215	-6.098	-4.572	-3.701
PUREX Large	-7.963	-7.100	-5.303	-4.277	-3.653
ARM Large	-8.888	-7.884	-5.402	-4.199	-3.520
ALL Large	-11.821	-10.404	-7.002	-5.355	-4.422
ERA Large	-10.628	-9.512	-6.812	-5.382	-4.540
WISK Large	-18.012	-16.388	-10.646	-7.939	-6.424
Private Large	-7.968	-7.146	-4.775	-3.645	-3.004
Other Large	-11.708	-10.741	-7.221	-5.535	-4.540

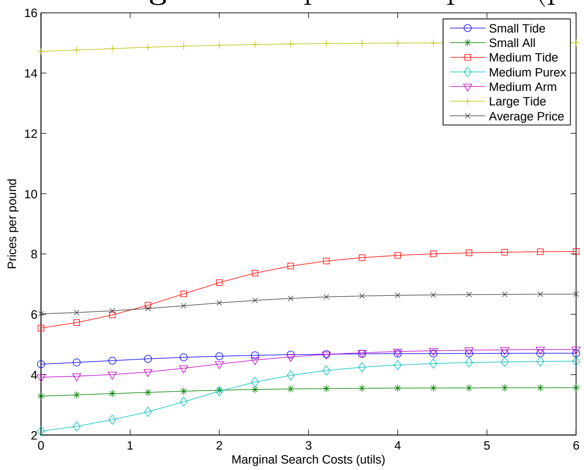
Note: Each cell reports the percent change in the market share of a product with a 1 percent change of its price. The results are based on the estimates in table 1.

Table 3: Marginal Costs

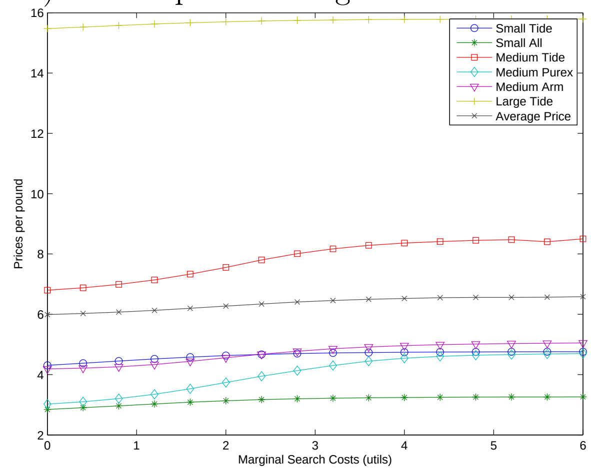
	λ =0.000	λ =0.250	λ =0.500	λ =0.750	λ =1.000
TIDE Small	2.437	2.487	2.282	2.103	1.976
DYNAMO Small	2.989	2.822	2.355	1.888	1.469
PUREX Small	1.738	1.610	1.109	0.626	0.184
ARM Small	1.982	1.873	1.349	0.845	0.381
ALL Small	2.271	2.103	1.767	1.433	1.150
ERA Small	2.477	2.356	1.844	1.352	0.902
WISK Small	4.702	4.496	4.108	3.691	3.314
Private Small	1.221	1.047	0.681	0.328	0.029
Other Small	1.517	2.322	2.165	1.925	1.717
TIDE Medium	0.339	4.742	4.968	4.990	4.990
XTRA Medium	-1.189	-0.020	0.175	0.197	0.202
DYNAMO Medium	1.365	2.940	2.921	2.782	2.653
PUREX Medium	-0.508	1.353	1.526	1.528	1.515
ARM Medium	2.441	2.560	2.415	2.220	2.056
ALL Medium	1.969	2.771	2.801	2.727	2.661
ERA Medium	1.878	2.831	2.877	2.789	2.703
WISK Medium	3.781	4.439	4.453	4.286	4.114
Private Medium	1.509	1.466	1.312	1.106	0.927
Other Medium	1.638	2.973	3.040	2.965	2.890
TIDE Large	0.417	12.958	13.066	12.923	12.762
XTRA Large	4.080	3.946	3.743	3.444	3.170
DYNAMO Large	8.548	8.358	7.966	7.469	6.990
PUREX Large	7.724	7.607	7.518	7.199	6.875
ARM Large	7.751	7.692	7.338	6.912	6.523
ALL Large	10.383	10.189	9.775	9.307	8.877
ERA Large	9.867	9.906	9.884	9.543	9.187
WISK Large	15.486	15.547	15.131	14.617	14.130
Private Large	6.774	6.655	6.130	5.631	5.179
Other Large	-7.109	8.649	9.703	9.548	9.193

Note: Marginal costs are the mean over all the stores and weeks in our data. The results are based on the estimates in table 1.

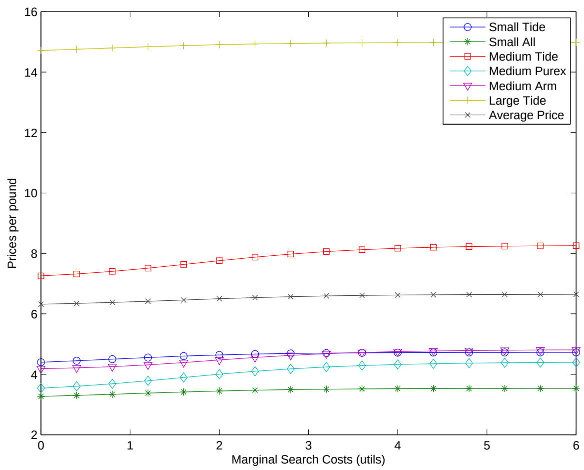
Figure 1: Equilibrium prices (per pound) with respect to marginal search costs



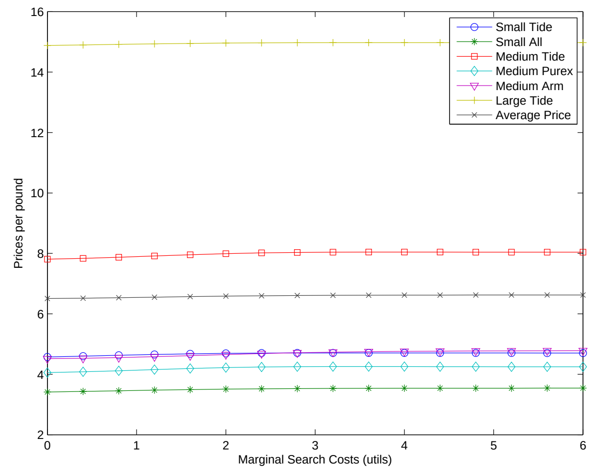
(a) $\lambda = 0$



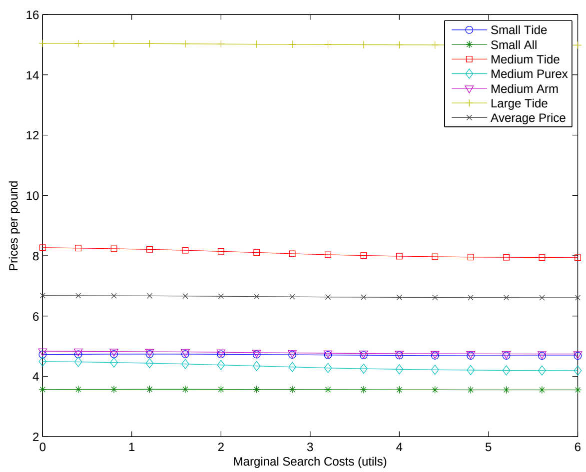
(b) $\lambda = 0.25$



(c) $\lambda = 0.5$



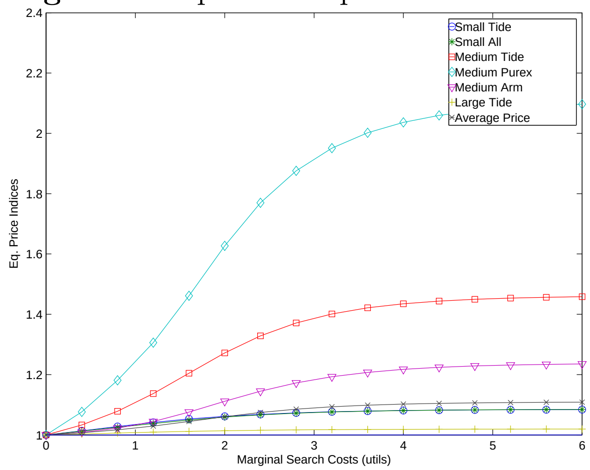
(d) $\lambda = 0.75$



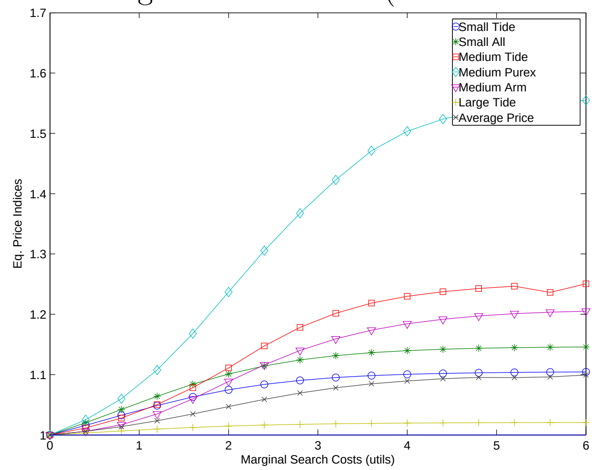
(e) $\lambda = 1$

Note: The marginal-search-cost value varies on the x-axis from 0 to 6 utils. The y-axis is the equilibrium price of a product. Equilibrium prices are the median for each product obtained from the equilibrium simulation using the demand estimates presented in table 1 and the recovered marginal costs. The simulation considers 50 draws (for each product) from the empirical distribution of marginal costs (excluding values below the 25th percentile and above the 75 percentile). Panel (a) considers $\lambda = 0$, panel (b) considers $\lambda = 0.25$, panel (c) considers $\lambda = 0.5$, panel (d) considers $\lambda = 0.75$, and panel (e) considers $\lambda = 1$.

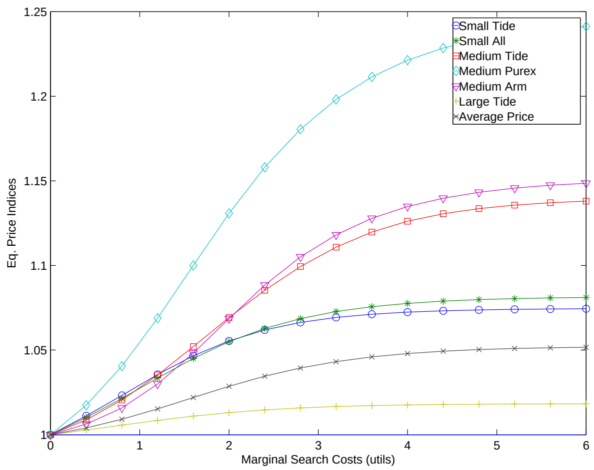
Figure 2: Equilibrium price indices with respect to marginal search costs (Zero search cost = 1)



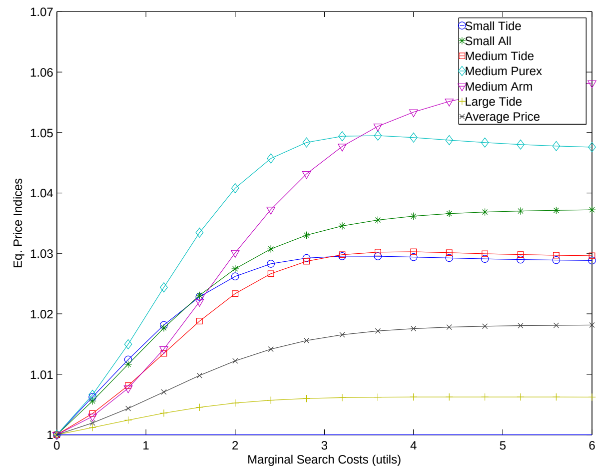
(a) $\lambda = 0$



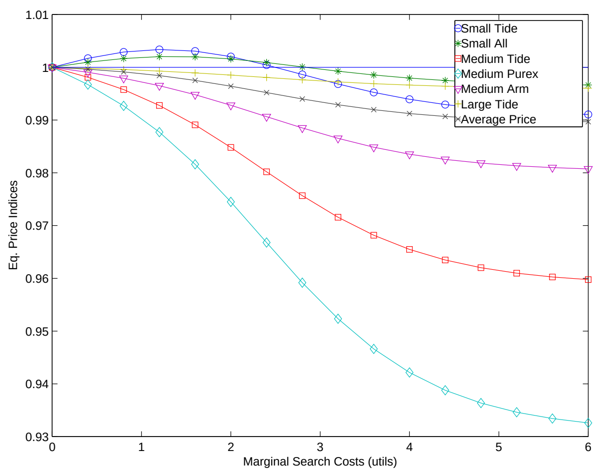
(b) $\lambda = 0.25$



(c) $\lambda = 0.5$



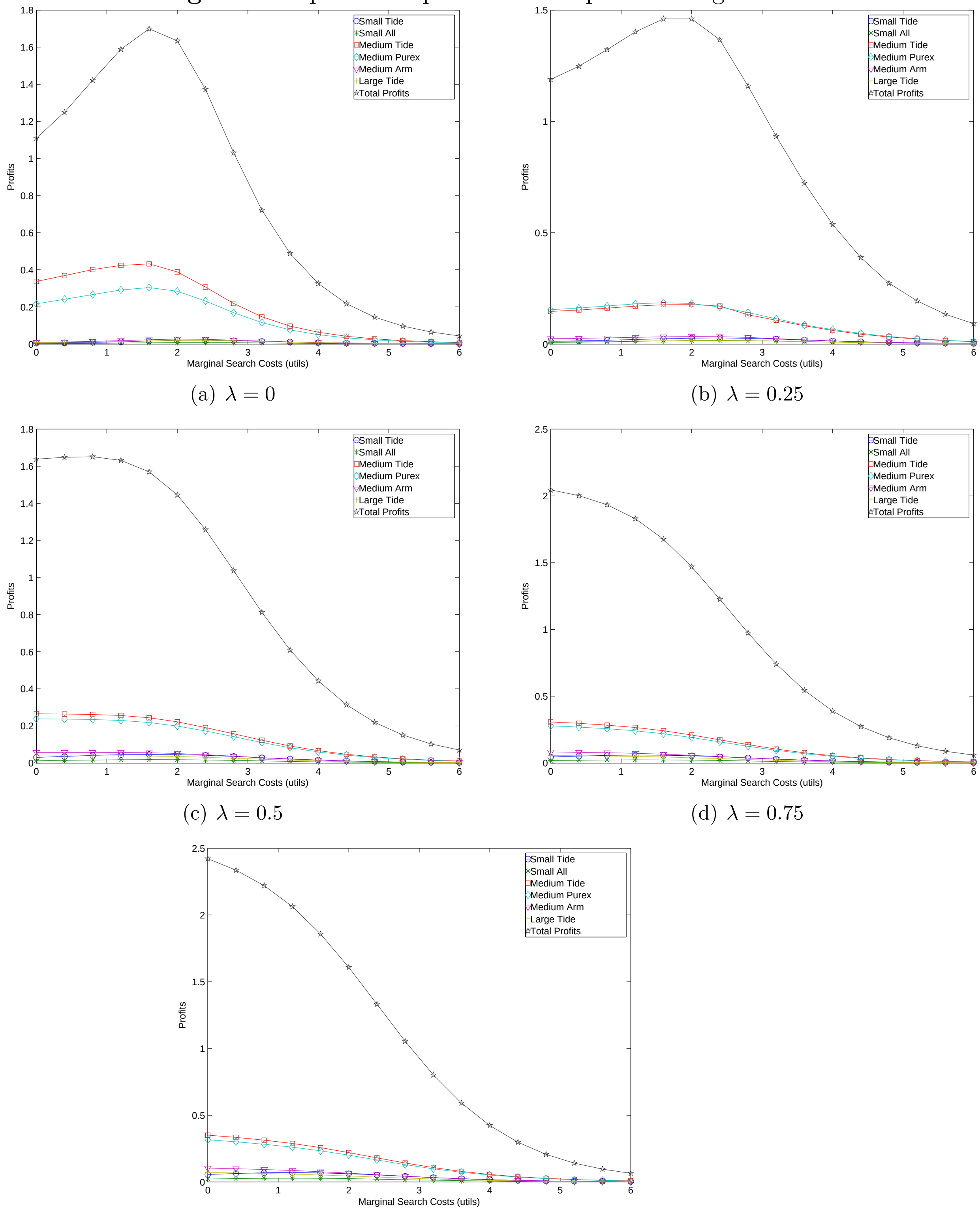
(d) $\lambda = 0.75$



(e) $\lambda = 1$

Note: The equilibrium price index of a product at a specific value of marginal search costs is the ratio of the equilibrium price of that product at that value of marginal search costs to the equilibrium price of that product at a zero marginal search cost. The equilibrium prices indices are equal to 1 for a zero marginal search cost. Indices calculated using the equilibrium prices reported in figure 1. The marginal-search-cost value varies on the x-axis from 0 to 6 utils. Panel (a) considers $\lambda = 0$, panel (b) considers $\lambda = 0.25$, panel (c) considers $\lambda = 0.5$, panel (d) considers $\lambda = 0.75$, and panel (e) considers $\lambda = 1$.

Figure 3: Equilibirum profits with respect to marginal search costs



(a) $\lambda = 0$

(b) $\lambda = 0.25$

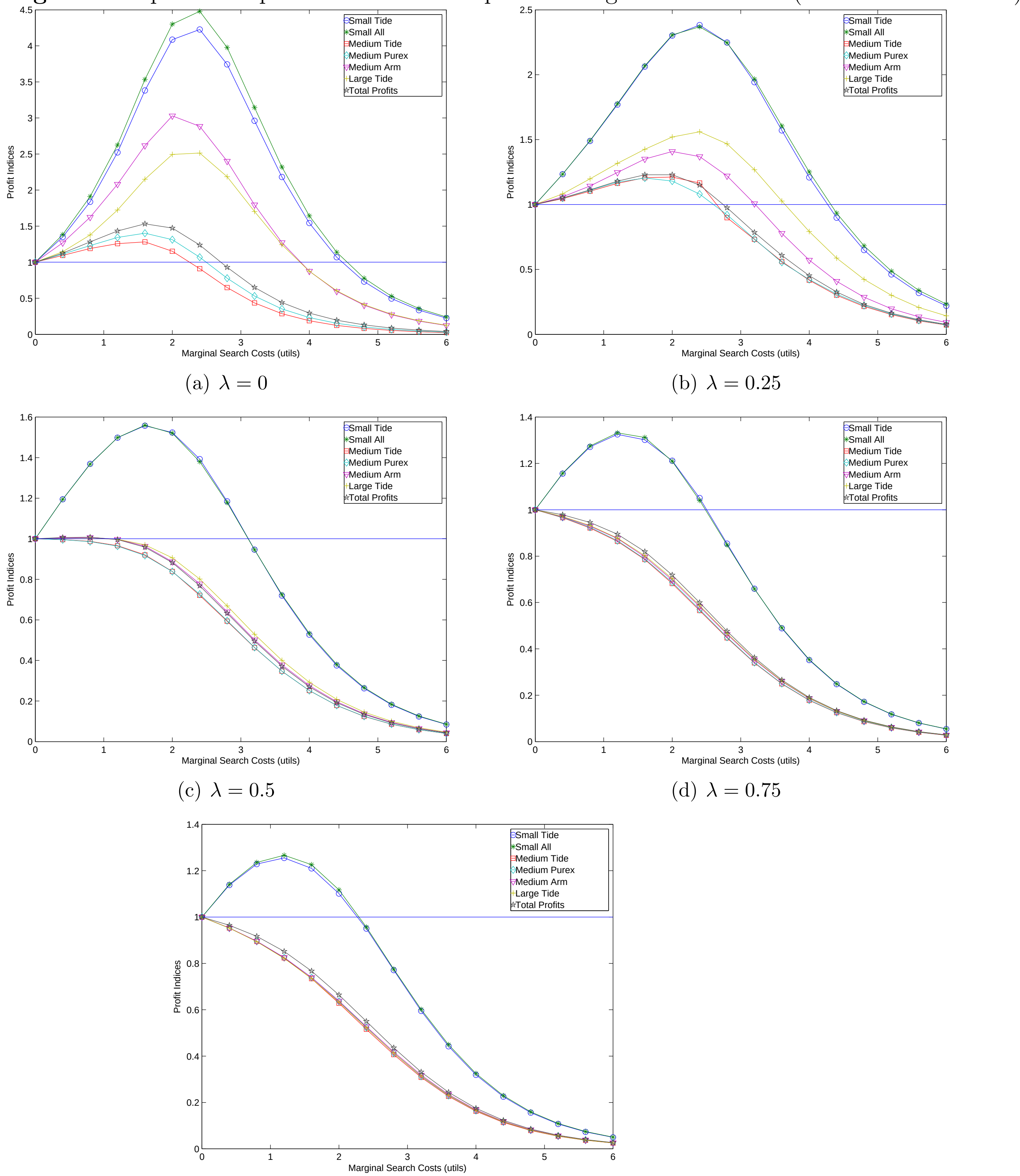
(c) $\lambda = 0.5$

(d) $\lambda = 0.75$

(e) $\lambda = 1$

Note: The marginal-search-costs value varies on the x-axis from 0 to 6 utils. Equilibrium profits are the median for each product obtained from the equilibrium simulation using the demand estimates presented in table 1 and the recovered marginal costs. Panel (a) considers $\lambda = 0$, panel (b) considers $\lambda = 0.25$, panel (c) considers $\lambda = 0.5$, panel (d) considers $\lambda = 0.75$, and panel (e) considers $\lambda = 1$.

Figure 4: Equilibrium profit indices with respect to marginal search costs (Zero search cost = 1)



(a) $\lambda = 0$

(b) $\lambda = 0.25$

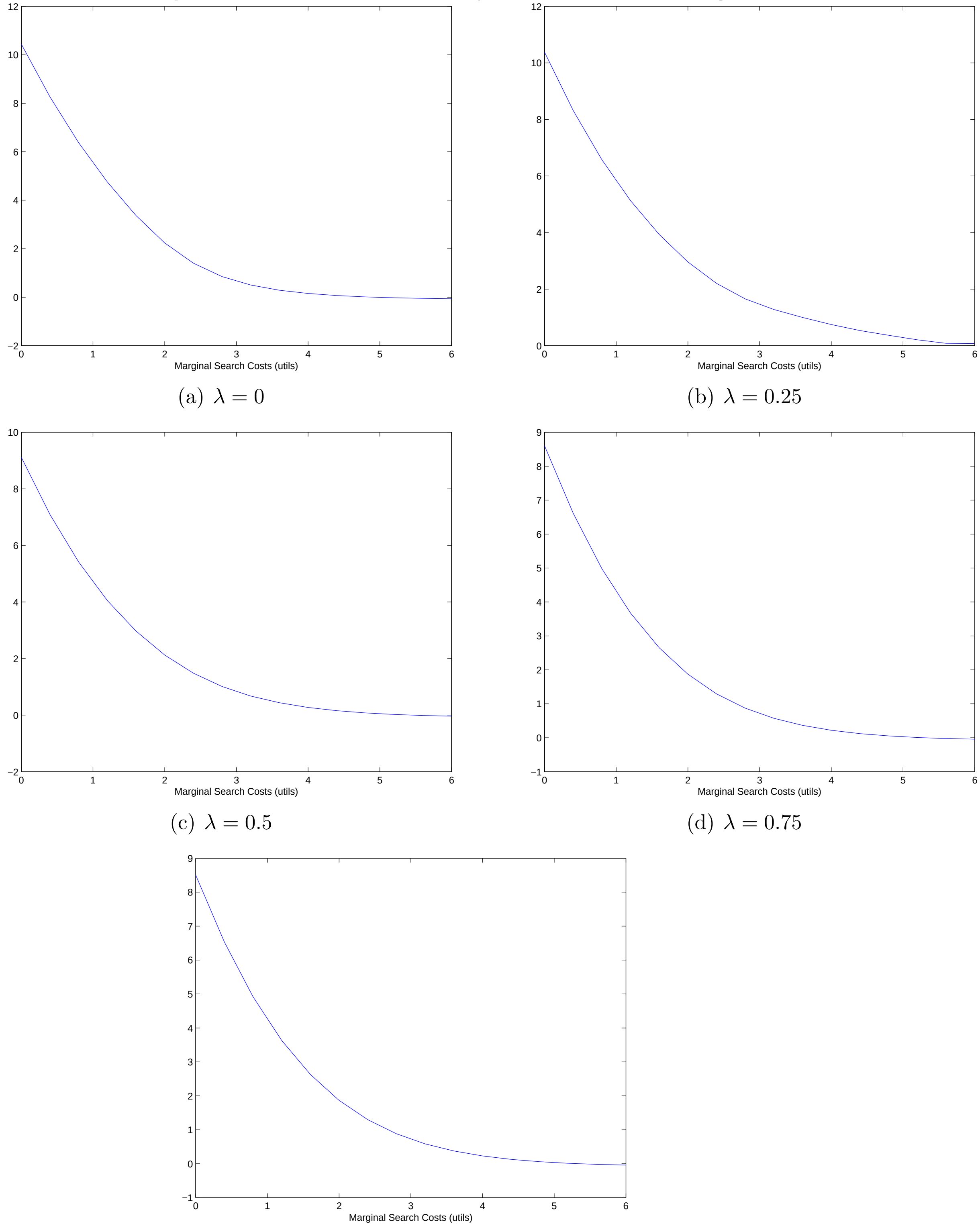
(c) $\lambda = 0.5$

(d) $\lambda = 0.75$

(e) $\lambda = 1$

Note: The equilibrium profit index of a product at a specific value of marginal search costs is the ratio of the equilibrium profit of that product at that value of marginal search costs to the equilibrium profit of that product at a zero marginal search cost. Indices calculated using the equilibrium profits reported in figure 3. The marginal-search-cost value varies on the x-axis from 0 to 6 utils. Panel (a) considers $\lambda = 0$, panel (b) considers $\lambda = 0.25$, panel (c) considers $\lambda = 0.5$, panel (d) considers $\lambda = 0.75$, and panel (e) considers $\lambda = 1$.

Figure 5: Expected net utility with respect to marginal search costs



(a) $\lambda = 0$

(b) $\lambda = 0.25$

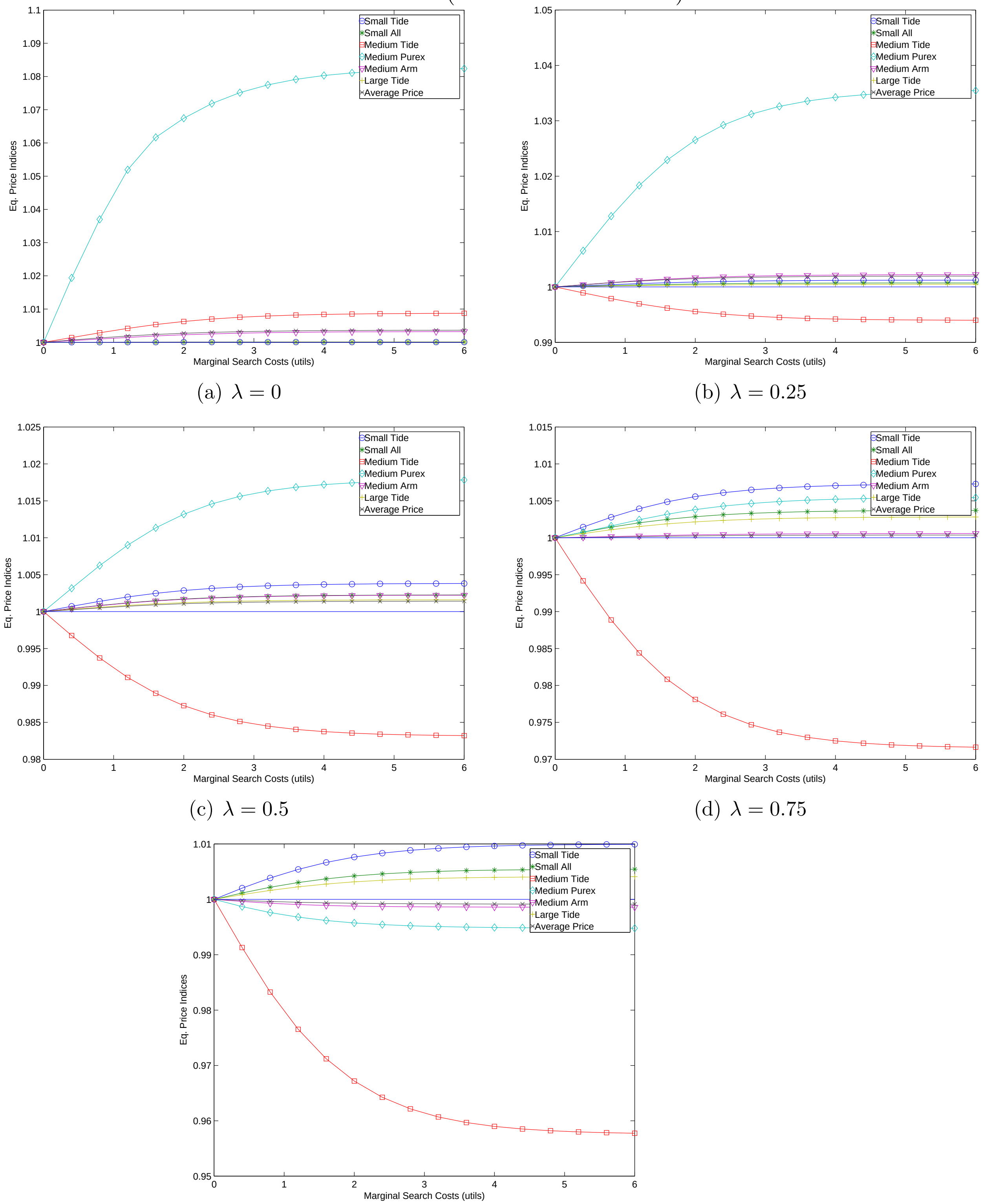
(c) $\lambda = 0.5$

(d) $\lambda = 0.75$

(e) $\lambda = 1$

Note: The expected net utility is the integral over the random shocks to consideration-set choice and consumers of the value of the best consideration set. Expected net utility calculated using the equilibrium prices. The marginal-search-cost value varies on the x-axis from 0 to 6 utils.

Figure 6: Equilibrium price indexes with respect to medium-package-Tide marginal search costs (Zero search cost = 1)



(a) $\lambda = 0$

(b) $\lambda = 0.25$

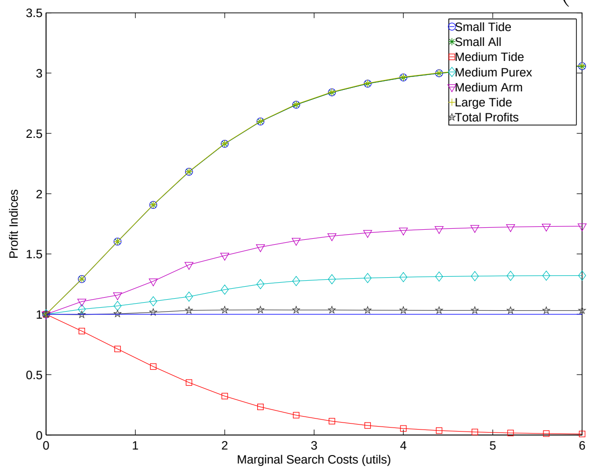
(c) $\lambda = 0.5$

(d) $\lambda = 0.75$

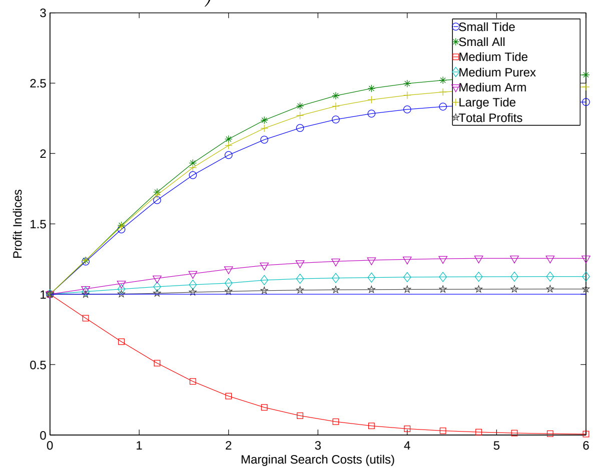
(e) $\lambda = 1$

Note: The equilibrium prices indexes are equal to 1 for a zero marginal search cost. The medium-package-Tide marginal-search-cost value varies on the x-axis from 0 to 6 utils. Panel (a) considers $\lambda = 0$, panel (b) considers $\lambda = 0.25$, panel (c) considers $\lambda = 0.5$, panel (d) considers $\lambda = 0.75$, and panel (e) considers $\lambda = 1$.

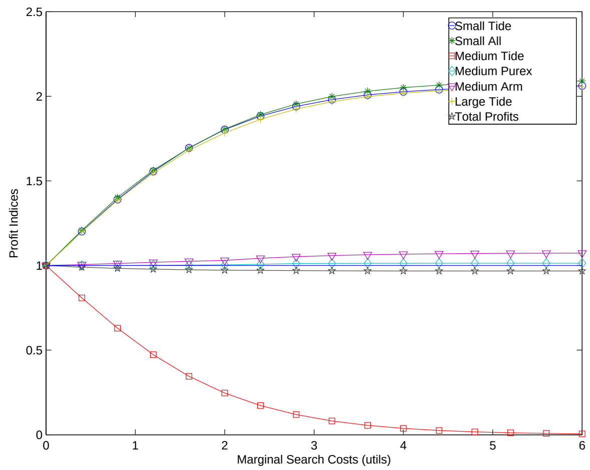
Figure 7: Equilibrium profit indexes with respect to medium-package-Tide marginal search costs (Zero search cost = 1)



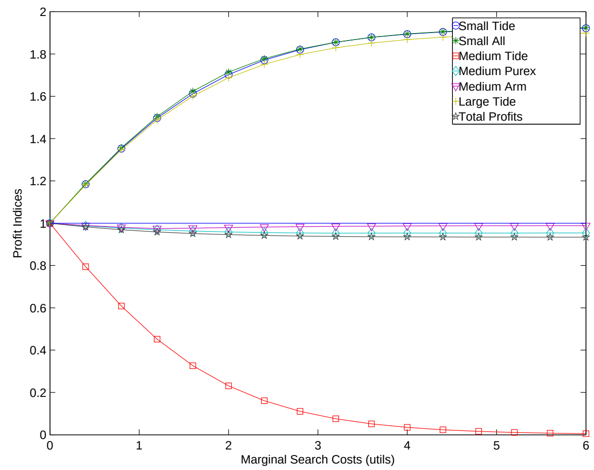
(a) $\lambda = 0$



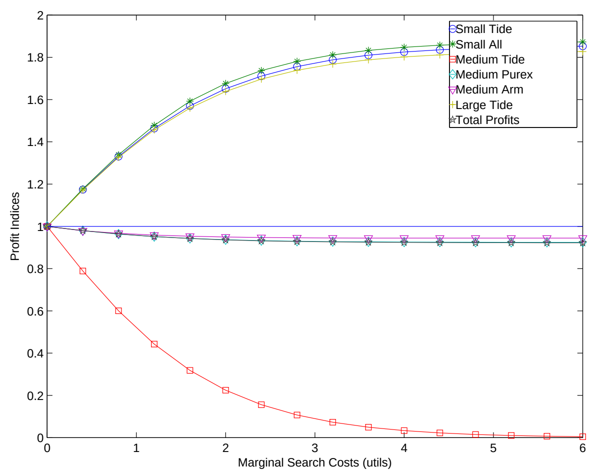
(b) $\lambda = 0.25$



(c) $\lambda = 0.5$



(d) $\lambda = 0.75$



(e) $\lambda = 1$

Note: The medium-package-Tide marginal-search-cost value varies on the x-axis from 0 to 6 utils. Indices calculated using the equilibrium profits reported in figure 3. Panel (a) considers $\lambda = 0$, panel (b) considers $\lambda = 0.25$, panel (c) considers $\lambda = 0.5$, panel (d) considers $\lambda = 0.75$, and panel (e) considers $\lambda = 1$.