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# Economics of an Information Intermediary with Aggregation Benefits

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**Abstract**

The widespread use of the Internet has led to the emergence of numerous information intermediaries that bring buyers and sellers together and leverage their knowledge of the marketplace to provide value added services. Infomediaries offer matching services that facilitate establishment of a buyer-seller agreement, and value-added services that either provide a stand-alone benefit or enhance benefits from matching services. This paper develops and analyzes economic models of intermediation to examine their pricing and product line design strategies. Intermediaries provide aggregation benefits: buyers find an intermediary's service more valuable if it provides access to more sellers, and sellers value it more if it provides access to more buyers but also when they compete with fewer sellers. Due to this unique combination of network effects, we find that an intermediary has stronger incentives to provide quality differentiated versions of its service relative to other information goods sellers. When buyers have constant marginal valuations for service quality, the intermediary should offer only two levels of service. While it is optimal for the intermediary to offer two levels of service, increasing the quality of the low level service reduces the intermediary's profits due to increased cannibalization of the premium service. Hence the optimal menu consists of a basic matching service and a premium service that includes matching and value added services. The intermediary's profits are larger when positive network effects are stronger and lower when negative network effects are stronger.

# 1 Introduction

It is often said that information is power in today's economy, and this is aptly demonstrated by the emergence of many new types of information intermediaries in the last decade. The term infomediary is used for many such intermediaries, since their role is to capture, aggregate, and exploit information about participating parties in order to facilitate the efficient allocation of goods or services. Wise and Morrison (2000) note, in the context of business-to-business markets, that with the spread of digitization "value has shifted from the product itself to information about the product." Intermediaries create value via information collection, aggregation, display and information processing; by managing workflow for a set of transactions between a buyer and seller; by coordinating logistical services to buyers and sellers; or by providing information processing services for end-to-end transaction management. Such infomediaries are becoming commonplace in many business and consumer market settings, including in hotel and travel coordination (Dube and Renaghan 2000), retail marketing (Chen, Iyer, and Padmanabhan 2002), and private online exchanges for B2B commerce (Hoffman, Keedy, and Roberts 2002).

Bailey and Bakos (1997) discuss four services offered by intermediaries: a) aggregation of buyer demand and seller products, b) providing trust between participants, c) market facilitation, and d) matching buyers and sellers. Kaplan and Sawhney (2000) reinforce the notion that electronic intermediaries fulfill aggregation and matching roles (e.g., via catalogs and auctions respectively), bringing "a large number of buyers and sellers under one roof" and enabling real-time negotiation of terms and price discovery. More recently, the academic and industry literature suggests that infomediaries have evolved from being merely match-makers to purveyors of an array of services (see e.g., Sarkar, Butler, and Steinfield (1995) and Wise and Morrison (2000)).

This paper studies the design of infomediary services and examines how a potential versioning strategy may impact the menu of service levels offered. We draw a contrast with prior results in versioning with respect to information goods, and show that the intermediary-specific aggregation benefit improves the incentives for versioning. From a practical perspective, our findings

are significant in that they suggest that intermediaries can increase their chances of success by employing a versioning strategy. Our conclusions are derived on the basis of an economic model of intermediation where buyers (and sellers) perceive greater value when there is a larger network of sellers (respectively, buyers) affiliated with the intermediary. We find that an intermediary's use of a versioning strategy is closely linked to this aggregation benefit and the categories of services offered by the intermediary. We discuss these features in the rest of this section, following which we develop and analyze the intermediary model in §2—§4. In §5, we discuss how our results contribute to understanding the design of intermediary services. §6 concludes the paper.

### 1.1 Aggregation Role of Intermediaries

An important characteristic of intermediaries is the *aggregation benefit* they provide to buyers and/or sellers. For example, `Priceline.com` allows buyers to place quotes on airline seats, hotel rooms, or car rentals, and it matches these quotes against block purchases it makes from travel service providers. Intuitively, `Priceline`'s value to providers increases with the number of buyers that submit quotes; conversely, the likelihood of acceptance of a buyer's bid increases with the number of providers that `Priceline` links with. Another example is `OneMediaPlace.com`, an intermediary between buyers and sellers of advertising space on print and broadcast media. Its `MediaPassage` service manages end-to-end transactions between buyers and sellers, covering functions such as price discovery, order placement, invoice handling, and settlement. The value of this service to buyers (or sellers) goes up as `MediaPassage` builds a larger network of sellers (or buyers).

The aggregation benefit is a positive network externality. Network externalities have been studied for many years (see Katz and Shapiro (1985) and Katz and Shapiro (1986)), and generally the network benefit is defined as a function of $N$, the size of the network. Similar effects are observed in interorganizational systems e.g., by Chismar and Meier (1992) and Clemons and Kleindorfer (1992). The *intensity of aggregation benefit* provided by an intermediary to buyers (sellers) is determined by market characteristics and the mix of information processing features made available to buyers (sellers). For example, if an intermediary makes information such as seller or product

features and price available in an aggregated form, then buyers realize an aggregation benefit. The benefit might increase if buyers are able to sort and search this information, or perform more complex computations to select the best seller with respect to their preferences.

### 1.2 Value-added Services and Matching Services

We classify intermediary services into two categories: *matching services* such as listing, matching, and price discovery that facilitate establishment of a buyer-seller agreement; and *value-added services* such as workflow coordination, transaction management, industry reports and account management. For example, the B2B exchange `GNX.com` offers various *marketplace tools* (i.e., matching services, such as conducting an auction) to facilitate buyers and sellers in creating a match, and various *collaborative tools* (i.e., value-added services such as exchange of real time information about inventory levels between trading partners) which either facilitate execution of an agreement or provide benefits independent of a buyer-seller relationship.

- *Matching services* are marketplace tools such as listing, price discovery, and matching of buyers and sellers, which facilitate establishment of a buyer-seller agreement. The aggregation benefit obtained by buyers or sellers stems solely from the matching services provided by the intermediary.

- *Value-added services*—such as workflow coordination, transaction management, industry reports, account management, and consultation about safety and environmental aspects of materials—provide additional value to participants. We distinguish between two kinds of value-added services: *stand-alone value-added* and *enhanced matching* services.

  Enhanced matching services include those, such as logistical services, payment and settlement systems, and collaborative workflow integration, that make transaction execution more efficient: the infomediary sets itself up in a better position to manage the data, document, and monetary flows between the transacting firms. Enhanced matching services are valuable only when used in conjunction with the basic matchmaking role of the infomediary. Stand-alone

value-added services include industry reports, account management, and consultation about safety and environmental aspects of materials; such services provide value to the user even when the infomediary is not employed for choosing the trading partner or setting up the transaction.

For example, consider `Elemica.com`, an online B2B exchange which represents pharmaceutical and chemicals firms. `Elemica`'s matching services include contract management, creation of customized buyer-specific searchable catalog of suppliers, and online negotiation and approval. It also offers a range of value-added—enhanced matching—services covering order fulfillment and logistics planning and execution. In contrast, consider the travel agency `AAA.com` stand-alone value-added services such as traveler's checks, international driving permits, and trip protection insurance, in addition to basic matching services (for selection of flights, car rentals, and hotel rooms that match the member's criteria).

### 1.3 Infomediary Services and Versioning

How might an infomediary employ a versioning strategy in the design of its services? In the early years when infomediation firms such as online exchanges entered the market, most infomediaries—like many other new firms and products—tended to employ a "one size fits all" strategy, offering only a single set of matching related services that enabled buyers and sellers to agree on a transaction. More recently we have witnessed various efforts at service differentiation. As explained in §1.2 infomediary firms offer both stand-alone value-added services and those that enhance the execution of the transaction. The quality level of an intermediary's product relates to the collection of services that are offered at a specific price. For example, `AAA.com` has a primary membership level that includes services such as traveler's checks, international driving permits, and insurance protection. It also offers a higher-priced premium level (AAA Plus) which includes the above services as well as travel accident insurance and additional trip protection insurance.[1]

[1] AAA offers a premium membership level (AAA Plus) at $75 and a basic primary membership level at $46. July 31, 2001, from http://www.aaa.com/

This discussion suggests a natural set of possibilities for versioning. An infomediary could offer a menu consisting of basic matching and (various levels of) value-added services. When users are heterogeneous in their valuation of matching services, the intermediary can offer a premium service where the value-added services are enhanced matching services. This approach allows the infomediary to induce self-selection and separation between higher and lower type users. On the other hand, when users are homogeneous in their valuation of matching services, then the infomediary can use stand-alone value-added services to create a menu of offerings. For example, premium levels might include a variety of stand-alone value added services in addition to matching service, while the entry level service would consist of matching services only.

We explore these ideas in a systematic way by developing and analyzing models of infomediary services, in which the infomediary chooses quality levels and price while buyers and sellers make decisions to participate while taking into account both quality levels and aggregation benefits. We first develop a general model of intermediary service and pricing, and then analyze pricing and versioning decisions for two specific types of intermediaries: those who provide stand-alone value-added services, and those whose value-added services enhance the value of matching services.

## 2 Model Formulation

The focus of our analysis is on the intermediary, and its relationship with buyers and sellers. In our setting, the intermediary does not own or price the goods or services that might be transacted between buyers and sellers. Buyers and sellers may interact with each other as well, but we do not model the buyer-seller interaction in detail, instead capturing it abstractly through the seller's profit expectations from future interactions with buyers. The intermediary provides services to facilitate interactions between buyers and sellers. Buyers and sellers participate with the intermediary due to an increase in surplus from such interaction, due to a better match, reduced transaction costs or better supply chain management. Following prior research in information goods and services, we analyze intermediary services with negligible marginal costs, and with sunk fixed costs of service

development. The results are easily extended to the case of positive marginal costs but the zero cost assumption is consistent with prior research. For example, Jones and Mendelson (1998) and Meyer (1996) examine versioning strategies for vertically differentiated information goods with zero marginal costs. Bhargava and Choudhary (2001) have shown that these versioning results hold even for products which exhibit positive marginal costs that are concave in product quality. Our research and model structure is also related to other work in vertical differentiation (e.g., Mussa and Rosen (1978), and Jing (2002)), but is different from the intermediation analysis of Spulber (1996), who examines the role of search costs in the pricing power of an intermediary who earns profit by arbitraging price differences between the buyers and sellers, rather than by charging for intermediation.

To examine the intermediary's versioning strategy we assume the context where the intermediary is endowed with two quality levels $q_L$ and $q_H$. In §3.3 and 4.3 we show that it is optimal to offer just two quality levels. We study separately the cases of enhanced matching and stand-alone value-added services. We solve the intermediary's pricing problem to obtain a rational expectations equilibrium where these rational expectations are fulfilled in equilibrium. In the first stage, the intermediary is endowed with quality levels $q_L$ and $q_H$. These quality levels are public information and all players including buyers and seller have perfect information about the intermediary's quality. Based on this information, and knowledge of the demand function of buyers and sellers, the intermediary determines its optimal pricing strategy in the second stage. Finally buyers and sellers form rational expectations about the level of participation by other buyers and sellers and decide whether or not to subscribe to the intermediary's service.

From the buyers' perspective, the quality levels $q_L$ and $q_H$ are vertically differentiated substitutes, hence each buyer will choose to use at most one service; the one that maximizes her surplus. The intermediary charges buyers a price $p_j$ for a service of quality $q_j$ (this price does not include any products supplied by the seller). When optimal prices are such that each quality level gets a strictly positive market coverage, then it is optimal for the intermediary to offer both versions. Following the literature cited in §1.1, a buyer's valuation of the intermediary services depends on

the number of sellers listed with the intermediary, due to the aggregation benefit. Similarly, the sellers' valuation depends on the number of buyers who participate with the intermediary. In addition, sellers compete among themselves, therefore the addition of a seller reduces the valuations of existing sellers. We write $n$ to denote the fraction of sellers who list with the intermediary, and $m$ to denote the fraction of buyers who participate in the intermediated market.

Sellers are heterogeneous in their expectations about the increase in profits due to listing with the intermediary, and decide to subscribe if their expected profit exceeds the listing fee. Let $y$ represent seller type. Following Banker, Khosla, and Sinha (1998) the seller-side demand function for listing with the intermediary is given by $\tau = bm - cn$, where $\tau$ is the intermediary's listing fee for sellers, and $n$ is the fraction of sellers who subscribe to the intermediary. Note that the intermediary can charge a higher listing fee when there are more buyers ($m$) and fewer sellers ($n$). Without loss of generality, we normalize seller type ($y$) to lie in the interval $[0, 1]$ and assume that $y$ is uniformly distributed in this interval. Let $y_i$ be the seller who is indifferent to subscribing, therefore $n = 1 - y_i$ and $\tau = bm - c(1 - y_i)$. Table 1 summaries the notation used in the paper.

Buyers are heterogeneous in their valuation of the intermediary's services. We model buyer heterogeneity with a type parameter $\theta$. Buyers are distributed in the interval $[0, 1]$ as given by a cumulative density function $F(\theta)$. We assume that the term $\frac{F'(\theta)}{1-F(\theta)}$ (often called the hazard rate function) is non-decreasing, which is true for most commonly used distributions such as the uniform, normal, and exponential distributions (Fudenberg and Tirole 1991).

Let $U(\theta, q_j, n)$ represent the benefit derived by a type $\theta$ buyer for service level $q_j$ when a fraction $n$ of sellers lists with the intermediary. The intermediary benefits buyers by providing both value-added services $q_j$ and matching services that depend on the number of sellers ($n$). By construction, the valuation function satisfies $U(\theta, q_H, n) > U(\theta, q_L, n)$ and is increasing in $n$ due to positive aggregation benefits hence $U_n = -U_{y_i} > 0$ (since $n = 1 - y_i$). Further, without loss of generality buyer types $\theta$ may be ordered such that $U_\theta > 0$. We define two marginal buyer types: $\theta_L$ type buyers are indifferent between buying the low quality service and not buying, whereas type $\theta_H$ buyers are indifferent between buying the low quality service and the high quality service. Based

| | |
|---|---|
| $q_j$ | quality level of value-added service $j$ |
| $p_j$ | price for $q_j$ |
| $\theta$ | index for buyer types, $\in [0, 1]$ |
| $F(\theta)$ | distribution of buyers |
| $\theta_H$ | buyer type who is indifferent between $q_H$ and $q_L$ |
| $\theta_L$ | buyer type who is indifferent to $q_L$ |
| $m$ | fraction of buyers who transact via intermediary, $= 1 - F(\theta_L)$ |
| $y$ | index for seller types, $\in [0, 1]$ |
| $y_i$ | indifferent seller type |
| $n$ | fraction of sellers who subscribe with intermediary, $= 1 - y_i$ |
| $\tau$ | listing fee for sellers |
| $e$ | intensity of aggregation benefit to buyers (quality of matching service) |
| $b$ | intensity of aggregation benefit to sellers |
| $c$ | negative externality due to competition between sellers |

Table 1: Summary of notation

on this definition, we obtain the following indifference equations

$$\begin{aligned} U(\theta_L, q_L, n) &= p_L \\ U(\theta_H, q_H, n) - p_H &= U(\theta_H, q_L, n) - p_L \end{aligned}$$

All buyers of type $\theta \in [\theta_H, 1]$ buy the high quality service from the intermediary and buyers of type $\theta \in [\theta_L, \theta_H)$ buy the low quality service. Recall that the cumulative density of buyers along $\theta$ is given by $F(\theta)$, therefore the fraction of buyers using the high quality service ($q_H$) is $1 - F(\theta_H)$ and the fraction of buyers using $q_L$ is $F(\theta_H) - F(\theta_L)$. Hence the total fraction of buyers subscribing to the intermediary's service is $m = (1 - F(\theta_L))$.

The intermediary's profit function combines the fees from buyers and sellers:

$$\pi = p_H(1 - F(\theta_H)) + p_L [F(\theta_H) - F(\theta_L)] + \tau(n)$$

Replacing for $p_L$, $p_H$, $\tau$ and using $m = 1 - F(\theta_L)$ and $n = 1 - y_i$, the profit function simplifies to

$$\begin{aligned} \pi &= [U(\theta_H, q_H, n) - U(\theta_H, q_L, n)] (1 - F(\theta_H)) + U(\theta_L, q_L, n) [1 - F(\theta_L)] \\ &\quad + [b(1 - F(\theta_L) - c(1 - y_i)] (1 - y_i) \end{aligned} \tag{1}$$

The intermediary's decision problem is to choose prices to maximize profits. Alternately, we can solve for optimal indifference points $\theta_L^*$, $\theta_H^*$, and $y_i^*$. The optimal prices $p_L^*$, $p_H^*$, and $\tau^*$ are then obtained from the indifference equations. Buyers and sellers both care about the number of sellers and buyers , and make decisions based on their expectations; the optimal indifference points are determined simultaneously and endogenously to obtain a rational expectations equilibrium. The stationary points for the profit function are the feasible triplets $(\theta_H, \theta_L, y_i)$ that satisfy the conditions

$$\theta_H^* \quad \text{solves} \quad \left[ \begin{array}{rcl} 1 &=& \frac{1-F(\theta_H)}{F'(\theta_H)} \frac{[U_\theta(\theta_H, q_H, n) - U_\theta(\theta_H, q_L, n)]}{U(\theta_H, q_H, n) - U(\theta_H, q_L, n)} \end{array} \right] \tag{2}$$

$$\theta_L^*, y_i^* \quad \text{solve} \quad \left[ \begin{array}{rcl} 1 + \frac{b}{1+y_i} \frac{1}{U(\theta_L, q_L, n)} &=& \frac{1-F(\theta_L)}{F'(\theta_L)} \frac{U_\theta(\theta_L, q_L, n)}{U(\theta_L, q_L, n)} \\ (1 - F(\theta_L))(b - U_y(\theta_L, q_L, n)) &=& 2c(1 - y_i) - \kappa(y_i) \end{array} \right] \tag{3}$$

where $\kappa(y_i) = (1 - F(\theta_H))[U_y(\theta_H, q_H, n) - U_y(\theta_H, q_L, n)]$

If the solution $(\theta_L^*, \theta_H^*, y_i^*)$ is unique and satisfies second-order conditions for optimality, we have an optimal solution to the intermediary's problem. Further analysis of this solution requires additional information about the benefit functions. Knowledge about specific real-world intermediaries allows us to develop specific formulations to suit specific categories of intermediated markets. In the next two sections, we develop two such models, determine the optimal versioning strategy in each, and examine comparative statics. However, before doing so, a few general observations can be made using the system of simultaneous equations stated above.

- The system of equations yields feasible solutions when it satisfies the constraints $0 \leq \theta_L^* \leq \theta_H^* \leq 1$ and $0 \leq y_i^* \leq 1$. When $\theta_L^* < \theta_H^*$, it is optimal for the intermediary to offer multiple versions.

- The first order conditions for $y_i$ and $\theta_L$ show the interlinked nature of the intermediary's problem where the number of buyers and the price charged to buyers is dependent on the number of sellers while the price charged to sellers depends on the number of buyers.

- When is it optimal for the intermediary to offer multiple qualities of value-added services? The first order conditions emphasize the unique nature of this optimization and how it is different from standard price discrimination. The model presented in this section is a generalization of the standard price discrimination model and it can be verified that setting $b = c = 0$ in Eq. 3 would eliminate the seller side of the intermediary's pricing problem so that the model would become the standard price discrimination model.

# 3 Enhanced Matching Services

Matching services provided by intermediaries enable buyers and sellers to reach an agreement to conduct a transaction. In many such intermediated markets the intermediary offers additional value-added services that pertain to the execution of the transaction. For example, `Elemica.com`

helps chemicals buyers by managing RFQs, creating customized buyer-specific searchable catalog of suppliers, and online negotiation and approval. These matching services enable a buyer to develop a purchase contract with a seller. Execution of the contract involves several additional steps such as logistics and financial settlement. `Elemica` provides many such value-added services including preparation of shipping documents, cost-effective credit evaluation, invoicing and payment solutions, and tax, duty, and currency computations. These services have little stand-alone benefit, but they enhance the buyers' gains from the matching services. Further, since the value-added services pertain to the execution of a contract, they are useful only in conjunction with matching services. This suggests the following specific form for the buyers' valuation function: $U(\theta, q, n) = \theta eq(1 - y^2)$, where the fraction of sellers listed with the intermediary is $1 - y$.

When buyers are heterogeneous in valuations, this raises the possibility that offering quality-differentiated versions $q_j$ can lead to better allocations and profits for the intermediary. Not all buyers may be willing to pay a premium price for high-end value-added services such as greater information and automated workflow. Is the intermediary better off following a versioning strategy and offering multiple quality levels for the matching service? For example, the intermediary may offer a very basic matching service that simply matches buyers and sellers, and a premium service that bundles other value-added services that support additional steps in execution and fulfillment of a match. How should the basic and premium services be configured, and should the intermediary offer two or more service levels?

This section analyzes the case where the value-added services enhance the buyers' gains from the matching services, but provide no stand-alone benefit. Plugging the valuation function $U(\theta, q_j, n) = \theta eq_j(1-y^2)$ into the intermediary's profit function (Eq. 1), for the case when there are at most two quality levels for the value-added service, $q_L$ and $q_H$, we get

$$\begin{aligned}
\pi &= p_H(1 - F(\theta_H) + p_L(F(\theta_H) - F(\theta_L)) + \tau(1 - y_i) \\
&= ((1 - F(\theta_H))\theta_H(q_H - q_L) + (1 - F(\theta_L))\theta_L q_L)\, e(1 - y_i^2) + b(1 - F(\theta_L)(1 - y_i) - c(1 - y_i)^2
\end{aligned}$$

Using Eq. 2 and 3 the stationary points are the triplets ($\theta_L$, $\theta_H$, $y_i$) that satisfy the first-order

conditions:

$$\theta_H^* \quad \text{solves} \quad \left[ \; 1 \;=\; \frac{1-F(\theta_H)}{F'(\theta_H)} \frac{1}{\theta_H} \; \right] \tag{4}$$

$$\theta_L^*, y_i^* \quad \text{solve} \quad \left[ \begin{array}{rcl} 1 + \frac{b}{1+y_i} \frac{1}{\theta_L e q_L} & = & \frac{1-F(\theta_L)}{F'(\theta_L)} \frac{1}{\theta_L} \\ (1 - F(\theta_L))(b + 2eq_L\theta_L y_i) & = & 2c(1-y_i) - 2y_i K \end{array} \right] \tag{5}$$

where $K = (1 - F(\theta_H^*))\theta_H^* e(q_H - q_L)$. These equations in general may have multiple solutions that satisfy second-order conditions for maxima; the optimal solution is either a feasible triplet in the interior region or may have components at the boundary. We will characterize the optimal solution and examine the implications on the intermediary's versioning strategy. For ease of exposition, we illustrate our results in the case where $F$ is a uniform distribution over the interval $[0, 1]$. For this case, setting $F(\theta) = \theta$ and $F'(\theta) = 1$, Eq. 4 yields a unique solution $\theta_H^* = \frac{1}{2}$. For the other two indifference points, the first-order conditions reduce to

$$1 + \frac{b}{1+y_i} \frac{1}{\theta_L e q_L} \;=\; \frac{1-\theta_L}{\theta_L} \tag{6}$$

$$-(1-\theta_L)(b + 2q_L e\theta_L y_i) \;=\; 2y_i \left( \frac{e(q_H - q_L)}{4} + c \right) - 2c \tag{7}$$

### 3.1 To Version or Not?

**Proposition 1** *It is optimal for the intermediary to offer multiple versions of matching service.*

The formal proof is given in the appendix, but we illustrate it here for the case where $F$ is uniform in $[0, 1]$. In this case, as noted earlier, $\theta_H^* = \frac{1}{2}$, and Eq. 6 yields

$$\theta_L^* = \frac{1}{2} - \frac{1}{2} \left( \frac{b}{(1+y_i)eq_L} \right)$$

proving that $\theta_L^* < \frac{1}{2}$. This finding contrasts with prior literature in versioning of information goods (without aggregation benefit, see e.g., Jones and Mendelson (1998), Meyer (1996) and Bhargava and Choudhary (2001)) which states that versioning is not optimal when consumers have constant marginal valuations for quality (as when $U(\theta, s) = \theta s$). In the case of intermediary's matching services, we see that versioning is optimal even when consumers have constant marginal valuations

for quality of matching service. This is consistent with Jing's (2002) result derived under the setting of consumption externality.

### 3.2 Comparative Statics

As stated earlier, the profit function may have multiple stationary points that satisfy conditions for maxima. The detailed conditions that characterize the *global maximum* are tedious and unnecessary. The versioning result, as shown above, follows directly from the implicit functions (Eq. 5) that define the stationary points. In addition, we can derive important properties of the equilibrium outcome and examine how these outcomes change with changes in the quality levels and other exogenous parameters, as follows. The comparative statics are obtained as an application of the conjugate pairs theorem, and the impact of parameter changes on the profit is understood by applying the envelope theorem (see Currier (2000, p. 80-83) and Varian (1992, p. 491-3)).

**Proposition 2** *When the intensity of aggregation benefits to the supplier (b) is greater, the intermediary i) achieves a greater profit in equilibrium, ii) obtains a greater number of buyers ($\theta_L^*$ reduces), and iii) increases its coverage on the sellers' side ($y_i^*$ reduces).*

**Proof.** Applying the envelope theorem, $\frac{\partial \pi^*}{\partial b} = (1 - y_i)(1 - F(\theta_L)) > 0$ hence the intermediary makes greater profit when $b$ is greater. To compute the effect on the optimal indifference points, we apply the conjugate pairs theorem, $\frac{\partial^2 \pi^*}{\partial b \partial \theta_L} = (1 - y_i)(-F'(\theta_L)) < 0$ hence higher $b$ leads to a lower $\theta_L^*$. Similarly, a higher $b$ leads to a smaller value of $y_i^*$ since $\frac{\partial^2 \pi^*}{\partial b \partial y_i} = -(1 - F(\theta_L)) < 0$ ■

An increase in $b$ has all-round positive effects for the intermediary. It not only increases the valuations and participation of sellers but, due to the aggregation effect, this also increases participation of buyers. This in turn implies greater surplus for each of the participating buyers. The intermediary's desire to expand the number of participating sellers is limited by two factors: the negative externality due to competition, $c$, and the buyers' valuation for $q_L$. When $b$ is sufficiently large relative to $q_L$ and $c$, the intermediary wants all buyers to enter the market even if this reduces the price of $q_L$. It is willing to forego revenue from $q_L$ because it gets additional listing revenue

from sellers because there are more buyers, and because it can increase the price of $q_H$ due to the increased aggregation benefit. When $b$ is large enough relative to $q_L$ and $c$ the positive effects dominate the loss in revenue. However, when $q_L$ is large, the potential revenue loss from making $q_L$ free is larger, hence $q_L$ is priced high enough to exclude low-value buyers; similarly, when $c$ is large, sellers have a higher disutility due to competition, hence the intermediary wants to limit the number of sellers in the market, and consequently is less willing to sacrifice revenues from $q_L$. Specifically, for the uniform case, $b > 2eq_L$ implies that $\theta_L^* = 0$ (this follows from Eq. 6); it is then easy to show that $y^* = \frac{2c-b}{2c+2K}$ (when $c > \frac{b}{2}$; 0 otherwise) where for uniform $F$, $K = e\frac{q_H - q_L}{4}$.

**Proposition 3** *When the intensity of the competition among suppliers (c) is greater, this i) reduces the intermediary's profit in equilibrium, and ii) leads to reduced coverage on the sellers' side ($y_i^*$ increases).*

**Proof.** Applying the envelope theorem, $\frac{\partial \pi^*}{\partial c} = -(1-y_i)^2 < 0$ hence the intermediary's profit drops when $c$ is greater. We see that it reduces coverage on the sellers' side, since $\frac{\partial^2 \pi^*}{\partial c \partial y_i} = 2(1-y_i) > 0$ ■

This result is not surprising. Greater intensity of competition among suppliers forces the intermediary to limit the number of suppliers in the marketplace. This actually improves revenues from listing fees, because the result moves towards the monopoly optimal, however it reduces buyer valuations and revenues by a greater amount.

**Proposition 4** *An increase in $q_L$ reduces the intermediary's profit; it also reduces market coverage on the buyer side ($\theta_L^*$ increases) and seller side ($y_i^*$ increases).*

**Proof.** Applying the envelope theorem, we examine the derivative

$$\frac{\partial \pi^*}{\partial q_L} = (1 - F(\theta_L^*))\theta_L^* - (1 - F(\theta_H^*))\theta_H^*$$

The optimality condition for the term $(1 - F(\theta))\theta$ is $\frac{1-F(\theta)}{F'(\theta)}\frac{1}{\theta} = 1$, which is identical to Eq. 4. Therefore, $(1 - F(\theta))\theta$ is maximized at $\theta_H^*$, the unique solution of Eq. 4. Consequently the term $(1-F(\theta_L^*))\theta_L^* - (1-F(\theta_H^*))\theta_H^*$ is negative. Hence the intermediary's profit reduces with an increases in $q_L$.

To see the impact on the indifference points, we see that $\theta_L^*$ increases, because $\frac{\partial^2 \pi^*}{\partial q_L \partial \theta_L} = (1 - y_i^2)(1 - F(\theta_L) - \theta_L F'(\theta_L)) > 0$. Similarly, $\frac{\partial^2 \pi^*}{\partial q_L \partial y_i} = 2y_i(\theta_H(1 - F(\theta_H)) - \theta_L(1 - F(\theta_L))) > 0$ so that $yi^*$ also increases with $q_L$. ■

An increase in $q_L$ reduces the differentiation between the high and low quality levels. This increases the potential for cannibalization, since high-type buyers are now more willing to switch to the lower quality level. This effect reduces the intermediary's profits.

**Proposition 5** *When the intensity of the aggregation benefit to buyers (e) is greater, this i) increases the intermediary's profit in equilibrium, ii) leads to increased coverage on the buyers' side ($\theta_L^*$ decreases), and iii) leads to increased coverage on the sellers' side ($y_i^*$ decreases).*

**Proof.** Applying the envelope theorem, the intermediary's profit increases with $e$, since $\frac{\partial \pi}{\partial e} = ((1 - F(\theta_H))\theta_H(q_H - q_L) + (1 - F(\theta_L))\theta_L q_L)\,(1 - y_i^2) > 0$. The intermediary increases its coverage on the buyers' side, since $\frac{\partial^2 \pi}{\partial e \partial \theta_L} = (1 - F(\theta_L) - F'(\theta_L))(1 - y_i^2) < 0$. Similarly, it increases coverage on the sellers' side, since $\frac{\partial^2 \pi}{\partial e \partial y_i} = -2y_i\,((1 - F(\theta_H))\theta_H(q_H - q_L) + (1 - F(\theta_L))\theta_L q_L) < 0$. ■

The effect of an increase in the buyer-side aggregation benefit $e$ is similar to the effect of an increase in the seller-side aggregation benefit $b$. Hence we see that an increase in $e$ improves both intermediary profits and participation of buyers and sellers.

### 3.3 How Many Versions?

Now consider the more general case where the intermediary may offer $N$ quality levels $q_1 ... q_N$ for the matching service; for convenience let $q_0$ be a null service. Let the optimal indifference points be $\theta_j (j = 1...N)$ where $\theta_j$ is indifferent between $q_j$ and $q_{j-1}$. Let $p_j$ be the price for service level $q_j$, hence from the indifference equations we get $p_j = \theta_j(q_j - q_{j-1})(1 - y_i^2) + p_{j-1}$ for $j = 1...N$. The intermediary's profit function is

$$\pi = (1 - F(\theta_N))p_N + \sum_{j=1}^{N-1} (F(\theta_{j+1}) - F(\theta_j))p_j + b(1 - \theta_1)(1 - y_i) - c(1 - y_i)^2$$

Simplifying and computing first derivatives, we see that the stationary points $\theta_j$ satisfy the conditions

$$\text{for } j = 2...N, \quad \theta_j^* \quad \text{solves} \quad \left[ \; 1 \;\; = \;\; \frac{1-F(\theta_j)}{F'(\theta_j)} \frac{1}{\theta_j} \; \right] \tag{8}$$

$$\theta_1^* \quad \text{solves} \quad \left[ \; 1 + \frac{b}{1+y_i} \frac{1}{\theta_1 e q_1} \;\; = \;\; \frac{1-F(\theta_1)}{F'(\theta_1)} \frac{1}{\theta_1} \; \right] \tag{9}$$

Since Eq. 8 is identical for all $j = 2...N$, we see that $\theta_2^* = ... = \theta_N^*$, hence quality levels $q_2...q_{N-1}$ are not offered. Therefore, it is optimal for the intermediary to offer two quality levels only, and the pricing problem is reduced to the two-quality problem solved earlier.

**Proposition 6** *When the intermediary's value-added services only enhance the benefit from matching, then it is optimal for the intermediary to pursue a versioning strategy and offer exactly two quality levels for the value-added service.*

How should the intermediary set quality level $q_L$ and $q_H$? We assume that there is a convex cost function for the high quality service, and that the additional lower quality level can be developed costlessly. The higher quality level $q_H$ is defined by the intermediary's competitive desire to offer the best possible quality subject to development constraints, so that $q_H^*$ equals some upper limit $\bar{q}_H$. For the lower quality level $q_L$, Proposition 4 indicates that $q_L^*$ equals some minimal threshold level $\underline{q}_L$. From a practical perspective this means that the intermediary offers a lower-priced basic matching service (with no value-added services) and a higher-priced premium service that bundles matching service with additional value-added services. In essence, the basic matching service serves to expand the size of the buyer network (making the intermediary more attractive to sellers) while the higher quality service brings higher revenues from buyers; other quality levels in the middle are unattractive because they would only cannibalize the high-quality service without expanding the size of the buyer network.

# 4 Stand-alone Value Added Services

Several intermediaries provide stand-alone value-added services, in addition to their matching services. For example, many B2B exchanges have services such as industry reports, training and education courses, and consultation about safety and environmental issues. These services provide benefits to buyers even when they are not engaged in seller-oriented transactions with the intermediary. For example, `AAA.com` provides matching services to buyers to help them select travel products from airlines, car rental firms and hotels. In addition, `AAA` also offers its members additional value-added services such as maps, trip planning, and travel insurance. These services can be used independently of the matching services, in contrast to the value-added services of `Elemica` which are useful only in conjunction with matching services.

In this case we write the valuation of buyers for the intermediary's services as the sum of the benefits from matching services $e(1-y_i^2)$ and the benefits from value added services $\theta q_j$, $j \in \{L, H\}$. In the expression $e(1-y_i^2)$, $y_i$ refers to the indifferent supplier, $(1-y_i)$ is the fraction of suppliers expected to list with the intermediary, and $e$ is an exogenous scaling constant that represents the intensity of the aggregation benefits. Note that $e(1-y_i^2)$ is a concave function of the number of suppliers $(1-y_i)$ listing with the intermediary. As before $\theta$ is the buyers' type parameter and $q_j$, $j \in \{L, H\}$ the quality level purchased by the buyer. Formally we state these valuation functions as:

$$U(\theta, q_j) = \theta q_j + e(1-y_i^2) \tag{10}$$

This formulation is consistent with prior approaches for modeling utility functions under network-related benefits. Kauffman, McAndrews, and Wang (2000) and Saloner and Shepard (1995) write the valuation function as $a + b(N)$ where $a$ represents stand-alone benefit and $b(N)$ represents a benefit due to the network. Earlier work (e.g., Katz and Shapiro (1992), Farrell and Saloner (1992) and Farrell and Katz (1998)) also adopts a two-part additive valuation.

Substituting the valuation function into Eq. 1, the intermediary's profit function $\pi$ is

$$\begin{aligned}\pi &= p_H(1-F(\theta_H)) + p_L(F(\theta_H)-F(\theta_L)) + \tau(1-y_i) \\ &= (1-F(\theta_H))\theta_H(q_H-q_L) + (1-F(\theta_L))(\theta_L q_L + e(1-y_i^2) + b(1-y_i)) - c(1-y_i)^2\end{aligned}$$

Substituting Eq. 10 into Eqns. 2 and 3 we obtain the first-order conditions:

$$\theta_H^* \quad \text{solves} \quad \left[ 1 = \frac{1-F(\theta_H)}{F'(\theta_H)}\frac{1}{\theta_H} \right] \tag{11}$$

$$\theta_L^*, y_i^* \quad \text{solve} \quad \left[ \begin{array}{rcl} 1 + \frac{(1-y_i)(b+e(1+y_i))}{\theta_L q_L} & = & \frac{1-F(\theta_L)}{F'(\theta_L)}\frac{1}{\theta_L} \\ (1-F(\theta_L))(b+2ey_i) & = & 2c(1-y_i) \end{array} \right] \tag{12}$$

These equations in general may have multiple solutions that satisfy second-order conditions for maxima; the optimal solution is either a feasible triplet in the interior region or may have components at the boundary. Again, to examine the implications for the intermediary's versioning strategy, we illustrate our results for the case where $F$ is uniform on the support $[0,1]$. The first-order conditions reduce to

$$\theta_H = \frac{1}{2} \tag{13}$$

$$\theta_L = \frac{1}{2} - \frac{1}{2q_L}(b(1-y_i) + e(1-y_i^2)) \tag{14}$$

$$y_i = \frac{2c - b(1-\theta_L)}{2c + 2e(1-\theta_L)} \tag{15}$$

### 4.1 Versioning Strategy

**Proposition 7** *It is optimal for the intermediary to offer multiple versions of the value added service.*

This result can be easily verified for the case where $F(\theta)$ is uniform, since Eq. 14 shows that $\theta_L^* < \frac{1}{2}$. For the general case, we provide the proof in the Appendix. Interestingly, we note that the versioning result holds even when $b = 0$ i.e., sellers get no aggregation benefit by subscribing with the intermediary (e.g., when the intermediary given sellers access to buyers, but provides no information or aggregated content). This contrasts with the case of enhanced matching services where versioning is optimal only in the presence of seller-sided aggregation benefits.

### 4.2 Comparative Statics

The first order conditions for the case of general distribution $F(\theta)$ stated in Eq. 11 and 12 may yield multiple stationary points. As in §3.2, we compute comparative statics to examine the impact of changes in the exogenous parameters ($b$, $c$, $e$, $q_L$) on the decision variables $\theta_L$ and $y_i$ as well as profit (recall that $\theta_H$ is unaffected by any of the exogenous parameters).

**Proposition 8** *When the intensity of aggregation benefits to the supplier (b) is greater, the intermediary i) achieves a greater profit in equilibrium, ii) obtains a greater number of buyers ($\theta_L^*$ reduces), and iii) increases its coverage on the sellers' side ($y_i^*$ reduces).*

**Proof.** Applying the envelope theorem, $\frac{\partial \pi^*}{\partial b} = (1 - y_i)(1 - F(\theta_L)) > 0$ hence the intermediary makes greater profit when $b$ is greater. To compute the effect on the optimal indifference points, we see that $\frac{\partial^2 \pi^*}{\partial b \partial \theta_L} = (1 - y_i)(-F'(\theta_L)) < 0$ hence, applying the conjugate pairs theorem, higher $b$ leads to a lower $\theta_L^*$. Similarly, a higher $b$ leads to a smaller value of $y_i^*$ since $\frac{\partial^2 \pi^*}{\partial b \partial y_i} = -(1 - F(\theta_L)) < 0$. ■

**Proposition 9** *When the intensity of the competition among suppliers (c) is greater, this i) reduces the intermediary's profit in equilibrium, and ii) leads to reduced coverage on the sellers' side ($y_i^*$ increases).*

**Proof.** Applying the envelope theorem, $\frac{\partial \pi^*}{\partial c} = -(1 - y_i)^2 < 0$ hence the intermediary's profit drops when $c$ is greater. Coverage on the sellers' side is reduced, since $\frac{\partial^2 \pi^*}{\partial c \partial y_i} = 2(1 - y_i) > 0$. ■

**Proposition 10** *When the intensity of the aggregation benefit to buyers (e) is greater, this i) increases the intermediary's profit in equilibrium, ii) leads to increased coverage on the buyers' side ($\theta_L^*$ decreases), and iii) leads to increased coverage on the sellers' side ($y_i^*$ decreases).*

**Proof.** Applying the envelope theorem, $\frac{\partial \pi^*}{\partial e} = (1 - F(\theta_L))(1 - y_i)^2 > 0$ hence the intermediary's profit increases when $e$ is greater. The intermediary increases its coverage on the buyers' side since $\frac{\partial^2 \pi^*}{\partial e \partial \theta_L} = -F'(\theta_L)(1 - y_i^2) < 0$. Similarly, an increase in $e$ increase coverage on the sellers' side, since $\frac{\partial^2 \pi^*}{\partial e \partial y_i} = -2y_i(1 - F(\theta_L)) < 0$. ■

**Proposition 11** *An increase in the quality of the low level value added services ($q_L$) i) reduces the intermediary's profit in equilibrium, ii) leads to reduced coverage on the buyers' side ($\theta_L^*$ increases).*

**Proof.** Applying the envelope theorem we get $\frac{\partial \pi^*}{\partial q_L} = \theta_L^*(1 - F(\theta_L^*)) - \theta_H^*(1 - F(\theta_H^*))$. Following the proof given in Proposition 4, this derivative is negative, hence profit reduces as $q_L$ increases. To compute the effect of an increase in $q_L$ on $\theta_L^*$, we apply the Conjugate Pairs theorem,

$$\frac{\partial^2 \pi}{\partial q_L \partial \theta_L} = (1 - F(\theta_L) - \theta_L F'(\theta_L)) > 0$$

which shows that $\theta_L^*$ increases. ■

### 4.3 How Many Versions?

Now consider the more general case where the intermediary may offer $N$ quality levels $q_1 ... q_N$ of the value-added service. Let the optimal indifference points be $\theta_j (j = 1...N)$ where $\theta_j$ is indifferent between $q_j$ and $q_{j-1}$. Let $p_j$ be the price for service level $q_j$, hence from the indifference equations we get $p_j = \theta_j(q_j - q_{j-1}) + p_{j-1}$ for $j = 2...N$ and $p_1 = \theta_1 q_1 + e(1 - y_i^2)$. Therefore the intermediary's profit function is

$$\pi = (1 - F(\theta_N))p_N + \left[ \sum_{j=1}^{N-1} (F(\theta_{j+1}) - F(\theta_j))p_j \right] + b(1 - \theta_1)(1 - y_i) - c(1 - y_i)^2$$

Simplifying and computing first derivatives, we see that the stationary points $\theta_j$ satisfy the conditions

$$\text{for } j = 2...N, \quad \theta_j^* \quad \text{solves} \quad \left[ \; 1 \;\; = \;\; \tfrac{1 - F(\theta_j)}{F'(\theta_j)} \tfrac{1}{\theta_j} \; \right] \tag{16}$$

$$\theta_1^* \quad \text{solves} \quad \left[ \; 1 + \tfrac{(1 - y_i)(b + e(1 + y_i))}{\theta_1 q_1} \;\; = \;\; \tfrac{1 - F(\theta_1)}{F'(\theta_1)} \tfrac{1}{\theta_1} \; \right] \tag{17}$$

Since Eq. 16 is identical for all $j = 2...N$, we see that $\theta_2^* = ... = \theta_N^*$, hence quality levels $q_2 ... q_{N-1}$ are not offered, reducing the problem to the two-quality problem solved earlier. Hence it is optimal for the intermediary to offer just two quality levels.

# 5 Discussion

This paper has examined the design of infomediary services especially with regard to the use of a versioning strategy. We find that versioning would help improve an infomediary's profitability and participation of buyers and sellers in the marketplace. While versioning is well-understood to be profitable in general, researchers in information systems have shown that under certain circumstances—zero marginal costs, and constant marginal valuations for quality—versioning is not optimal, because the revenue loss due to cannibalization is not offset by any savings in costs. In contrast, our analysis of an intermediary's pricing strategy demonstrates that versioning is optimal even under these circumstances (Propositions 1 and 7). How do we explain this increased incentive to version? The answer is in the aggregation benefit that is an essential characteristic of infomediaries: since the infomediary aggregates information about the participants and offerings in the marketplace, its users (buyers and, respectively, sellers) obtain greater value from the infomediary's services when there is a larger number of sellers (buyers). Therefore, the intermediary has a greater incentive to deploy an additional low-quality service, at a relatively lower price, that will obtain participation of low-type buyers who are not willing to purchase the higher-priced premium quality service. That in turn provides a greater incentive to sellers to participate, and when there is a larger number of sellers in the market, this substantially increases the valuation of the high-type buyers, therefore the infomediary can charge a higher price from users of the high-quality service.

Comparing with the traditional argument for versioning, the impact of the aggregation benefit on the intermediary's versioning strategy is as follows. The number of listed sellers is a critical element in buyers' valuation of the intermediary's matching service. If this were not the case (i.e., we remove the term $1 - y_i^2$ from the valuation function, or assume that all sellers are listed), then the intermediary would have no incentive to segment the market (standard result in prior literature cited above). Were the intermediary to offer just one quality level, then increasing participation of buyers would carry the cost of a lower price, thus reducing revenue. Offering multiple versions provides a solution to this problem: the intermediary introduces a low-priced service $q_L$ to attract


Figure 1: `Basic matching and value-added services (ERP connectivity) offered by Elemica, an infomediary in the chemical industry.`

more users, this increases the number of sellers and the valuation of high-type buyers, allowing the intermediary to get higher revenues for the premium service.

Our versioning results and the qualitative distinctions and analysis of matching vs value-added services offer concrete ideas regarding how to design differentiated versions. We have shown that it is optimal to offer exactly two—rather than multiple—quality levels. Further, we find that the intermediary's profits decline as the lower quality version improves: the cannibalization effect increases as the two quality levels move closer. Therefore it is optimal for the intermediary to make the low quality service as basic as possible, i.e., to offer only matching services in the low-quality service. The basic matching service helps the intermediary to expand the size of the buyer network (making the intermediary more attractive to sellers) while the higher quality service brings higher revenues; other quality levels in the middle are not offered because they would only cannibalize the high-quality service without expanding the size of the buyer network.

In settings where there are stand-alone value-added services, the intermediary should offer a

basic matching service and a second premium service that bundles matching and stand-alone value-added services. In this case, the value-added services include features such as industry data and intelligence, conferences, insurance, and litigation support. A popular example of this is AAA.com, which provides various matching services for travel planning and also offers its members additional value-added services such as maps, trip planning, and travel insurance. In settings where value-added services have no stand-alone value but tend to enhance the benefit from matching, the intermediary's menu would again consist of a basic matching service and a premium service that includes enhanced matching services. These enhanced matching services include IT services—such as collaborative workflow, data integration, systems connectivity, and automatically checking adherence of transaction to business rules–that provide support for logistics, fulfillment and execution. Figure 1 illustrates the use of such a strategy by an intermediary in the chemical industry, which offers a basic *transaction enabling engine* and a premium *ERP connectivity* service that promises to increase efficiency through seamless data exchange flows. This analysis finds support in the real-world where intermediaries initially offered only a single quality level—a matching service—but have more recently employed a versioning strategy, treating value-added services as a critical offering to high-end users. This transition is also documented in the recent industry and academic literature (see e.g., (Sarkar, Butler, and Steinfield 1995) and (Wise and Morrison 2000)).

# 6 Conclusions

This paper has developed a model of infomediary services, in which the infomediary chooses quality levels and price while buyers and sellers make decisions to participate while forming rational expectations about how many buyers and sellers would participate with the intermediary. The intermediary offers a number of services such as matching, price discovery, transaction management, industry reports and account management. Services that help establish an agreement between buyers and sellers are considered to be matching services and other services are called value-added services. Participants in an intermediated market care about the size of the intermediary's network.

Buyers find an intermediary's service more valuable if it provides access to more sellers, and sellers value it more if it provides access to more buyers. Further, competition between sellers lowers the benefit to sellers when there are many sellers subscribing to the intermediary's service.

We have examined two settings of intermediary services: one where value-added services increase the benefits from matching services but have no stand-alone value, and the second where value-added services provide a stand-alone benefit independent of the matching services. Adopting a buyer-oriented perspective, we have shown that it is optimal for the intermediary to pursue a versioning strategy and offer two quality levels to buyers, where the lower quality level consists of matching services and the higher quality includes additional value-added services. This paper contributes to existing literature on versioning and intermediary services by formally analyzing the intermediary pricing—taking into account the aggregation effects and the different types of intermediary services—and showing that versioning is an especially useful strategy for intermediaries, more so than for other information goods sellers. Further we provide insights into implementing such a strategy by creating two versions, one that includes matching services and another that bundles matching and value added services. We have also examined different types of value added services to classify them into those that help in transaction management and execution such as logistics and payment services and other value added services that provide stand-alone benefits such as reports, education, and training.

Intermediation services such as online exchanges face the well-known chicken-and-egg problem: initially, the lack of sellers makes the service unattractive to buyers, and lack of buyers makes it unattractive to sellers. While we have solved for a single period rational expectations equilibrium, in the real world, different players are likely to have a variety of different expectations and the evolution and eventual success of an intermediary depends on how buyers and sellers make a decision to join when the network is still quite small. Therefore value added services can be used as a catalyst to jump start the process of aggregation. This is consistent with Wise and Morrison's (2000) conclusion that intermediaries will survive only if they go beyond the matching role. This may be modeled formally by extending our analysis to a multi-period setting. This paper can

also serve as a useful framework for examining the recent trend among sellers to setup their own retailing websites while some large buyers are experimenting with private marketplaces where the buyer can directly interact with various sellers.

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# A Technical Appendix

**Proof of Proposition 1** The RHS in Eq. 4 is decreasing in $\theta$ (under the assumption of nondecreasing price elasticity of demand) and lies between $\infty$ and 0, hence the equation yields a unique $\theta_H^* \in (0,1)$. Now consider the first part of Eq. 5: the RHS is identical to that of Eq. 4 while the LHS always exceeds 1. Hence, while Eq. 5 may have multiple solutions—critical points for $\theta_L$—all are strictly less than $\theta_H^*$. Therefore we conclude that it is optimal for the intermediary to segment the market and offer both the lower and higher quality service. Figure 2 graphically explains the result.

**Proof of Proposition 7** The proof is similar to that of Proposition 1. The RHS is identical in Eq. 11 and the first part of Eq. 12; it is decreasing in $\theta$ (under the assumption of nondecreasing price elasticity of demand) and lies between $\infty$ and 0, hence Eq. 11 yields a unique $\theta_H^* \in (0,1)$. Further, the LHS of Eq. 12 always exceeds the LHS of Eq. 11 (which equals 1). Hence, while Eq. 12

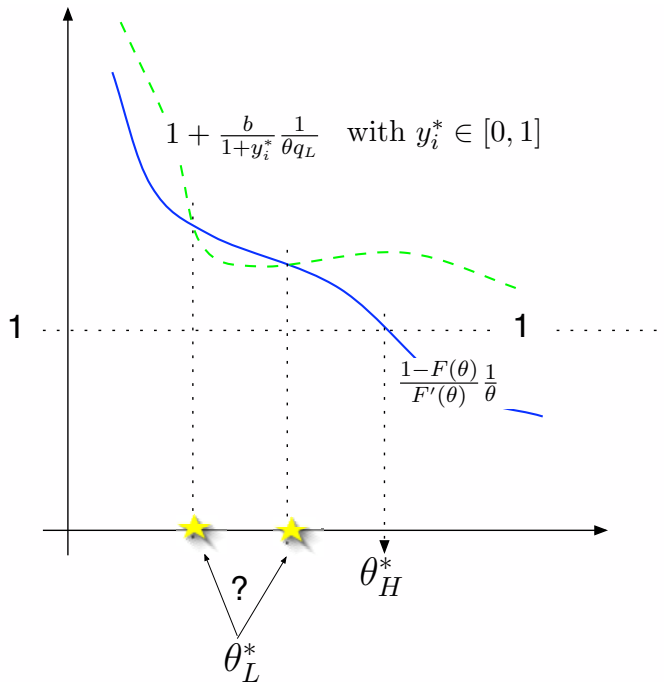


Figure 2: Optimal indifference points $\theta_L^*$ and $\theta_H^*$ for intermediary service: enhanced matching case. There may be multiple candidates for $\theta_L^*$ but all must lie strictly to the left of $\theta_H$.

may have multiple solutions—critical points for $\theta_L$—all are strictly less than $\theta_H^*$. Therefore it is optimal for the intermediary to segment the market and offer both the lower and higher quality service.