Competition in mediation services: Modeling the role of expertise, satisfaction, and switching costs

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Competition in mediation services: Modeling the role of expertise, satisfaction, and switching costs

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Short Title: Competition among intermediaries

Abstract

This paper analyzes competition among mediation service providers that match clients and vendors in a horizontally differentiated market. This is an issue that is important for decision support of mediators in determining pricing and service strategies. We present a simulation model to simultaneously represent search as well as the behaviors of clients, vendors, and

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multiple competing mediators. Among our findings: intermediaries find it optimal to offer registration fee incentives and derive revenues from transaction fees from successful matches; as switching costs increase, incumbent utilities increase and entrant utilities decrease; expertise, modeled as the ability of mediators to assess vendor attributes accurately, is a powerful competitive weapon for entrants to erode the incumbent intermediary’s first mover advantage. On the other hand, client satisfaction is an instrument for an incumbent intermediary to deter entrance by competitors.

Keywords: Mediation; competition; search, expertise, satisfaction, switching costs

1. Introduction

Mediators are entities (computational, human or organizational) that can be utilized as a bridge on an information stream between separate entities to tailor or otherwise extend functions as the information flows along the stream (Barrett and Maglio 1999). A body of work dealing with mediation appears in the electronic market literature (Lee, Hwang et al. 2011). Findings from this research include the following: When buyers have constant marginal valuations for service quality, a monopoly mediator should offer only two levels of service - a basic matching service and a premium service that includes matching and value-added services (Bhargava and Chaudhary 2004). In the presence of competition among mediators, mediators differentiate based on fees. Often, some service providers offer high registration fees and low transaction fees, while other providers offer a mirror pricing policy (Caillaud and Jullien 2003). In a market with many mediators and a monopoly market-maker, it has been found that a range of outcomes is possible.
Based on two parameters – search costs and transaction costs for the market-maker and mediators (Rust and Hall 2003).

Existing research on intermediaries has two major limitations. The first is that, although the utility of mediation is driven by the benefits of facilitating matches between clients and vendors, the matching process itself is not modeled – matching outcomes are exogenous to most models (e.g. Bhargava and Chaudhary 2004). The models generally assume that all matching is facilitated by mediators. However, in most markets, a large fraction of the matching does not occur through mediators. For example, in the steel market, about half of all matches occur through interactions between buyers and sellers using direct search (Rust and Hall 2003). The second issue is the difficulty of modeling competition among mediation service providers. The rationalization required to simultaneously analyze the behaviors of clients, vendors and mediators leads to unrealistic simplification, such as assuming that there is a unique matching agent on the other side (Caillaud and Jullien 2003).

These limitations constrain the usefulness of these models. For example, most markets have more than one matching intermediary, but conclusions from monopoly intermediary models do not provide guidance on dealing with competition in the marketplace. For example, monopoly models cannot provide guidance on strategies that entrants can use (e.g. expertise) to enter the market profitably and strategies that incumbents can use (e.g. customer satisfaction) to defend themselves against entrants. Models that do not include search behavior as an integral part of the model cannot easily predict the impact of search costs (arising, for example, from product or industry features) on intermediaries.
This paper addresses these limitations by extending current mediation models for matching services and by developing an extensible model for competition among intermediaries offering matching services. Its contributions include: (1) the computational approach (Stinstra and Hertog 2007) is leveraged to relax many constraints common in prior research; (2) instead of assuming the utility from direct search to be known, it is determined through direct search; (3) instead of being restricted to vendors with local monopolies and homogeneous products as in (Baye and Morgan 2001), our approach allows differentiated products and competitive vendors, where the utility of mediation is driven by the superiority of mediated matching over direct matching; (4) instead of a unique matching agent on either side of the market (Caillaud and Jullien 2003), we consider the more realistic case where matching with any agent on either side is profitable, but the utility of the match depends on the compatibility between client preferences and vendor capabilities; (5) instead of a market for homogeneous products (Stahl 1988), we consider a horizontally differentiated market where clients and vendors are defined by their landscapes of preferences and capabilities; (6) these interactions between buyers and sellers occur in a market with two competing intermediaries providing matching services. These six features allow our model to provide a more realistic representation of mediation. Our approach also allows us to include typical competitive behaviors (e.g. expertise, subsidies, and customer satisfaction) in our model. It may be noted, however, that the paper does not model vertical differentiation, such as the provision of value-added services (Bhargava and Chaudhary 2004).

The mediation modeled in this paper closely approximates the matching services provided by most professional service firms. For example, in the enterprise systems market, one of the important services offered by systems integrators is their ability to identify the best vendors to
implement a client’s needs. While clients could perform this selection on their own, system
integrators have the opportunity to improve the match based on their extensive prior knowledge
of both the client needs and vendor capabilities. They can then extract some of the surplus
generated as professional service fees. Similar matching services are provided by other
professional service firms as well (including law firms in private placement) to identify the best
buyers for prospective sellers.

The research yields several findings relevant to managers. For example, we find that there are no
benefits to an incumbent mediator from deterring the entrance of a competing mediator. Further,
the first-mover advantage of the incumbent mediator is larger at high values of vendor
satisfaction. From the perspective of the entrant, we find that instead of reducing prices,
improving service quality (measured as higher accuracy of assessments) is a better strategy for
the entrant to outperform an incumbent mediator. Other key results include the following.
Transaction fees are the dominant source of mediator profits. The reduction in fees required to
deter entrants limits the utility of being the sole matching mediator in the market. An entrant
with greater expertise (better estimation accuracy) out-performs the incumbent and overcomes
the incumbent’s first-mover advantage. This potential for an entrant to overcome the first mover
advantage is an important extension of prior research (Caillaud and Jullien 2003), henceforth
called the CJ03 model. An incumbent’s optimal subsidies increase profits for both the incumbent
and entrant, but the entrant’s optimal subsidy transfers utility from the incumbent to the entrant.

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2 We thank an anonymous reviewer for suggesting this example
The remainder of the paper is organized as follows. Section 2 covers prior research and sets the stage for the research model. Section 3 describes the research model and simulation setup to evaluate the model. Results are in section 4 and conclusions, and directions for future research are in section 5.

1. Prior research

Prior research on mediation has primarily focused on monopoly mediators. For example, Bhargava and Chaudhary (2004) consider an intermediary in a market where the value of mediation is a function of the sizes of buyer and seller networks, yet buyers and sellers differ in their valuation for mediation services. Yoo and colleagues (2003) examine the impacts of buyer and seller switching costs on profits for a monopoly intermediary. Rust and Hall (2003) analyze the entry of a market maker in a market for homogenous goods. Agrawal et al. (2005) examine revenues earned by a monopoly intermediary in the presence of direct search. A study by Bandyopadhyay et al. (2005) examines competition among sellers in online exchanges.

Most markets, however, are characterized by competing mediators. Whereas mediator profits in monopoly models are constrained only by participation constraints for buyers and sellers, competitive pressures impose constraints on mediator fees. Therefore, it is necessary to introduce competition among mediators to develop more realistic models of mediation.

Models for competition among mediators have been developed in prior research. Stahl (1988) showed that in markets for homogenous goods, when merchants (who act as the mediators in these markets) competed for supplies from sellers to later sell them to buyers, the unique
equilibrium (when it existed) led to zero mediator profits when there was more than one mediator in the market. Modeling mediators as information gatekeepers, research has found price dispersion to be optimal and that prices advertised by the gatekeeper are lower than unadvertised prices (Baye and Morgan 2001; Baye, Morgan et al. 2006). Chang et al. (2009) found that a firm’s product offerings, market conditions, and purchase patterns determine the profitability of the B2B e-Commerce channel from the perspective of the buyer.

Caillaud and Jullien (2003) developed a model of two competing mediators in a market of ex-ante identical agents on both buyer and seller sides. For each buyer and seller, there is only one unique matching partner on the other side with whom trade is profitable. Buyers and sellers pay a one-time registration fee and a fee per-transaction. The assumptions of the CJ03 model significantly limit its utility. These include (1) probabilities of direct match are zero; (2) agents on either side (clients and vendors) are ex-ante identical; (3) there is one unique profitable trading partner on the opposite side, so mediation is successful only when the trading partner on the other side also uses the mediator’s services; and (4) mediators use identical technologies. These assumptions help to ensure that the match results in equilibrium market clearance. The CJ03 model illustrates the challenge of modeling competition among mediators. It is difficult to reconcile ex-ante identical clients and vendors with unique matching partners.

The model presented in this paper builds on these approaches and allows for specialization and competition among mediators offering matching services. Specifically compared to CJ03, in our model, direct match is possible, agents on either side are horizontally differentiated instead of
being identical, the benefits of matching depend upon the specific partner selected, and the mediators are not identical.

1. Basic model

Clients have unit demand. When they choose a mediator, they pay a one-time registration fee and a part of their utility from the match as the mediator’s transaction fee. Clients and vendors are allowed to use either of the two mediators. Clients have two potential incentives to use the services of one mediator over the competing mediator or direct search. The first is the likelihood that the selected mediator identifies a superior match compared to the competing mediator. The second is the reduction in transaction fees if the second mediator charges a lower transaction fee than the first mediator, when both mediators I (incumbent) and E (entrant) identify the same match, which is superior to the match identified in direct search. Notations used in the paper are in Table 1.

Focusing on the incumbent mediator I, client i chooses mediator I over both mediator E and direct search if it offers the greatest utility among the three. This is written as:

\[ u_{iI}(1 - p_{cI}^{T}) - p_{cI}^{R} > u_{iD} \]

(1)

In (1), \( u_{iI} \) and \( u_{iE} \) are the utilities obtained by client i from the vendor identified by mediator I and E respectively. These utilities depend upon the mediator’s search technology and the total
number of trading partners who choose to register with I or E. The LHS in both equations is client i’s trade surplus from choosing mediator I. The RHS $u_{id}$ in the first equation is the trade surplus for client i from direct match. Clients use the optimal search rule to find a match in direct search (Rothschild 1974). The RHS in the second equation is the trade surplus from trading with mediator E. $p_{ci}^R$ and $p_{ce}^R$ are the one-time client registration fees charged by I and E, and $p_{ci}^T$ and $p_{ce}^T$ are the client transaction fees charged by I and E respectively. No matching fees are paid when choosing direct search. Similarly, client i chooses mediator E over both I, the incumbent, and direct search if both the following conditions are satisfied:

$$u_{ie}(1 - p_{ce}^T) - p_{ce}^R > u_{id}$$

$$u_{ie}(1 - p_{ce}^T) - p_{ce}^R \geq u_{ij}(1 - p_{ci}^T) - p_{ci}^R$$

Following the standard model of horizontal differentiation, in equilibrium, all vendors charge the same price (Tirole 1988, pg 280). Accordingly, vendor prices paid by clients for each matched transaction are normalized to 1, and all utilities and prices are calculated with respect to this normalized price. Similar to other mediator models and common practice, if the transaction is matched through a mediator, vendors pay a part of this revenue to the mediator as a transaction fee (Caillaud and Jullien 2003).

Once clients make their choices, vendors register with mediator, I or E, if the utility from transaction fees from clients matched through the mediator net of the mediator’s registration fees is positive and exceeds the switching threshold from the utility obtained from the other mediator when it charges optimal fees. For the incumbent mediator and vendor indexed $j$, we write this as:
Note that when the incumbent mediator first enters the market, \( U^*_j \) is 0. Given the participation (individual rationality) constraints for both clients and vendors, mediators choose registration and transaction fees for clients and vendors that maximize their utilities. We can now write the mediators’ objective function as in (4):

\[
\text{Mediator I’s objective function:} \quad \max_{p_{cl}^R, p_{cl}^T, P_{cl}^R, P_{cl}^T} \left( \sum_{j \in C_j} (p_{cl}^R + u_d) * P_{cl}^R \right) + \sum_{j \in V_j} p_{cl}^R + \sum_{i \in C_i} p_{cl}^T
\]

subject to

Client participation constraint, \( \forall \ c_{il} \in C_i \)

\[u_d(1 - p_{cl}^T) - p_{cl}^R > u_D\]

\[u_d(1 - p_{cl}^T) - p_{cl}^R \geq u_E(1 - p_{cl}^T) - p_{cl}^R\]

and vendor participation constraint, \( \forall \ v_{jl} \in V_j \)
$U_{\beta} = \sum_{i \in \mathcal{E}_T} (1 - p_{iT}^R) - p_{iT}^R > 0$

$U_{\beta} > (1 + s_{m})U_{\beta}^*$

Mediator E’s objective function:

$$\max_{p_{cE}^R, p_{cE}^T, p_{cE}^R, p_{cE}^T} \sum_{i \in \mathcal{E}_I} (p_{iE}^R + u_{iE}^* p_{iE}^T) + \sum_{j \in \mathcal{E}_V} \left( p_{jE}^R + \sum_{i \in \mathcal{E}_I} p_{iE}^T \right)$$

Subject to

Client participation constraint, $\forall \ c_i \in \mathcal{C}_E$

$u_{iE}(1 - p_{cE}^T) - p_{cE}^R > u_{iD}$

$u_{iE}(1 - p_{cE}^T) - p_{cE}^R \geq u_{iD}(1 - p_{cI}^T) - p_{cI}^R$

and vendor participation constraint, $\forall \ v_j \in \mathcal{V}_E$

$U_{jE} = \sum_{i \in \mathcal{E}_L} (1 - p_{jE}^R) - p_{jE}^R > 0$

$U_{jE} > (1 + s_{m})U_{jE}^*$

Mediators set utility-maximizing registration and transaction fees for clients and vendors, given their participation constraints. The two objective functions of the mediators are related because vendor participation constraints depend upon the prices set by the competing mediator.
1.1. Computational setup

Seen as a sequential game, the system in (4) has an infinitely large search space. Also, closed-form analytical solutions to the system are difficult because the utility from direct search, $u_{iD}$, cannot be directly calculated (Kohn and Shavell 1974). Computer simulations and numerical experiments are often used to deal with these complexities. Where it is not easy to obtain closed-form solutions from an analytical model, or when closed-form solutions require restrictive assumptions, simulations have become a commonly used technique in management research (Konana, Gupta et al. 2000). One common condition is when the search problem is hard. For example, (Dawande, Johar et al. 2008) used numerical experiments in pair programming when the time minimization and effort minimization problems were NP-hard. Rivkin (2000) used simulations to study the impact of the complexity of strategies on their duplication by competitors. Simulations have also been used to identify the number of candidate solutions (Roth 2002). Other contexts where simulations have been used include online exchanges (Bandyopadhyay, Rees et al. 2006), planning for network services (Dutta 2001), team processes (Rao, Chaudhury et al. 1995) (Chaudhury, Nam et al. 1995) and evaluating the tradeoff between cost and performance of various organizational forms (Lin and Carley 1997).

The setup in eq (4) is therefore analyzed using a computational testbed that implements direct and mediated search in a market of horizontally differentiated clients and vendors (Figure 1). At a high level, the market includes a population of clients, vendors and two competing mediators. Clients compare mediated search with direct search to determine their preferred sourcing mode given mediator fees.
Mediators move sequentially, starting with the incumbent, and earn revenues from clients and vendors for transactions completed through the mediator. Each mediator selects fees that maximize its revenues, given the fees of the competing mediator. Competition stops when the termination condition for the experiment is reached. It can be seen that the system in (4) does not reach equilibrium. When one mediator maximizes its profits, its competitor has the opportunity to lower fees marginally and accept slightly lower profits. At the end of this sequence, when one of the mediators has the lowest possible profits, it will corner all vendors in the market so that the opponent mediator will have no opportunity to attract clients. At this point, the mediator that has succeeded in cornering the market can raise fees significantly and capture large profits, starting the fee attrition cycle all over.

The terminating condition in our model is quasi-equilibrium when the change in utility for both mediators between successive moves is less than 25%. Results are averaged across repetitions.

At a more detailed level, when the computations begin, an incumbent mediator and the population of vendors are introduced into the market where the incumbent mediator declares its registration and transaction fees. Clients have the option of using either direct search or mediated search. Clients have unit demand, and each client compares the results from direct search and mediated search to determine its preferred sourcing mode. In mediated search, mediators charge clients a fee and identify the best possible vendors in the pool for each client, subject to the mediators’ expertise. In direct search, clients evaluate vendors sequentially and select the best vendor found until the termination rule suggests that further search is unlikely to improve utility.
(Kohn and Shavell 1974; Rothschild 1974). If the client uses direct search, it avoids paying mediator fees, but risks selecting a sub-optimal vendor.

The information available to clients is the following: (1) awareness of a forum where vendors can be sampled for evaluation and verification (direct search), (2) a rule to evaluate the utility of each vendor and (3) awareness of the existence of two mediators which provide matching services between clients and vendors. Mediators make their pricing decisions sequentially and respond to prices posted by their competitor in its previous move. Clients choose between direct search, the competing mediator and the mediator making the current pricing decision.

Mediators are assumed to have evaluated every vendor in the marketplace. After the client completes direct search, it compares the utilities obtained from the vendor identified in direct search and by the competing mediator with the utility from the vendor identified by the mediator making the current move. The client chooses the current mediator if it offers the best utility of the three choices (equations (1) and (2)). Mediators derive revenues from both clients and vendors.

Client i’s utility from matching with mediator I is \( u_I(a^*_i, a_{jI}) \) where \( a_{jI} \) represents the specifications of the vendor j identified by mediator I and \( a^*_i \) denotes client i’s ideal preferences. The utility from direct matching is \( u_D(a^*_i, a_{jD}) \) where \( a_{jD} \) represents the specifications of the vendor identified in direct search. \( a_{jI} \) and \( a_{jD} \) are generally different because \( a_{jI} \) is identified by mediator I as the best available vendor in the market (subject to I’s own accuracy of estimating vendor characteristics), but direct search may stop before the optimal vendor is identified.
All vendors are available in the direct search market. However, the utility from mediated search is affected by the number of vendors that choose to register with the incumbent mediator. Because registration is potentially expensive, vendors that do not find an adequate number of clients from the mediator will choose not to register with the mediator. To implement this self-selection on the vendor side, client selection of the preferred sourcing mode is done in two steps. In the first step, all vendors register with the mediator and each client compares direct and mediated search to indicate its preferred sourcing mode. Once all client choices are known, vendors that find mediation profitable commit to participation with the mediator. Clients then perform their final evaluation of sourcing mode, comparing direct search over the full population of vendors with mediated search over a reduced population of committed vendors. Mediator revenues are calculated from the fees earned from clients and vendors.

Once the incumbent mediator selects its optimal fee, the entrant mediator enters the market. Mediator search for price in our model is look ahead-free. The operations of the entrant are similar to the operations of the incumbent and are shown in Figure 2. The major difference is that clients now compare both direct search and search with the incumbent with search with the entrant. The operations in the incumbent’s response are shown in Figure 3. Again, the operations are similar to those in the incumbent’s initial entry.

1.1.1. Modeling client and vendor preferences

Instead of homogenous products, we consider horizontal differentiation in client preferences and vendor capabilities to obtain a more realistic representation of the market (Xu, Wang et al. 2007). One method of examining horizontal differentiation is the goods-characteristics approach.
(Lancaster 1975). In this approach, consumers are assumed to derive utility not from the goods themselves as is the case in spatial models (Salop 1979), but rather from a set of characteristics that define the product category. Every good or service in a product category incorporates all the characteristics that define its product class. However, goods and services differ in the proportions in which they incorporate the characteristics.

Levinthal (1997) introduced a model called the N-K model (described in more detail in the next para), which is particularly useful to model search using the goods-characteristics approach. In this model, the complexity of the search problem is defined using two parameters, N and K. N is the number of attributes defining the search problem. When a vendor is evaluated, the evaluation is defined as the vector \([a_1, \ldots, a_N]\) where each attribute \(a_i\) is identified as either 0 or 1. K, the second parameter of the search problem is the extent to which each attribute interacts with other attributes in determining client utility. The utility of each attribute to the client depends not only upon the value of the attribute, but also upon the value of K other attributes. The overall utility of a vendor to the client is the sum of the utilities offered by each attribute. The N-K model has been used to model decision complexity and its various impacts, such as those on organizational strategy, imitation and modularity in designing complex systems (Rivkin 2000; Rivkin and Siggelkow 2003; Ethiraj and Levinthal 2004).

1.1.1. Direct search

Most search models assume that clients know the prior distribution of prices or service specifications in the marketplace, though they do not know who offers what. In these models, vendor strategies adapt to client search behaviors (Bhattacharjee, Gopal et al. 2006) and
mechanisms, such as SLAs, are used to govern the relationships between clients and vendors (Goo and Huang 2008). An innovation in the computational setup is the implementation of direct search. We implement the optimal search algorithm developed by Rothschild (Rothschild 1974) for the case where the vendor distribution is unknown and clients have no ability to recall. In our experiments, clients learn about the distribution of vendors through the search process. (The details of the search algorithm are available in (Rothschild 1974)). In direct search, clients examine vendors sequentially until their search-termination rule indicates that further search is unlikely to improve utility. The optimal search policy takes the form of a switch point level of utility $s$. Search stops when the utility currently available exceeds $s$ and continues otherwise (Kohn and Shavell 1974). As new samples are drawn, $s$ may change to reflect updated information. This is similar to the approach of (Rust and Hall 2003) which used Bellman equations for direct search. Mediators offer utility because direct search may not identify the optimal vendor when the termination rule suggests that search be stopped. Direct search, therefore, has 3 costs: (1) opportunity costs associated with loss of utility during search, (2) loss of utility due to identifying a sub-optimal provider at the end of search, and (3) a fixed search cost $s_c$, per time period, to evaluate a vendor. Because clients in most markets have at least some knowledge about the distribution of vendors in the market, we allow clients to perform two iterations of direct search to initialize expectations before performing direct search. After each iteration, clients reject vendors who offer a weak match. In our simulations, weak match was defined as utility lower than 80% of the utility found in direct search so far.
1. Results

The model in (4) can be used to examine market outcomes for competing mediators. In this section, we provide examples of such analysis. Default values for the simulation parameters are shown in Table 2. Client and mediator accuracy are the probabilities by which the clients and mediators correctly estimate the value of each attribute of the vendor. Vendor satisfaction is the probability that a vendor will continue to register with its current mediator. Mediator utilities are averaged over all repetitions.

There were 200 clients and 50 vendors in the market. The time horizon for search and consumption is 50 time periods. Discount factor was 10%. All clients had the same search costs of 0.1 and paid a small transaction fee, but no registration fee. Vendors had a switching cost of 10%, implying that vendors chose to register with the competing mediator only if registration offered at least 10% more utility than the current mediator. Both client and mediator were equally accurate in estimating vendor attributes. This ensured that the utility in mediation was exclusively from facilitating search. Three-fourths of the vendors were willing to continue their association with a mediator for the next round, if registering with the mediator offered positive utility (vendor satisfaction). This accounted for non-monetary factors that may affect participation (Baye and Morgan 2001; Bhargava and Chaudhary 2004).

Unless otherwise specified, all simulations were repeated 30 times and the mean values over these 30 simulations were used in the plots. With 200 clients, 15 values of transaction fees, 11 values of registration fees, a minimum of 5 rounds of response and counter-response between incumbent and entrant and 30 repetitions, each observation on each graph aggregates information.
from over 10 million data points. All simulations were run on a state of the market SunFire T2000 server with 8GB RAM and Ultrasparc T1 processor with 16 parallel processing threads at a clock speed of 1.0 GHz. The parallel processing threads greatly simplified the simulation procedure by allowing simulations with up to 16 different parameter values to be run simultaneously.

We focus on the mediators and identify the impacts of mediator decision parameters on their utilities. We then report the impacts of changing parameters in Table 2 - client search costs, vendor switching costs, size of client side of market, estimation accuracy and vendor satisfaction on mediator profits. We also introduce two forms of look ahead by mediators – subsidies and entry-deterrence.

1.1. Mediator fees

We start by examining the patterns of mediator utilities over the entire range of vendor registration and transaction fees considered in the simulations, using the default parameters in Table 2. In later sections, we will only consider optimal fees. We consider N = 4, K = 0 (results for N = 4, K = 3 were similar). Simulation time was slightly over 10 hours for N= 4, K = 0 and 18 hours for N = 4, K = 3.

Results for the incumbent are shown in Figure 4 (results for the entrant are available on request). The first row in the figures shows the number of member vendors and the second row shows the utilities. Both are plotted as a function of registration and transaction fees. The two columns show the same information, but from two perspectives - the y-axis has been inverted in the
second column to show information that is sometimes hidden behind the peaks in the first column.

We see that having negative registration fees (possibly in the form of a gift or an outright cash payment) is necessary to secure vendor participation. For positive registration fees, we see that the number of member vendors drops rapidly to 0 as the registration fee increases. Transaction fees are, therefore, the primary source of mediator profits. Negative transaction fees are not effective in increasing member participation.

Comparing these results to the exclusive case in (Caillaud and Jullien 2003), we find similarities and differences. Though we do find that negative registration fees are optimal, we do not have a dominant firm, and the entrant competes successfully with the incumbent. Both the incumbent and entrant are able to earn positive profits. Compared to the non-exclusive case in (Caillaud and Jullien 2003), we find that the incumbent does not enjoy a first-source advantage.

Our model considers heterogeneous agents that are potentially capable of matching with any agent on the other side, though different matches provide different utilities. This removes many benefits of a divide-and-conquer strategy in prior research (Caillaud and Jullien 2003). Even if a mediator succeeds in preventing some agents on one side of the market from contracting with the competing mediator, the remaining agents on the same side may be adequate to provide a sizeable number of profitable transactions matched by the competing mediator. Thus, mediators balance the costs and competitive rewards of cornering one side of the market. In addition, all agents may find a match through direct search, a market that cannot be cornered by either mediator.
In this context, the small negative vendor registration fees play an important role in securing vendor participation. Negative registration fees are effective for mediators because they increase participation, leading to greater matching probabilities. With positive registration fees, vendors that are unable to attract an adequate number of clients to recover registration fees will choose not to use the mediator (even if they may have found a small number of clients). This reduces the likelihood that clients will have matching benefits from the mediator, thereby reducing client participation. Negative transaction fees do not increase vendor participation. This suggests the following finding:

**Finding 1(a):** An optimal one-time registration fee incentive will benefit mediators by encouraging vendor participation.

**Finding 1(b):** Transaction fee incentives are not effective in increasing vendor participation.

1.1. Look ahead free competition among mediators

In this section, we report on the impacts of changes in default experiment parameters, as mediators use look ahead free mechanisms to determine optimal fees.

1.1.1. Client search costs in direct search

An important parameter in search models is client search costs (Kohn and Shavell 1974; Caillaud and Jullien 2003). Search costs do not directly affect results because a comparison of direct search and mediated search is not possible before direct search is completed. Thus, search costs are sunk costs in both mediated and direct search. However, when clients follow the optimal
search policy in direct search, an increase in search costs reduces the number of vendors sampled by clients in direct search, leading to lower expected utility from direct search. As a result, an increase in search costs should generally favor mediators. These effects are not observed in intermediary models that do not explicitly consider search as an integral part of the model.

Client search costs in our model are measured relative to client’s expected unit utility from selected vendors in direct search (Rothschild 1974). Results are shown in Figure 5 and as expected, an increase in client search costs improves utilities for both mediators. Simulations took 65 hours to complete, with simulations for lower client search costs taking the longest time because of the increased number of vendors sampled.

As search costs increase, the two mediators make the greatest gains at different values of client search costs. The incumbent benefits most when search costs rise from almost negligible levels (0 to 0.1). At these low levels of search costs, the incumbent is able to retain most of the surplus associated with mediated search. Because direct search costs are still comparatively low, the entrant finds it a challenge to attract vendors from both the incumbent and direct search.

The entrant makes significant gains when search costs become high (> 0.5). In this case, direct search is unfavorable and the incumbent is the only real competition facing the entrant. As can be seen from Table 3, the profits of both mediators increase as search costs increase, indicating that more clients prefer mediated search as direct search costs rise. For reference, summary statistics on mediator utilities for two values of client search costs are provided in Table 3. This suggests the following:
Finding 2: While an increase in direct search costs is always favorable for the incumbent mediator, the entrant benefits only when direct search costs are high (greater than 0.5).

1.1.1. Optimal search compared to budget-constrained search

In many cases, clients use a strategy of satisficing in direct search, where they sample a small number of vendors and choose the best vendor found in this limited sample. We call this “budget-constrained” search. A comparison of budgeted search and optimal search is indicated Figure 6. As with finding 2, these effects are not visible in intermediary models that do not model direct search.

We find that mediator utilities, when clients perform optimal search, are comparable to utilities in budgeted search, even though mediator utility from optimal search slightly dominated budgeted search. We attribute this difference to lack of recall in optimal search, whereas our model of budgeted search allowed recall. For reference, summary statistics for the incumbent for two values of client search costs are presented in Table 4. This suggests the following:

Finding 3: Mediator utilities under budget-constrained search with recall in the direct market are comparable to mediator utilities under optimal search without recall in the direct market.

1.1.1. Vendor switching costs

Technological factors in the industry and managerial decisions by mediators can influence costs for vendors to switch between mediators. Switching costs include transaction costs, learning costs and contractual costs (Klemperer 1987). Because ex-ante homogenous products become
ex-post heterogeneous by virtue of these switching costs, switching costs give service providers some degree of market power (Klemperer 1995). In this section, we examine the impact of vendor costs in switching between mediators.

Another useful effect of including vendor switching costs in our model is that it enables us to parameterize the exclusivity choice and entry issue in prior research (Caillaud and Jullien 2003). Whereas prior research models consider a binary choice between exclusive and non-exclusive mediation services, switching costs enable us to consider varying degrees of exclusivity. When there are no switching costs for vendors, our model is similar to the non-exclusive case as vendors can register with the competing mediator as long as the competitor offers at least non-negative utility. When switching costs rise, vendors in our model become increasingly exclusive, choosing to register only with one vendor.

In our model, when a competing mediator makes its pricing decision, vendors register with it only when the expected utility from such registration exceeds the threshold utility defined by the switching cost. We defined switching costs in terms of the utility from the current mediator. The threshold utility for a vendor to register with a competing mediator is \((1 + \text{switchingCosts}) \times \text{currentUtility}\). Thus, a switching cost of \(-1\) yields a threshold utility of 0. When switching costs are 0, vendors decide to join the competing mediator when the utility from the competing mediator is at least equal to the utility from the current mediator. We find that an increase in switching costs generally benefits the incumbent at the expense of the entrant, though the impact is not large. Results are shown in Figure 7.
However, looking at the simulation details, we found that the mechanism of impact of switching costs changes as switching costs increase. At very low switching costs, there is no mediator lock-in and vendors sometimes register with both mediators. Also, all vendors act alike most of the time. Thus, if the incumbent is preferred, all vendors prefer the incumbent; if the entrant is preferred, all vendors prefer the entrant, and if both mediators are useful, all vendors register with both. However, as switching costs increased significantly (>= 1), a clear partition of vendors among the incumbent and entrant emerged. As would be expected, the incumbent generally had the advantage, and more vendors preferred the incumbent than the entrant.

This observation is very interesting as we find that as our model gets closer to the exclusive case (high switching costs), the market often partitions in a manner similar to that predicted by prior research (Caillaud and Jullien 2003). The incumbent is usually preferred, the entrant serves the remaining vendors and high switching costs prevent either mediator from successfully attracting the competitor’s member vendors. This suggests the following:

*Finding 4: Even though high switching costs (greater than or equal to 1) separate vendors between the competing mediators, the resulting separation is more beneficial to the incumbent than the entrant.*

The simulation approach used in this paper enables the identification of a mechanism for creating the exclusive case in the market and also for examining market outcomes for the entire spectrum of switching costs.
1.1.1. Expertise - client and mediator accuracy of evaluation

Prior research suggests that mediators offer two primary services – matching agents on two sides of a market (as matchmakers or market makers) and offering expert services (Biglaiser 1993; Biglaiser and Friedman 1993). Much prior research has focused on the matching role of mediators (Caillaud and Jullien 2003; Weber and Zheng 2007). This paper has also focused primarily on the matching role of mediators. However, the computational approach allowed us to model one form of mediator expertise – the ability of mediators to accurately assess the attributes of vendors.

So far, our simulations have assumed that both clients and mediators assess all vendor attributes with perfect accuracy. In this section, we relax this assumption and consider different cases of estimation accuracy of vendor attributes by clients and mediators.

We consider five cases to include a broad range of scenarios. These cases may be identified with reference to Figure 8. From the left hand side, in the first case, both clients and mediators make perfect assessments of vendor attributes. This is the base case considered in all other simulations in this paper and indicates the utility extracted by mediators simply from superior matching compared to direct search. The mediators have no special “estimation expertise” compared to the clients in this case.

In all other cases in Figure 8, both mediators have superior estimation accuracies compared to clients. We fix the client’s own accuracy of assessing vendor attributes at 60%. This means that for each of the 4 parameters that define vendor characteristics (N = 4), clients are capable of
accurately assessing each attribute 60% of the time. In the second case from the left in Figure 8, the incumbent provides 80% accuracy of assessment whereas the entrant provides 90% accuracy (the entrant has greater expertise compared to the incumbent). We find that in this case, the entrant succeeds in outperforming the incumbent and even attains higher utility than in the case where clients and vendors had 100% accuracy of assessment. In the third case, the incumbent is more accurate than the entrant and, as expected, outperforms the entrant. However, compared to the first case, we see a penalty associated with a loss of accuracy from 100% to 90%.

In the last two cases, the two mediators have the same accuracy. In the fourth case, they are more accurate than clients (80% compared to 60%) and in the fifth case, they are as accurate as the clients (60% each). In both these cases, we find that the incumbent and entrant have comparable utilities and both attain higher utility when they are more accurate than the clients.

These results partially validate the conclusions in prior research. (Caillaud and Jullien 2003) suggest that the entrant can successfully enter the market only if $\lambda_E > \lambda_I$ (where $\lambda$ is the matching probability). We find that entry is possible in our model even when $\lambda_E < \lambda_I$, though superior matching technology is a powerful mechanism for the entrant to compete with the incumbent. Our simulations indicate that the incumbent cannot use pricing to match the performance of the entrant if the entrant has greater accuracy of assessment. In the context of professional services firms, one of the implications of this finding is that the most opportune moments for entrants might be during times of rapid change in the industry, when incumbent firms may not have any special matching expertise. An entrant with an advantage could use the opportunity to take on the
incumbent. Simulations reported in this section took about 31 hours. For reference, summary statistics are presented in Table 5. This suggests the following:

Finding 5: In order for the entrant to outperform the incumbent mediator, improving service quality (measured as higher accuracy of assessments), is a better strategy than reducing prices.

1.1.1. Vendor satisfaction

Thus far, we have examined variables, such as search costs and switching costs, that are traditionally associated with mediators and search. The computational approach allowed us to consider variables that are not traditionally considered in the context of mediation and search, but are relevant to markets and service providers. In this paper, we have considered one such variable – customer satisfaction of vendors.

Customer satisfaction is a popular concept built on the theory that more-satisfied customers will return and buy again in the future, thereby giving the firm some degree of market power. The idea has been empirically tested with a number of different measures for firm outcomes (Anderson, Fornell et al. 1997) and at different units of analysis. Customer satisfaction may be seen as one of the impacts of offering value-added services by a mediator (Bhargava and Chaudhary 2004).

Because vendors are customers of the mediator’s services, we modeled vendor satisfaction as the probability that a vendor would be willing to continue working with the current mediator. A satisfied vendor would register with the competing mediator, only if the expected utility from registering with the competing mediator exceeded the vendor’s threshold utility. However, a
dissatisfied vendor would register with the competing mediator if the expected utility was non-negative. Increased satisfaction therefore raised the bar for the competing mediator to attract vendors that were not already registered with it. Simulations took 38 hours and results for various values of vendor satisfaction are shown in Figure 9.

We find that vendor satisfaction is a very powerful tool at the disposal of the incumbent to establish dominance in the market. When vendor satisfaction is 1, almost all vendors that find it profitable to work with the incumbent in the first round, continue to do so. Though these vendors are open to membership with the entrant when the entrant enters the market (as in the non-exclusive case of CJ03), the barrier for the entrant is too high. When clients compare the utility they can attain from direct search and both mediators, the opportunities for the entrant to add value to clients over and above that offered by the incumbent are very limited. In this situation, very few vendors register with the entrant, and the entrant is only marginally profitable. We, therefore, see that vendor satisfaction can serve as an effective mechanism to create the exclusive case of CJ03. This finding may also explain the very high emphasis placed by professional service firms on customer satisfaction.

When vendor satisfaction is zero, both mediators are comparably profitable because vendors exhibit no loyalty to either mediator and switch mediators as soon as the competing mediator makes its pricing decision. In fact, in this situation, there is really no distinction between an incumbent and an entrant as vendors switch when the competitor offers non-negative utility. This suggests the following.
Finding 6: The first-mover advantage of the incumbent mediator is larger at high values of vendor satisfaction (greater than 0.5).

1.1. Competition among mediators with look ahead policies

In this section, we consider mediators adopting fee-setting policies that may be sub-optimal in the short run, but are likely to improve competitive outcomes. Two such policies are considered in this paper – subsidies and entry-deterrence. Subsidies are common in the form of discounted trials, bundled discounts, and so forth. Entry deterrence is common in the form of price reductions in response to entrants.

1.1.1. Effect of subsidies

Subsidies may reduce utility in the current round, but it is possible that by lowering fees compared to optimal values, the mediator could succeed in pre-empting the ability of the competing mediator to attract vendors. We consider both registration and transaction fee subsidies. Subsidies are relative to optimal fees. When fees are positive (transaction fees), subsidy lowers its magnitude. When fees are negative (registration fees), subsidy increases the magnitude of the fee (making it even more negative).

Results for transaction fee subsidies are shown in Figure 10 and 11. Each simulation took about 31 hours. Results indicate that transaction fee subsidies have a greater impact on mediator outcomes than registration fee subsidies for both the incumbent and entrant. A transaction fee subsidy of about 10% leads to the highest utility for both incumbent and entrant.
Results indicate a difference in the mechanisms by which the subsidies from the two mediators impact utilities. Though the incumbent’s optimal transaction fee subsidy level does not adversely impact entrant utilities (in fact, the entrant’s mean utility increases marginally, as seen in Figure 10), the entrant’s optimal subsidy leads to a significant drop in the incumbent’s utilities. This suggests that, whereas mediator transaction fee subsidies lead to increased use of mediated search in general (possibly due to a reduction in overall levels of mediator prices), entrant subsidies lead to a transfer of utilities from the incumbent to the entrant. This suggests the following.

**Finding 7(a):** Transaction fee subsidies have a greater impact on mediator profits than registration fee subsidies.

**Finding 7(b):** While the entrant is not adversely affected by the optimal transaction fee subsidy level of the incumbent, the optimal transaction fee subsidy of the entrant significantly reduces the incumbent’s profits.
1.1.1.1 Interaction between vendor satisfaction and optimal subsidies

To verify the stability of the results for subsidies, we consider the impact of changes in vendor satisfaction on mediator utilities. Vendor satisfaction was 0.75 in the simulations in the previous section. We now consider the impact of subsidies on mediator utilities for different values of vendor satisfaction. Simulations took about 30 hours for each value of vendor satisfaction. Figure 12 shows results for incumbent utilities and Figure 13 shows entrant utilities. For reference, Table 6 shows statistics for vendor satisfaction = 0.6.

We find that the patterns of mediator utilities as a function of subsidies do not change with vendor satisfaction, though their magnitudes are affected by change in vendor satisfaction. For intermediate values of vendor satisfaction, incumbent utilities increase with vendor satisfaction. However, incumbent utilities are comparable for vendor satisfaction = 0.0 and 1.0.

The increase in utilities as a result of increasing vendor satisfaction at intermediate levels of vendor satisfaction was expected. But the similarity in incumbent utilities for vendor satisfaction = 0 and 1 appears surprising. However, it can be explained by the fact that in both cases, the incumbent has comparable ability to offer matching services to vendors (this is also seen in the results on vendor satisfaction in the paper). When vendor satisfaction = 0, though the incumbent is unable to retain vendors, neither is the entrant. So, the incumbent can attract all vendors when it makes its pricing decision without competition from the entrant. When vendor satisfaction = 1, all vendors who find the incumbent profitable are willing to continue working with the incumbent. In this case, the incumbent starts off without competition from the entrant and is able to hold on to all member vendors.
Vendor satisfaction has a more predictable effect on entrant utilities, which decrease monotonically with increase in vendor satisfaction. As vendor satisfaction increases, the incumbent’s first mover advantage becomes more valuable. In the extreme case of vendor satisfaction = 0, the incumbent and entrant are identical and compete only with direct search when they make their pricing decisions. However, as vendor satisfaction increases, the entrant finds it progressively more difficult to offer enough utility to attract vendors from the incumbent. Therefore, given the incumbent’s first mover advantage, increasing vendor satisfaction has less utility for the entrant than for the incumbent. This suggests the following:

*Finding 8a:* For each value of vendor satisfaction, there exists an optimal incumbent transaction fee subsidy that maximizes the incumbent’s profits.

*Finding 8b:* Entrant profits are not affected by incumbent transaction fee subsidies for each value of vendor satisfaction.

**1.1.1. Benchmark with no entrant**

The second look-ahead policy examined in this paper is entry-deterrence by the incumbent to achieve a dominant position in the market where the entrant cannot earn positive profits. This is accomplished by modifying the model in (4) in the paper to (5) below, which adds a non-positive profit constraint on the entrant.
Mediator I's objective function:

\[
\max_{P_{cl}^R, P_{cl}^T, P_{vd}^R, P_{vd}^T} \sum_{c_{il} \in C_i} \left( p_{cl}^R + u_{il} \cdot p_{cl}^T \right) + \sum_{v_{jl} \in V_l} \left( p_{vd}^R + \sum_{c_{jl} \in C_j} p_{vd}^T \right)
\]

sub to

Client participation constraint, \( \forall c_{il} \in C_i \)

\[
u_{il}(1 - p_{cl}^T) - p_{cl}^R > u_{il}
\]

\[
u_{il}(1 - p_{cl}^T) - p_{cl}^R \geq u_{il}(1 - p_{cE}^T) - p_{cE}^R
\]

Vendor participation constraint, \( \forall v_{jl} \in V_l \)

\[U_{jl} = \sum_{c_{jl} \in C_j} (1 - p_{vl}^T) - p_{vl}^R > 0\]

\[U_{jl} > (1 + s_{vl}) U_{jl}^*\]

And mediator E’s profit constraint

\[\max \text{ Int E’s profit}^* \leq 0\]

Mediator E’s objective function:
\[ \max_{p_{iE}, p_{vE}} \sum_{c_{iE} \in C_E} \left( p_{iE} + u_{iE} \right) + \sum_{v_{jE} \in V_E} \left( p_{vE} + \sum_{c_{jE} \in C_E} \right) \]

subject to

Client participation constraint, \( \forall \ c_{iE} \in C_E \)

\[ u_{iE}(1 - p_{cE}^T) - p_{cE}^R > u_{iD} \]

\[ u_{iE}(1 - p_{cE}^T) - p_{cE}^R \geq u_{id}(1 - p_{cE}^T) - p_{cE}^R \]

and vendor participation constraint, \( \forall \ v_{jE} \in V_E \)

\[ U_{jE} = \sum_{c_{jE} \in C_E} (1 - p_{cE}^T) - p_{cE}^R > 0 \]

\[ U_{jE} > (1 + s_{im}) U_{jI} \]

Results are presented in Table 7 below. For reference, results for \( K = 3 \) have also been presented. Simulations took 9 hours. Results indicate that the primary difference between free competition and incumbent dominance is in registration fees. Optimal registration fees in free competition are only marginally negative. However, to prevent the entrant from profitably entering the market, the incumbent has to offer a registration fee that is close to the minimum allowed in the simulations. This is because when the incumbent raises registration fees from these minimum levels, the entrant is able to offer lower registration fees and attract vendors that find it profitable to switch.
The loss of utility from lower registration fees is partly recovered through higher transaction fees. Because mediator utilities are largely derived from transaction fees, the lower registration fees do not significantly hurt the incumbent’s utility. The high negative registration fees are required to deter entrants from entering the market and the lost revenues from these one-time fees to participating vendors eliminate the benefits obtained from blocking the entrant. For reference, Table 7 also provides the mean utility under competition. It is interesting to note that contrary to expectations, the incumbent does not benefit from maintaining a dominant status in the market in our model due to the costs of maintaining dominance. These observations suggest the following propositions.

Finding 9: There are no benefits to the incumbent from entry deterrence.

1. Discussion and managerial implications

This paper presents a model of competition between two mediators offering matching services in a horizontally differentiated market. It improves prior models of mediation by introducing competition among mediators, relaxing the assumptions of ex-ante identical agents on both sides of the market and by integrating direct search into the model of mediation. Clients and vendors are defined by their landscapes of preferences and capabilities in a model of horizontal differentiation. Further, instead of a unique matching agent on the other side of the market as in past research, the paper considers the more realistic case where matching with any agent on the other side is profitable, though the utility of the match depends upon the compatibility between client preferences and vendor capabilities. The model was used to derive inferences about the profitability of incumbent and entrant mediators under a wide range of pricing policies.
One common result we found in all contexts was that both mediators find it optimal to offer an optimal registration fee incentive. Both mediators derived most of their revenues from transaction fees from successful matches consummated through the mediator. These marginal registration fee subsidies are analogous to account-opening incentives offered by most firms, indicating that such incentives are optimal. Transaction fee incentives do not improve vendor participation.

As expected, we found that mediated search becomes preferable as search costs increase and the utilities of both mediators increase with client search costs. However, increasing search costs impact incumbent and entrant utilities at different values. Whereas the incumbent attains most of its benefits when search costs rise to moderate levels (from 0 to 0.2), the entrant does not benefit significantly until direct search become extremely unfavorable (search costs > 0.5). An interesting observation was that a simple search strategy of budget-constrained search provided very good performance in direct search compared to the optimal search strategy implemented in the rest of the simulations. This can be partly attributed to the presence of recall in budget-constrained search and its absence in optimal search.

As switching costs increase, incumbent utilities increase and entrant utilities decrease. However, what is interesting is that the mechanism of impact of increasing switching costs changes when switching costs become very high. At low levels of switching costs, most vendors have similar preferences – all vendors choose the incumbent mediator most of the time. When switching costs increase prohibitively, vendors partition among the incumbent and the entrant. A majority of vendors register with the incumbent, leading to an increase in the incumbent’s utility. The rest of
the vendors register with the entrant. This can be explained by the fact that once a vendor chooses to register with a mediator, it is not efficient to switch mediators when switching barriers are high.

Although the incumbent mediator generally outperformed the entrant mediator, expertise, modeled as the ability of mediators to assess vendor attributes accurately, emerged as a powerful competitive weapon available to the entrant to compete with the incumbent to erode its first mover advantage. When the entrant had higher accuracy of evaluation than both the incumbent and clients, it obtained greater utility than the incumbent. Higher accuracy of assessments is, therefore, even more effective than reduced pricing as a strategy for the entrant to outperform the incumbent.

Customer satisfaction emerged as a powerful tool at the disposal of the incumbent to prevent the entrant from getting a strong foothold in the market. Thus, superior expertise allowed entrants to outperform the incumbents, and high levels of satisfaction of vendors allowed the incumbent to outperform the entrant.

Because subsidies (or discounts) are a common competitive instrument, we considered the impacts of fee subsidies on mediator profits. Transaction fee subsidies have a greater impact on mediator profits than registration fee subsidies. Surprisingly, the incumbent’s optimal transaction fee subsidy actually improved utilities for the entrant as well. By contrast, a small subsidy by the entrant improved the entrant’s utility, but at the cost of the incumbent’s utilities.
Finally, we find that preventing entry is not very profitable for the incumbent mediator. A significant reduction in registration fees is necessary to block the entrant and the resulting loss in profits is not recovered from increased revenues from higher transaction fees.

Overall, our experiments suggest that mediation in matching services is a tough business. Under the conditions examined in the paper, pricing to attain a dominant status is not more profitable for the incumbent than a competitive market with the entrant. An entrant with greater estimation expertise is capable of outperforming the incumbent. In addition, the incumbent is vulnerable to low customer satisfaction. In many cases, the entrant does not have to limit itself to being the more expensive second-source provider as suggested in prior research.

1. Conclusions

While the paper offers a generalized model of mediator competition for matching services, it has a number of limitations. The most significant is that the model is myopic. While setting prices, the mediators only consider the known prices of the competing mediator. Mediators do not consider the likely competitive response of the prices they set. The subsidy policy examined in the paper is an initial attempt to overcome this limitation.

The research may also be extended by looking at additional roles for mediators. This paper considers the search basis for mediators. Other mediator roles include the provision of value-added services, such as service guarantees (Bhargava and Chaudhary 2004). Also, once a mediator invests in developing an IT platform to link to multiple vendors, clients may find it advantageous to join the platform rather than develop their own. These roles could be integrated
into the model. Another direction is to introduce asymmetry in mediator parameters. Impact of market attributes on client fees can be examined. Interaction effects between variables can also be studied, for example between mediator expertise and vendor satisfaction. Future research can also introduce various forms of market imperfections, such as the inability of mediators to extract all transaction revenues. Various approaches to help the model in (4) come to equilibrium could be considered. One potential approach would be to include trade frictions. It may also be useful to allow both mediators to declare prices simultaneously as in normal form games. In such a model, clients would choose between one or the other mediator.

1. Acknowledgments

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1. References


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Table 1: Notations

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
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<tbody>
<tr>
<td>$u_{iI}, u_{iE}$</td>
<td>Client $i$’s utility from matching with mediator Incumbent (I) and Entrant (E)</td>
</tr>
<tr>
<td>$U_{jI}, U_{jE}$</td>
<td>Vendor $j$’s utility from registering with mediator I and E</td>
</tr>
<tr>
<td>$U^<em>_j I, U^</em>_j E$</td>
<td>Vendor $j$’s utility from I and E when the mediator sets optimal fees</td>
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<tr>
<td>$u_{id}$</td>
<td>Client $i$’s utility from direct matching</td>
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<td>$p^R_{cI}, p^R_{cE}$</td>
<td>One-time registration fees charged by mediators I and E to clients</td>
</tr>
<tr>
<td>$p^R_{vI}, p^R_{vE}$</td>
<td>One-time registration fees charged by mediators I and E to vendors</td>
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<td>$p^T_{cI}, p^T_{cE}$</td>
<td>Transaction fees charged by mediators I and E to clients</td>
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<tr>
<td>$p^T_{vI}, p^T_{vE}$</td>
<td>Transaction fees charged by mediators I and E to vendors</td>
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<tr>
<td>$C_I, V_I$</td>
<td>Set of clients and vendors that use mediator I</td>
</tr>
<tr>
<td>Symbol</td>
<td>Description</td>
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<tr>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td>$C_E, V_E$</td>
<td>Set of clients and vendors that use mediator E</td>
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<tr>
<td>$C_{jI}, C_{jE}$</td>
<td>Set of clients matched with vendor $j$ through mediator I and E</td>
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<tr>
<td>$s_{int}$</td>
<td>Switching threshold to join new mediator, given membership with current mediator</td>
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<td>$sc$</td>
<td>Client’s cost per time period to evaluate a vendor</td>
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<td>$a^*_i$</td>
<td>Client i’s ideal preferences</td>
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<tr>
<td>$a_{jI}, a_{jE}$</td>
<td>Attributes of vendor $j$ identified by mediator I or E</td>
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<tr>
<td>$a_{jD}$</td>
<td>Attributes of vendor $j$ identified from direct search</td>
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<tr>
<td>$T$</td>
<td>Time horizon for each search iteration</td>
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Table 2: Default simulation parameters

<table>
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<th>Vendors</th>
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<td>Clients</td>
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<td>Client registration fees</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Client transaction fees</td>
<td>0.1 (incumbent, entrant)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Subsidy</td>
<td>0.0 (incumbent, entrant; registration, transaction fees)</td>
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</table>
Table 1: Summary statistics for intermediary utilities for different values of search costs

<table>
<thead>
<tr>
<th>Incumbent utility</th>
<th>Entrant utility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Search cost = 0.1</td>
</tr>
<tr>
<td>Mean</td>
<td>670</td>
</tr>
<tr>
<td>Min</td>
<td>0</td>
</tr>
<tr>
<td>Max</td>
<td>1456</td>
</tr>
<tr>
<td>Std. Dev</td>
<td>614.3</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.16</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-1.92</td>
</tr>
</tbody>
</table>
### Table 2: Incumbent utility for optimal and budgeted search at two values of search costs

<table>
<thead>
<tr>
<th></th>
<th>Optimal search</th>
<th></th>
<th>Budgeted search</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Search cost = 0.5</td>
<td>Search cost = 0.9</td>
<td>Search cost = 0.5</td>
<td>Search cost = 0.9</td>
</tr>
<tr>
<td>Mean</td>
<td>1176.5</td>
<td>781.3</td>
<td>418.5</td>
<td>739.4</td>
</tr>
<tr>
<td>Min</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Max</td>
<td>2309.5</td>
<td>2313.3</td>
<td>1661.8</td>
<td>1691.5</td>
</tr>
<tr>
<td>Std. Dev</td>
<td>1049.6</td>
<td>984.8</td>
<td>625.7</td>
<td>773.7</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.06</td>
<td>0.87</td>
<td>1.38</td>
<td>0.25</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-2.05</td>
<td>-1.25</td>
<td>0.18</td>
<td>-1.99</td>
</tr>
</tbody>
</table>
Table 3: Summary statistics for intermediary utilities for 3 values of intermediary accuracy

<table>
<thead>
<tr>
<th></th>
<th>Incumbent</th>
<th>Entrant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>cl=0.6</td>
<td>cl=0.6</td>
</tr>
<tr>
<td></td>
<td>Inc=0.8 Ent=0.9</td>
<td>Inc=0.9 Ent=0.8</td>
</tr>
<tr>
<td>cl=0.6</td>
<td>Inc=0.8 Ent=0.8</td>
<td>cl=0.6</td>
</tr>
<tr>
<td>Inc=0.8</td>
<td>Ent=0.9</td>
<td>Inc=0.9 Ent=0.8</td>
</tr>
<tr>
<td>Ent=0.9</td>
<td>Ent=0.8</td>
<td>Inc=0.6 Ent=0.8</td>
</tr>
<tr>
<td>Mean</td>
<td>337.4</td>
<td>333.1</td>
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<tr>
<td>Min</td>
<td>173.5</td>
<td>0</td>
</tr>
<tr>
<td>Max</td>
<td>450.6</td>
<td>420</td>
</tr>
<tr>
<td>Std. Dev</td>
<td>69.7</td>
<td>76.4</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.83</td>
<td>-2.99</td>
</tr>
</tbody>
</table>

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Table 4: Summary statistics for vendor satisfaction = 0.6

<table>
<thead>
<tr>
<th></th>
<th>Incumbent</th>
<th>Entrant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Subsidy=0.05</td>
<td>Subsidy=0.5</td>
</tr>
<tr>
<td>Mean</td>
<td>594.1</td>
<td>377.8</td>
</tr>
<tr>
<td>Min</td>
<td>0</td>
<td>74.4</td>
</tr>
<tr>
<td>Max</td>
<td>1467.7</td>
<td>872.8</td>
</tr>
<tr>
<td>Std. Dev</td>
<td>385.4</td>
<td>276.8</td>
</tr>
<tr>
<td>Skewness</td>
<td>1.12</td>
<td>0.85</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>0.43</td>
<td>-1.05</td>
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</tbody>
</table>
Table 7: Comparison of incumbent utility under competition and entry-deterrence

<table>
<thead>
<tr>
<th>Category</th>
<th>Competition</th>
<th>No entry for E</th>
<th>Competition</th>
<th>No entry for E</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>4</td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>0</td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Optimal registration fee</td>
<td>-0.91 (-3 - 0.25)</td>
<td>-15.86 (-16 - 15)</td>
<td>-0.75 (-3 - 0.25)</td>
<td>-15.83 (-16 - 15)</td>
</tr>
<tr>
<td>Optimal transaction fee</td>
<td>0.83</td>
<td>0.96</td>
<td>0.86</td>
<td>0.95</td>
</tr>
<tr>
<td>Incumbent's Optimal utility</td>
<td>573.15 (0 - 1434)</td>
<td>561.31 (373 - 777)</td>
<td>791.33 (0 - 1611)</td>
<td>561.56 (414 - 750)</td>
</tr>
</tbody>
</table>
Figure 1: Overall computational testbed
Figure 2: Entrant mediator details

1. Entrant intermediary enters the market, all vendors sign up with the entrant
2. Initialize entrant intermediary fees and utilities
3. Entrant intermediary declares new registration and transaction fees
4. New clients enter market
5. Clients compare utilities from direct, incumbent and entrant
   - For each client, mediation by entrant better than incumbent and direct search?
     - Yes: Endorse entrant intermediary
     - No: Clients compare utilities from direct search, incumbent and entrant, only committed vendors available from each intermediary
6. Given client choices, for each vendor, participation with entrant profitable?
   - Yes: Commit to membership with entrant intermediary
   - No: New clients enter market
7. Incumbent intermediary’s response
   - No: All fees checked?
     - Yes: Entrant intermediary’s optimal fees and utilities with current fees and utilities
       - Yes: Entrant intermediary’s utility for current fees > optimal utility?
         - Yes: All committed vendors pay registration and transaction fees to entrant intermediary
         - No: Use entrant intermediary, pay registration and transaction fees
           - Yes: For each client, entrant offers highest utility?
Figure 3: Incumbent mediator details

- All vendors sign up with the incumbent
- Initialize incumbent intermediary fees and utilities
- New clients enter market
- Clients compare utilities from direct, incumbent and entrant
- For each client, mediation by incumbent better than entrant and direct search?
  - Yes: Endorse incumbent intermediary
  - No: Given client choices, for each vendor, participation with incumbent profitable?
    - Yes: Commit to membership with incumbent intermediary
    - No: New clients enter market

- Incumbent tries new fees
- Termination condition reached?
  - Yes: All fees checked?
  - No: Update incumbent intermediary’s optimal fees and utilities with current fees and utilities
    - Yes: Incumbent intermediary’s utility for current fees > optimal utility?
      - Yes: All committed vendors pay registration and transaction fees to incumbent intermediary
      - No: Use incumbent intermediary, pay registration and transaction fees
        - Yes: For each client, incumbent offers highest utility?
Figure 4: Incumbent’s utilities as a function of registration and transaction fees ($N = 4, K = 0$)
Figure 5: Impact of client search costs on optimal utilities
Figure 6: Optimal search and budget-constrained search
Figure 7: Impact of vendor switching costs
Figure 8: Impact of differences in client and intermediary accuracies of evaluating vendor attributes
Figure 9: Impact of vendor satisfaction on intermediary utilities
Figure 10: Impact of changes in incumbent’s transaction fee subsidy
Figure 11: Impact of changes in entrant’s transaction fee subsidy
Figure 12: Incumbent’s optimal utility as a function of incumbent’s transaction fee subsidy for different values of vendor satisfaction.
Figure 13: Entrant’s optimal utility as a function of incumbent’s transaction fee subsidy for different values of vendor satisfaction.