A Game-Theoretic Model of E-Marketplace Participation Growth

MICHAEL R. GALBRETH, SALVATORE T. MARCH, GARY D. SCUDDER, AND MIKHAEL SHOR

MICHAEL R. GALBRETH is a Ph.D. Candidate in Operations Management at the Owen Graduate School of Management, Vanderbilt University. He holds a B.S. in Business Administration from the University of Tennessee at Knoxville. His current research interests include reverse logistics and remanufacturing, supply chain management, and electronic procurement. Prior to entering the Ph.D. program, he was a manager with KPMG Consulting.

SALVATORE T. MARCH is the David K. Wilson Professor of Management at the Owen Graduate School of Management, Vanderbilt University. He received a B.S. in Industrial Engineering and an M.S. and a Ph.D. in Operations Research from Cornell University. His research interests are in information system development, electronic commerce, and distributed database design. His research has appeared in *ACM Transactions on Database Systems, Communications of the ACM, IEEE Transactions on Knowledge and Data Engineering, Journal of Management Information Systems,* and *Information Systems Research.* He served as Editor-in-Chief for *ACM Computing Surveys* and as Associate Editor for *MIS Quarterly.* He is currently a Senior Editor for *Information Systems Research* and an Associate Editor for *Decision Sciences Journal* and *Information Systems Frontiers.* He has served on organizing committees for the International Conference on Conceptual Modeling, the Workshop on Information Technologies and Systems (WITS), and the International Conference on Information Systems (ICIS).

GARY D. SCUDDER is Associate Dean of the MBA program and a Professor of Management at the Owen Graduate School of Management, Vanderbilt University. Professor Scudder holds a B.S. and an M.S. in Industrial Engineering from Purdue University and a Ph.D. in Industrial Engineering from Stanford University. He joined the Owen School faculty in 1990 after spending 10 years at the University of Minnesota. He has also visited at the Amos Tuck School at Dartmouth College. His teaching and research interests focus upon business strategy, manufacturing strategy, and the strategic management of technology and innovation. His current research efforts focus on optimizing supply chains in food distribution and fresh produce industries and on integrating business strategy, manufacturing strategy, and technology strategy. He has published in, and refereed for, numerous journals during his career, including *Management Science, Decision Sciences, International Journal of Production Research,* and *Operations Research.*

MIKHAEL SHOR is an Assistant Professor of Economics at the Owen Graduate School of Management, Vanderbilt University. He received a B.S. in Economics and Foreign Affairs from the University of Virginia and a Ph.D. in Economics from Rutgers Uni-

Journal of Management Information Systems / Summer 2005, Vol. 22, No. 1, pp. 295–319.

0742–1222 / 2005 $9.50 + 0.00.

versity. His research and teaching interests are in game theory and behavior in online markets. His current research focuses on human behavior in auction markets.

ABSTRACT: Despite their potential to significantly reduce transaction costs for both buyers and sellers, e-marketplaces have struggled. Recent literature has examined the value propositions of e-marketplaces and proposed conceptual frameworks for their analysis. In this research, we move beyond conceptual analysis by developing a game-theoretic model of return-on-investment (ROI)–driven e-marketplace participation growth. This model provides insights into expected e-marketplace growth and participation, and can be used to determine both the viability and expected long-run size of a given e-marketplace. Our results indicate that the pricing policy of the e-marketplace intermediary can affect the rate at which participation grows and, therefore, sentiment about its prospects. We focus on e-marketplaces that add value to buyers and sellers by increasing the efficiency of administrative tasks but also simultaneously add value to buyers and reduce value to sellers by lowering prices for goods purchased. Value to participants in these e-marketplaces is determined by the volume of transactions that can be conducted using the e-marketplace, resulting in a two-sided network effect—buyers reacting to sellers and sellers reacting to buyers. The game-theoretic model identifies an *e-marketplace equilibrium* at which participation growth is predicted to stop.

KEY WORDS AND PHRASES: business-to-business e-commerce, e-marketplace, game theory, network effect.

E-MARKETPLACES HAVE SIGNIFICANT POTENTIAL to reduce supply chain costs and to improve organizational efficiency in supply chain management [5, 19, 20]. Consequently, a number of e-marketplaces have emerged and have attracted interest from both buyers and sellers (see [9] for a complete discussion and numerous examples). However, participation in an e-marketplace requires potentially unrecoverable investments in software, training, and infrastructure specific to that e-marketplace. Before making such a commitment, an organization must assess the expected benefits of participation. Dai and Kauffman [9] discuss the uncertainty in the minds of practitioners and researchers as to which Web-based business models will be successful in the long term. Subramaniam and Shaw [26] point out the importance, especially in the current economic environment, of knowing the value of Web-based systems in motivating system adoption. For e-marketplaces that focus on transaction-cost reduction, the benefits are dependent upon the volume of transactions an organization can accomplish electronically. Prior research has shown that, without significant transaction volume, Web-based systems will not provide significant value to organizations [26]. For buyers, transaction volume depends on seller participation; for sellers, it depends on buyer participation. Hence, both buyers and sellers are concerned about the growth of the e-marketplace, and the value of participation for each increases as the installed base on the opposite side of the e-marketplace grows [9]. Although the importance of participation levels for e-marketplace success has been established [9, 26], analytical frameworks for examining the growth of e-marketplace participation are lacking. In this paper, we develop and analyze a game-theoretic model of e-marketplace growth that extends our understanding of phenomena surrounding the adoption of this important and emerging technology.

In their 2000 study, McKinsey & Company, together with the Center for Advanced Purchasing Studies (CAPS), categorize e-marketplaces into five types—project/specification managers, supply consolidators, liquidity creators, aggregators, and transaction facilitators [19]. We concentrate on the transaction facilitators, the largest single segment of e-marketplaces identified in that study. These are e-marketplaces that are owned and operated by a third-party intermediary. They typically charge a fixed annual participation fee plus a per-transaction fee. These fees may not be symmetric for buyers and sellers, depending on the particular market served.

Such e-marketplaces have no intrinsic value. Their benefits are derived solely from transaction-processing cost reductions achieved through reduced search costs, integration, and process automation. They typically offer integration with existing back-end systems at both buyers and sellers, resulting in increased operational efficiency for both sides of the market [8, 20, 23]. Trade-Ranger (Trade-Ranger.com), for example, is an independent transaction facilitator e-marketplace in the energy and petrochemicals industry. It facilitates product search through common product definitions and allows trading partners to set up specific trading interfaces. Trade-Ranger provides a variety of integration levels and services ranging from a simple hosted Web application through electronic message exchanges and middleware options to full integration with purchasing and sales and order processing systems. It also supports a number of XML standards for data exchange that are commonly used in the petroleum industry, including Petroleum Industry Data Exchange (www.PIDX.org), XML Common Business Library (www.xCBL.org), and Chemical Industry Data Exchange (www.CIDX.org).

Without such integration, the per-transaction benefits of e-marketplace participation are significantly reduced and the costs are harder to justify [10]. In his 2001 study, Croom [7] found that reductions in transaction-processing costs, along with the associated opportunity to redeploy resources, were the prima facie criteria justifying e-procurement.

Buyers and sellers will join an e-marketplace only if there is an expectation of sufficient transaction volume to justify the cost of participation. As discussed above, the benefits afforded by participation are driven by transaction volume. A buyer's transaction volume depends on the buyer's *desired* transaction volume, the available seller transaction volume, and the desired transaction volumes of all other buyers in the network. Similarly, seller transaction volume depends on the seller's *available* transaction volume, the desired transaction volume of all buyers, and the available transaction volume of all other sellers. Participation growth stops when no additional buyer or seller expects to conduct a sufficient transaction volume to justify its cost of participation. We demonstrate the existence of such a cessation of growth and term this point the *e-marketplace equilibrium.*

The interdependent nature of two-sided network growth suggests a game-theoretic analysis in which the decision to join the e-marketplace depends upon the adoption decisions of all other buyers and sellers. We develop an economic model of e-marketplace growth and use it to address our primary research question: Given a set of e-marketplace parameters and industry characteristics that define a set of expected costs and benefits for potential participants, what levels of participation can be expected for the e-marketplace in the long term?

By varying the distributions of buyer and seller volumes, we determine e-marketplace equilibria that inform decisions and policies for buyers, sellers, and e-marketplace intermediaries. In this initial study, we present two examples in which there are very large market participants who have early justification for joining the e-marketplace, thus ensuring an initial growth phase of buyer and seller participation. We use these two examples to identify e-marketplace equilibria that are confirmed through cost–benefit analysis. Our study provides a foundation for further game-theoretic analysis for modeling the growth of e-marketplaces, and suggests directions for future research.

Theoretical Foundations and Contribution

TRANSACTION FACILITATORS CAN PROVIDE significant value to their customers. Buyers that have implemented e-procurement through e-marketplace integration have significantly reduced costs, as workers are required to spend less time in search, ordering, error correction, and reconciliation tasks [3]. Sellers also benefit from improved efficiencies and can similarly realize lower transaction costs [14, 21].

Malone et al. [18] describe two mechanisms for coordinating the flow of goods and services between firms—markets and hierarchies. In markets, buyers compare possible sources and choose the one that provides the best combination of key attributes—price, design, delivery, and quantity. In hierarchies, buyers work with a predetermined source, either internal or external (e.g., a sole supplier relationship). In hierarchical mechanisms, the price, design, delivery, and quantity decisions are made by managers rather than by market forces. High coordination costs have been the main drawback of market mechanisms in comparison with hierarchical structures [7]. One explanation for the continued popularity of hierarchies is that the cost of creating market linkages is only justified when a meaningful volume of transactions is expected [7]. Hence, Malone et al. [18] hypothesized that a reduction in coordination costs should result in a commensurate decrease in hierarchical structures and increase in market mechanisms. Information technology (IT) solutions can drive this reduction in coordination costs [4, 6, 11].

Given the possibility of a high level of buyer and seller participation, electronic markets can enable nearly perfect competition [7]. Dai and Kauffman [8] model a simple case of the e-procurement adoption decision, but point out the need for a more robust, multibuyer, multisupplier model. In his survey of group and network formation, Bloch [2] states the need for models that endogenously determine the number of agents participating in exchange networks.

In their seminal paper, Katz and Shapiro [16] develop a model of network externalities in which the value of a product to a given consumer increases with the number of consumers owning a compatible product. Keskinocak and Tayur [17] discuss the need for economic models that reflect the unique dynamics that are being observed in emerging Internet-based tools such as e-marketplaces. Network effects are clearly present in many of these emerging areas. Yoo et al. [29] describe the value of e-marketplace participation as a combination of network effects, intrinsic e-marketplace value, switching costs, and participation costs. They use this definition as a basis for determining optimal pricing levels for intermediaries in e-marketplaces and determining the effect of input parameters on optimal prices. Their work focuses on determining pricing mechanisms and the resultant fraction of buyer participation that together enable the e-marketplace to maximize its profits.

Our work continues the research of Yoo et al. [29], and is differentiated in a number of ways. Yoo at al. is more general in the sense that the research predicts both equilibrium participation levels and optimal pricing for the intermediary, whereas we focus solely on e-marketplace growth. However, Yoo et al. assume that all firms are identical in terms of their value to the network and that firm differentiation is due to uniformly distributed switching costs. We take pricing decisions to be given, and focus on the link between anticipated transaction volume and network growth. We develop a model to explain and predict e-marketplace growth when buyers and sellers provide differentiated network value based on the transaction volume they wish to conduct and derive differentiated benefits based on the transaction volume available for them to actually conduct.

Yoo et al. assume that sellers are adversely affected by the existence of other sellers (competition), but that buyers are not affected by the number of other buyers. In addition, they model network effects as additively separable from an intrinsic value of network participation. This has the side effect that the e-marketplace has value in and of itself. In our model, the network has value only to the extent that a buyer or seller can expect to conduct transactions, and the network effect is symmetric in the sense that both buyers and sellers are affected by growth on both sides of the market.

Methodology

WE MODEL AN E-MARKETPLACE for a single, homogeneous good resulting in perfect buyer and seller substitution. In this case, all buyers in the e-marketplace are potential trading partners with all sellers, and vice versa. Furthermore, we assume that the net savings from participation in the e-marketplace for buyers (sellers) is proportional to the dollar volume of purchases (sales) transacted electronically.

Our model uses the parameters and variables listed in Table 1, described as follows. The total annual costs to buyers and sellers of participating in the e-marketplace, C_b and C_s, respectively, are assumed to be fixed and equal across all buyers and across all sellers. The cumulative distributions of purchasing and sales transaction volumes, F_b and F_s, with associated densities f_b and f_s, are obtainable from industry data for the market served.[1] Once sales or purchasing data are obtained, tools such as Palisade

Table 1. Parameters and Variables for the Model of E-Marketplace Participation

Parameter	Description
F_b, F_s	Cumulative distributions of purchasing volumes of buyers and of sales volumes of sellers who could potentially participate in the e-marketplace.
D_b, D_s	Net buyer and seller savings as a percent of the dollar transaction volume conducted.
T_b, T_s	Total purchasing and sales volumes of potential e-marketplace participants.
C_b, C_s	Annual e-marketplace participation costs for buyers and sellers.
Variable	**Description**
P_b, P_s	Current fraction of buyers and sellers participating in the e-marketplace.

Corporation's BestFit software can be used to find a distribution function that provides the best fit to the data.

The total transaction volumes of buyers and sellers who can potentially participate in the e-marketplace are given by T_b and T_s, respectively. If the existing market is in equilibrium, then $T_b = T_s$, a condition we assume in the examples discussed in the fifth section. The volume of a representative buyer or seller is denoted with lower-case letters, t_b or t_s. The actual proportions of buyers and sellers currently conducting business in the e-marketplace are given by P_b and P_s. Net buyer and seller savings as a percent of the dollar transaction volume conducted using the e-marketplace are given by D_b and D_s. The values of these parameters depend on a number of factors, as described below.

Savings obtained by e-marketplace participation can come from many sources. We represent them using two categories—administrative savings and price savings. Regarding administrative savings, it has been found that an integrated e-procurement system of the type analyzed in this study reduces not only data entry costs but also the costs to identify and correct data errors, which can be significant in a manual, labor-intensive environment [13]. Kauffman and Mohtadi [15] outline additional sources of administrative cost savings such as supplier search/selection costs and buyer acquisition costs. The total administrative cost associated with procurement activities is often 20 percent or more of the transaction amount [25]. In the case of the hospital industry, average administrative costs have been estimated at between 26.9 percent and 53.7 percent of the transaction amount [12, 22]. Studies have found administrative cost savings from e-procurement in hospitals of 60 to 95 percent [22]. Estimates of the total administrative cost savings that can be realized through automated procurement across industries vary from 67 percent [7] to 75 to 87 percent [13].

In addition to administrative savings, Wang and Seidmann [27] show that interorganizational systems based on electronic data interchange (EDI) result in positive externalities for buyers and corresponding negative (competitive) externalities for sellers. In their analysis of the factors that create value in third-party e-marketplaces, Subramaniam and Shaw [26] also note the existence of lower product prices for buyers, in addition to cost savings for both buyers and sellers. The price savings that buyers can achieve as a result of these network effects in an e-marketplace have been estimated at 5 to 10 percent [1], 17.4 percent [10], and 30 percent [7].

While there are other potential areas in which e-marketplaces add value, such as increased visibility in the industry, increased e-business experience in general, increased collaboration, improved information flow, and new customer acquisition [13], dollar benefits are difficult to determine. Therefore, although the model can include any costs and benefits that a company is able to determine, we focus on transaction-processing cost reductions and competitive penalties because they are the most easily quantified. Specifically, our analysis compares network effects, defined as net dollars saved, to participation costs. In order to determine the potential value of e-marketplace participation, the financial benefits of participation must be compared with the amortized costs of acquiring and maintaining the required systems.

Our assumption that the e-marketplace is strictly a transaction facilitator implies that the intrinsic value of the e-marketplace to its participants is zero—all benefits are the result of the network effects. This necessitates that we assume an existing level of participation in the e-marketplace at the outset of our analysis. This would most likely be the result of an agreement between the intermediary and some number of buyers or sellers to initially create an e-marketplace and jointly agree to participate.

In the early stages of an e-marketplace, many companies are unsure of how to assess when and whether their participation would be financially beneficial. This may result in the use of arbitrary and unjustified target e-marketplace participation levels as the decision criterion for joining. For example, one health-care buyer stated, somewhat arbitrarily, that supplier participation would "have to reach 70 percent to make [the e-marketplace] interesting" [10]. Our analysis models e-marketplace growth using a game-theoretic analysis, enabling the identification of participation-level equilibria for a given e-marketplace. This should enable buyers, sellers, and e-marketplace intermediaries to understand and appropriately respond to anticipated growth in an e-marketplace.

Value of Participation

AT ANY POINT IN THE GROWTH of the e-marketplace, if the value of participation for a given buyer or seller exceeds its costs, then the optimal strategy for that buyer or seller is to join the e-marketplace. In order to describe the process of determining the optimal strategy for all participants, we begin by considering the behavior of buyers, given that some total volume of sellers, V_s, and some total volume of buyers, V_b, is currently participating in the market. If $V_s \geq V_b$, then there is sufficient seller participation for buyers to transact all purchasing using the e-marketplace. Otherwise, the buyer can expect to conduct only a portion of its purchasing using the e-marketplace.

Given product homogeneity, buyers are all equally substitutable, and participating buyers conduct equal fractions of their purchasing using the e-marketplace, thus reflecting a negative network effect from increased participation on the same side of the market. Note that, contrary to this negative effect, increased participation on the same side of the market could have the indirect result of attracting more participation on the other side of the market, thus increasing the size of the e-marketplace as a whole. This increase in e-marketplace size may, in turn, attract increased participation on the same side of the market, and so on. This series of potential positive and negative effects, which is present throughout the growth and maturity phases of the e-marketplace, is the force that drives the e-marketplace toward equilibrium.

The assumption that each buyer conducts an equal fraction of its purchasing using the e-marketplace implies that no buyer has more "power" to force sellers to meet its purchasing needs with a higher priority. Alternately, we can imagine that prior to entry, a buyer must estimate the fraction of its purchasing that will be conducted via the e-marketplace. The best estimate available to buyers is likely to be the ratio of total seller volume to total buyer volume, or (V_s/V_b). Consider a buyer with total transactions equaling t_b dollars. The value of participation to this buyer, given total volumes of V_s and V_b, is given by:

Volume × Proportion of volume transacted in e-marketplace × Cost savings,

or

$$\text{Value}(\text{buyer}) = t_b \min\left[\frac{V_s}{V_b}, 1\right] D_b. \tag{1}$$

Equation (1) enables the definition of an optimal strategy for any buyer. A buyer joins if the value of participation exceeds the cost (given by C_b). It should be noted in Equation (1) that the value to a buyer increases with its volume, t_b. Thus, if any given buyer determines that it is cost-beneficial to join the e-marketplace, so will all larger-volume buyers. Thus, we can define the indifferent (or marginal) buyer as one with transaction volume t_b^* solving:

$$t_b^* \min\left\{\frac{V_s}{V_b}, 1\right\} D_b = C_b. \tag{2}$$

Thus, all buyers with $t_b \geq t_b^*$ will enter, whereas all those with $t_b < t_b^*$ will not. Similarly, larger sellers will derive greater benefit from the e-marketplace than smaller ones. The marginal seller, t_s^*, is given by

$$t_s^* \min\left\{\frac{V_b}{V_s}, 1\right\} D_s = C_s. \tag{3}$$

Since it is relatively more beneficial for larger-volume buyers and sellers to join the e-marketplace, we assume that they will join in order of *decreasing* volume. Hence, we define the complement to the distribution functions $\bar{F}_b(t) = 1 - F_b(t)$ and $\bar{F}s(t) = 1 - F_s(t)$. Further, whereas $\bar{F}_b(t)$ and $\bar{F}s(t)$ provide the probability that a buyer or seller has a volume of at least t, we must determine the volume of the *marginal* buyer or seller given that a certain proportion of larger-volume participants have already joined the e-marketplace. For this purpose, we define the inverse functions, $G_b = \bar{F}_b^{-1}$ and $G_s = \bar{F}s^{-1}$, which enable us to calculate these volumes. Using this notation, given that the current fraction of buyers participating is P_b, the purchasing volume of the largest remaining buyer who has not yet joined is $G_b(P_b)$. Similarly, a fraction P_s of sellers participating implies that all sellers with volumes of at least $G_s(P_s)$ have already joined. The total sales volume of all participating sellers can now be given by

$$V_s = T_s \frac{E\left[t \middle| t > G_s\left(P_s\right)\right] P_s}{E[t]} = T_s \frac{\int_{G_s(P_s)}^{\infty} tf_s\left(t\right) dt}{\int_0^{\infty} tf_s\left(t\right) dt}, \tag{4}$$

where the fraction represents the proportion of total sales volume that is represented by the largest P_s sellers in the e-marketplace. This fraction is multiplied by T_s, the total sales volume over all sellers. Analogously,

$$V_b = T_b \frac{\int_{G_b(P_b)}^{\infty} tf_b\left(t\right) dt}{\int_0^{\infty} tf_b\left(t\right) dt}. \tag{5}$$

We are now prepared to define an equilibrium notion for the e-marketplace. Given some proportion of buyers and sellers currently in the e-marketplace, Equations (4) and (5) define the total transaction volumes. However, these volumes, once present in the e-marketplace, induce participation by additional buyers and sellers up to the marginal entrants given by Equations (2) and (3). That is, entry changes the proportions of buyers, which can result in additional entry of sellers, which changes the proportion of sellers and thus can result in additional entry of buyers. The fixed point of this iterative process, the *e-marketplace equilibrium,* given by the pair (P_b, P_s), is defined by the simultaneous equations in Figure 1.

The equilibrium represents either a dynamic or static process of entry. Dynamically, we envision a small number of participants joining the e-marketplace. Since the cost of participation is the same for all participants on the same side of the market (e.g., sellers), it follows that the buyers and sellers with the largest volumes will enter first, followed by those with smaller volumes in decreasing order by volume. If a buyer or seller joins, then the value calculations are repeated (using the new participation levels) for the largest remaining seller or buyer who has not yet joined. E-marketplace growth will continue until neither the largest buyer nor the largest seller still remaining finds it profitable to join. Note that e-marketplace participation levels will stabilize at the equilibrium even when some or all of the potential participants evaluate entry based on their estimations of *future* participation instead of current participation levels. For example, if overly optimistic estimations of future value cause a company to join an e-marketplace in which it cannot conduct sufficient volume to recover its participation costs, then this company will eventually leave the e-marketplace after realizing that its optimistic expectations are not being met.

A pair (P_b, P_s) is an e-marketplace equilibrium if it satisfies:

$$G_b\left(P_b\right)\min\left\{\frac{V_s}{V_b},1\right\}=\frac{C_b}{D_b},\quad G_s\left(P_s\right)\min\left\{\frac{V_b}{V_s},1\right\}=\frac{C_s}{D_s}$$

$$V_b=T_b\,\frac{\int_{G_b(P_b)}^{\infty}t*f_b\left(t\right)dt}{\int_0^{\infty}t*f_b\left(t\right)dt},\quad V_s=T_s\,\frac{\int_{G_s(P_s)}^{\infty}t*f_s\left(t\right)dt}{\int_0^{\infty}t*f_s\left(t\right)dt}$$

Figure 1. Definition of an E-Marketplace Equilibrium

Over the long term, the e-marketplace participation as a whole will drive toward the equilibrium participation levels, even if some companies temporarily join for which participation in the e-marketplace is not justified in equilibrium. In the case of industrywide pessimism as to the e-marketplace's future, growth may be stagnated until rational expectations prevail. In the case that insufficient knowledge about the e-marketplace has been accumulated to make a judgment on its future prospects, we can assume that companies will make their decisions based on the information that is available, such as current participation levels. On the static side, we envision firms deciding whether or not to join based upon some expectation of the total participation in the e-marketplace. The above equilibrium defines what happens if participants have perfect foresight—that is, if each firm accurately predicts the participation of others and bases its entry decision on this prediction.

Yi [28], in his analysis of efficiency-enhancing joint ventures, has established that early participants in a network have significant incentive to strategically block access to the network of later movers in order to keep the later movers' costs high, even when efficiency gains might be lost by those actions. Although we assume that some firms agree to join the e-marketplace initially to start the growth process, the third-party ownership structure makes it difficult for them to strategically block later entrants—they have no power to deny participation rights to any other firms. Although early adopters may attempt to exert pressure on the e-marketplace owner, such considerations are beyond the scope of this research. In e-marketplaces with other ownership structures, strategic blocking and access restrictions are likely to be important considerations.

The following section uses the system of simultaneous equations in Figure 1 to analyze two market environments, determining e-marketplace equilibria for each.

Analysis

Example 1

CONSIDER A MARKET IN WHICH BUYERS have transaction volumes that follow a Weibull distribution with shape parameter 2 and scale parameter 800,000. Seller transaction

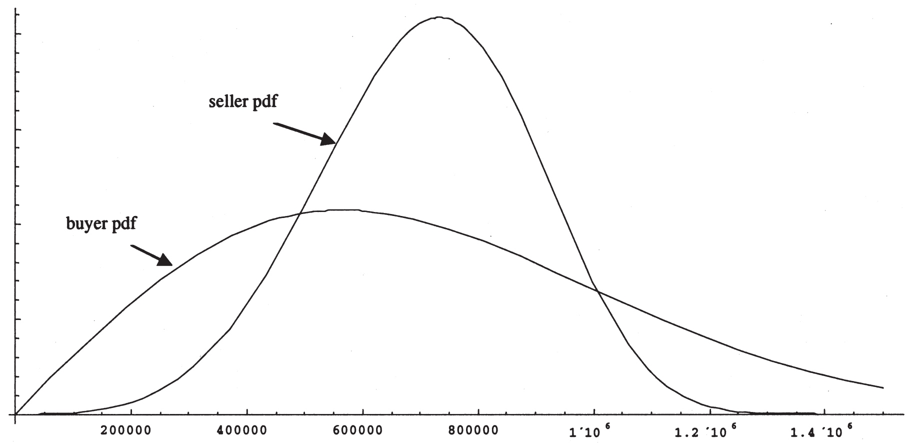

Figure 2. Probability Densities of Buyer and Seller Volumes in Example 1

volumes follow a Weibull distribution with shape parameter 4.3 and scale parameter 781,000. Although the model could be used with any continuous distribution, we feel that the Weibull is often a good choice in practice because its versatility allows us to accurately describe a wide variety of markets. The standard equation for the probability density function of a two-parameter Weibull distribution is given by

$$f(x) = \frac{\beta}{\eta} * \left(\frac{x}{\eta}\right)^{(\beta-1)} * e^{-(x/\eta)^{\beta}},$$

where β is the shape parameter and η is the scale parameter. The buyer and seller distributions in this example are illustrated in Figure 2.

As illustrated in Table 2, annual buyer participation costs are $150,000, whereas annual seller participation costs are $50,000. This is representative of an e-marketplace, such as Trade-Ranger, where buyers bear significantly larger participation costs than sellers. Total market volume is $150 million; however, the distribution of buyer and seller volumes represented by their respective Weibull distributions reflects a market with more small buyers than small sellers.

The net cost savings for buyers is calculated as a combination of price savings and administrative cost savings. Sellers also enjoy administrative cost savings; however, price savings to buyers result in additional costs to sellers—that is, sales discounts. Sellers will obtain a net cost savings only if the price reduction required to compete in the e-marketplace is more than offset by the administrative cost savings.

In this example, we use values derived from previous research [7, 10, 17, 22, 25, 27] to estimate net buyer and seller cost savings. Administrative costs for both buyers and sellers outside the e-marketplace are estimated to be 50 percent of the purchase-order amount. Buyer price savings (seller sales discounts) inside the e-marketplace are estimated to be 17 percent. The reduction in administrative costs for both buyers and sellers within the e-marketplace is estimated to be 75 percent. Therefore, the

Table 2. Model Parameters for Example 1

Distribution of buyer volumes	Weibull; β = 2, η = 800,000 (mean = 708,982)
Distribution of seller volumes	Weibull; β = 4.3, η = 781,000 (mean = 710,845)
Total volumes	$T_b = T_s$ = $150 million
Net cost savings	For a buyer, D_b = 55 percent; For a seller, D_s = 21 percent
Participation costs	C_b = $150,000; C_s = $50,000

buyer net cost savings as a percent of the dollar volume purchased using the e-marketplace is estimated to be (50 percent * 75 percent + 17 percent) = 55 percent. The seller net cost savings as a percent of the dollar volume sold using the e-marketplace is (50 percent * 75 percent – 17 percent) = 21 percent. A summary of the model inputs is given in Table 2.

Our results are not dependent upon these estimated values. Buyers and sellers have incentive to join the e-marketplace if their dollar volume of e-marketplace transactions multiplied by their net cost savings exceeds their participation costs. Relatively lower net cost savings require relatively larger dollar transaction volumes to enable buyers or sellers to recover their participation costs. Suppose, for example, that administrative costs outside the e-marketplace are only 10 percent of the purchase-order amount and that the e-marketplace obtains a 5 percent price discount, but still achieves a 75 percent reduction in administrative costs. Then the net cost savings is reduced to 12.5 percent for buyers and 2.5 percent for sellers. Buyers would need to conduct nearly five times the volume to recover their participation costs, whereas sellers would need to conduct approximately 14 times the volume. If they were unable to conduct this dollar volume, either due to participation levels in the e-marketplace or due to their size, it would not be beneficial for them to join.

Note that if administrative cost savings do not exceed sales discounts, then sellers have no incentive to join the e-marketplace, even if participation costs are zero. The combined effect of price reductions and administrative savings must result in a positive net effect for sellers. This positive effect could be due to high administrative costs outside the e-marketplace, high reductions in administrative costs in the e-marketplace, low price reductions in the e-marketplace, or any interaction of these factors that results in a positive overall value proposition for sellers.

Based on our assumptions, e-marketplace benefits are driven directly by transaction volumes. Therefore, the largest buyer or seller who has not yet joined the e-marketplace at any point is the most likely to have justification for joining. For any given level of buyer and seller participation, the value of joining the e-marketplace for the largest buyer and seller who have not joined can be calculated and compared to the cost of joining. If the value exceeds the cost, the buyer or seller will join. If value does not exceed cost, they will not join. When a point is reached where both buyers and sellers are indifferent to joining, the growth of the e-marketplace stops. At that point, neither the largest remaining buyer nor the largest remaining seller can

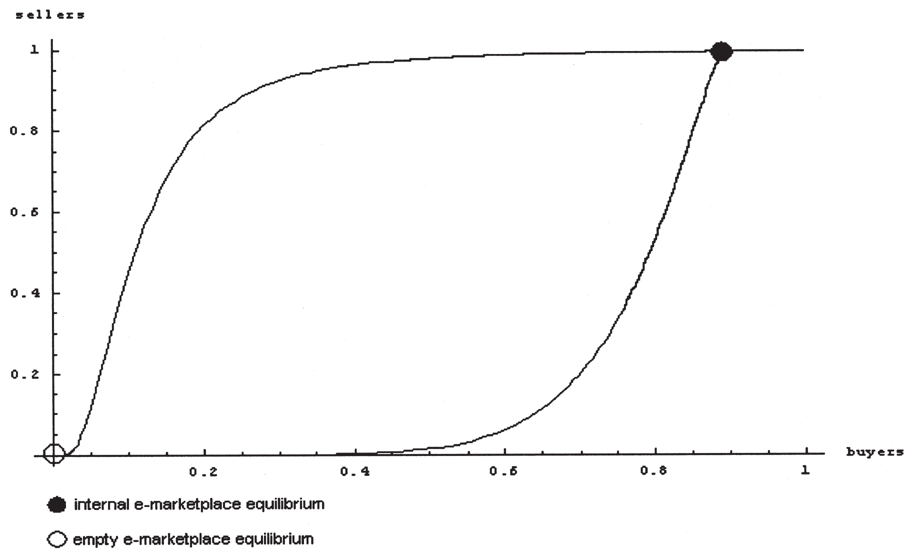

Figure 3. Adoption Pattern in Example 1

justify joining. It follows that smaller buyers and smaller sellers will similarly lack sufficient transaction volume to justify joining.

In this example, the equilibrium point is calculated (using Mathematica 4.2 to obtain the solution to the simultaneous equations in Figure 1) to be 99.33 percent of sellers and 89.03 percent of buyers participating. These participation levels reflect all players in the market following optimal strategies—for the largest 99.33 percent of sellers and the largest 89.03 percent of buyers, the optimal strategy is to participate in the e-marketplace. For all others, the optimal strategy is not to participate. Figure 3 shows the adoption pattern resulting in this equilibrium.

Note that in addition to the internal e-marketplace equilibrium, an equilibrium also exists at 0 percent of buyers and 0 percent of sellers participating—that is, an empty e-marketplace equilibrium. Given the absence of an intrinsic network value, it is intuitively obvious that no participants would have incentive to join an empty e-marketplace. Presumably, the e-marketplace intermediary would need to attract at least one buyer or one seller to begin the growth process. This (0, 0) equilibrium is discussed in more detail in the sixth section.

Figure 3 shows regions in which buyers and sellers will join or leave the e-marketplace, given the specified participation of other buyers and sellers. The two curves are the indifference curves for buyers and sellers. Additional sellers will join the e-marketplace whenever participation levels define a point in Figure 3 that is below the concave curve. Existing sellers will leave when levels define a point above it. Similarly, additional buyers will join the e-marketplace whenever participation levels define a point above the convex curve, and existing buyers will leave when levels define a point below it. The area enclosed by these curves is an area in which buyers and sellers both join.

When buyers and sellers make decisions based on rational expectation, growth eventually stops when it reaches the single internal e-marketplace equilibrium (89.03 percent, 99.33 percent). Notice that, at this point, there is more seller volume available in the e-marketplace than there is buyer volume required. Sellers must sell this excess supply outside of the e-marketplace at additional cost. They would prefer to sell it within the e-marketplace. Hence, the next buyer considering joining could buy all of the excess volume without affecting any other buyers; however, buyers who have not joined are simply too small to justify the cost of joining. Similarly, sellers who have not joined may have sufficiently large volumes to join if a sufficient portion of that volume could be supplied, but given the level of buyer participation, the fraction of their volumes they could expect to transact is too low to justify the cost of participation. Therefore, this e-marketplace is not expected to grow beyond the equilibrium participation levels illustrated in Figure 2. In fact, given the assumptions of this model, e-marketplace participation will always stabilize at these levels over the long term when the price structure given in Figure 1 is in place.

Since buyers and sellers can leave the e-marketplace (i.e., choose not to renew participation) as well as enter it, participation levels will adjust up or down until the equilibrium is reached. If, for example, due to temporary incentives designed to encourage initial participation, e-marketplace participation was initially higher than the equilibrium, a switch to the price structure given in Figure 1 would result in participation adjusting downward until the participation levels calculated above were reached.

As mentioned above, at equilibrium, there is more seller volume available than buyer volume required in the e-marketplace. Tracing the methodology of the previous section, 99.33 percent of sellers in the e-marketplace ($P_s = 0.9933$) implies a marginal seller with volume of \$244,444, given by $G_s(P_s)$. Summing over the volume of all sellers with volumes above this marginal seller (Equation (4)) yields total seller volume of \$149,718,000. For buyers, the total volume is \$145,829,000. Therefore, participating buyers are transacting all of their sales via the e-marketplace. By assumption, all sellers transact the same proportion when limited goods are available. Thus, a participating seller transacts a proportion of its total volume given by

$$\frac{V_b}{V_s} = \frac{\$145,829,000}{\$149,718,000} \approx 0.97.$$

That is, participating sellers conduct approximately 97 percent of their transaction volumes via the e-marketplace. The remaining transactions are accomplished through traditional channels. A simple calculation of the marginal seller's value confirms that growth has stopped where expected:

$$t_s\left[\frac{V_b}{V_s}\right]D_s = \$244,444\left[\frac{\$145,829,000}{\$149,718,000}\right]0.21 = \$50,000.$$

This \$50,000 value equals the annual cost of seller participation. A similar calculation for the marginal buyer can be done to verify that the model has identified an equilibrium that can be easily confirmed in this simple case.

Notice that even when seller participation level is very low in this example, a large proportion of buyers will join. For example, when 0.21 percent of sellers are participating, 40 percent of buyers can justify joining. This can be verified as follows. The marginal buyer, if 40 percent have joined, has a purchasing volume of $764,214. Total seller volume in the e-marketplace, with 0.21 percent participation, is $32,626,800, and total buyer volume, with 40 percent participation, is $91,242,200. Therefore, the marginal buyer can expect to conduct 35.69 percent of its purchasing in the e-marketplace, with a savings of 55 cents on the dollar. The value of participation to this buyer is $764,214 * 0.3569 * 0.55 = $150,000, which equals the cost of participation. Clearly, the e-marketplace is not at equilibrium at this point, since the high buyer participation will attract more sellers. However, this is an interesting possibility for an intermediate point during the growth of the e-marketplace.

Note that the net buyer and seller savings as a percent of the dollar transaction volume conducted (D_b and D_s) must be positive in order for an e-marketplace to be viable—otherwise, participants lose money on each transaction. In this example, D_b and D_s were calculated assuming that administrative costs were 50 percent of the value of the transaction and that the e-marketplace reduced administrative costs by 75 percent, and resulted in a 17 percent sales price discount. This e-marketplace would remain viable for sellers if administrative costs in the traditional (nonelectronic) market were as low as 23 percent of the value of the transaction. In that case, buyers' net savings would be 17.25 percent (23 percent * 75 percent + 17 percent), whereas sellers' net savings would be 0.25 percent (23 percent * 75 percent – 17 percent). Since sellers' net savings are so low, the e-marketplace intermediary would need to transfer virtually all of the e-marketplace costs to buyers in order to attract sellers. This is precisely what Trade-Ranger has done.

Our model is applicable to all viable administrative cost structures. Moreover, the equilibrium participation levels calculated by the model will remain the same if cost parameters are adjusted, provided that the ratios of cost savings to participation costs for buyers and sellers remain the same.

The seller savings parameter is one that could potentially change over time in an e-marketplace. In particular, certain sellers could lower prices in an effort to gain market share. In this case, it is likely that other sellers will lower prices as well in order to remain competitive. Therefore, buyer and seller savings in the e-marketplace as a whole would adjust to reflect the new price savings, and the equilibrium participation levels would adjust accordingly—including an adjustment to reflect the fact that lower prices might cause some sellers to leave the e-marketplace because participation was not profitable at the lower price level. Raising prices would similarly affect the equilibrium of the e-marketplace.

Based on the e-marketplace price reductions suggested by Croom [7] and Gonsalves [10], we performed sensitivity analysis to show the effects of varying the price-reduction percentage from 14 percent to 32 percent (Table 3). Note that as the percent price discount increases, more buyers are willing to join, but this effect is limited by the fact that seller participation decreases, as smaller-volume sellers are no longer able to justify the participation cost. Therefore, there is an increasingly smaller seller volume

Table 3. Seller Pricing Sensitivity Analysis

Price reduction in e-marketplace as a percentage of original price	Equilibrium participation levels as a percentage of total industry volume (buyer, seller)
14	87.81, 99.61
17	89.03, 99.33
20	90.01, 98.73
23	90.98, 97.35
26	91.58, 93.51
29	90.59, 79.36
32	66.20, 26.67

available to satisfy an increasingly larger buyer volume desired. As the price reduction becomes very high, the sellers that cannot justify joining are no longer in the extreme left tail of the seller volume distribution, but are closer to the mean, and therefore are far greater in number. At this point, there is so little volume for buyers to purchase that few buyers can justify joining. For this example, this occurs when the discount is 26 percent, resulting in the maximum buyer participation (91.58 percent). Further price reductions lower the volume available and, hence, the buyer participation. At a price reduction of 32 percent, only 26.67 percent of sellers and 66.20 percent of buyers participate. When the price reduction exceeds 37.5 percent, the net savings for sellers is negative and, as discussed above, no sellers will participate, even if there is no seller participation cost. This analysis clearly demonstrates the importance of a significant value proposition for both buyers and sellers, given the two-sided nature of e-marketplace growth.

Other parameters in our model could potentially change over time, and we have also conducted extensive sensitivity analysis to reflect the effect of changes in participation costs and volume distribution shape. In the case of participation costs (Table 4), note that although an increase in cost for one side of the market (e.g., buyers) always causes a decrease in participation from that side, it does not necessarily affect participation from the other side. For example, if available seller volume exceeds available buyer volume, then a decrease in seller participation does not necessarily restrict the ability of participating buyers to conduct all their transactions in the e-marketplace, so buyer participation would not decrease. In other words, even when an increase in seller cost reduces the number of sellers participating, there might still be enough volume for participating buyers to conduct all of their purchasing in the e-marketplace.

However, when the participation cost increase is so high that a significant number of participants leave, then the opposite side of the market is hurt as well, since sufficient volume is no longer available. In that case, both buyer and seller participation will decrease as a result of the participation-cost increase. The first data column of Table 4 illustrates this effect. With buyer costs held constant, seller costs increase as

Table 4. Participation-Cost Sensitivity Analysis—Equilibrium Participation Levels as a Percentage of Total Industry Volume (Buyer, Seller)

Seller participation costs (in thousands of dollars)	Buyer participation costs (in thousands of dollars)				
	130	150	170	190	210
30	91.64, 99.93	89.03, 99.92	86.13, 99.92	82.99, 99.91	79.63, 99.91
50	91.64, 99.35	89.03, 99.33	86.13, 99.29	82.99, 99.24	79.63, 99.18
70	91.64, 97.37	89.03, 97.23	86.13, 97.13	82.99, 96.95	79.63, 96.72
90	91.37, 92.71	88.87, 92.71	86.13, 92.60	82.99, 92.20	79.63, 91.69
110	90.28, 83.57	87.53, 83.57	84.65, 83.57	81.71, 83.57	78.77, 83.57

we move down the column. For each seller cost increase, we see a corresponding decrease in seller participation. However, buyer participation does not decrease until seller costs reach the $90,000 level. For cost levels lower than that, the total volume of sellers in the e-marketplace was still higher than the buyer volume, so buyers could still conduct all their transactions. At the $90,000 cost level for sellers, enough sellers leave so that there is no longer sufficient volume for participating buyers to conduct all of their transactions. Therefore, some buyers can no longer justify participation, and buyer participation drops.

Changes in the shape of buyer and seller volumes distributions are shown in Table 5. By adjusting the shape parameter of the Weibull distribution, we can effectively control the number of very small buyers or sellers (increasing the shape parameter implies fewer small buyers or sellers). Increasing the shape parameter of buyers (sellers) resulted in higher equilibrium participation levels for buyers (sellers). This is expected, since it results in fewer companies with very small volumes, and it is such companies that have difficulty justifying the participation costs.

Example 2

In this example, we relax the assumption of fixed participation cost and consider an e-marketplace in which participation cost is a function of the participation level, or total size, of the e-marketplace. In this analysis, we consider both a case where cost increases as e-marketplace size increases (i.e., the e-marketplace owner reduces participation fees as economies of scale are achieved) and a case where cost decreases as e-marketplace size increases (i.e., the e-marketplace owner increases participation fees as the e-marketplace becomes more valuable to participants). In either case, assume that participation cost is driving toward a target level (either from above or below) as participation grows, and that this target level would be achieved with 100 percent participation. Using Example 1 as a baseline, we discuss the implications of participation-dependent costs in this section.

In order to facilitate comparison with our baseline Example 1, we set target participation costs to be equal to the fixed participation costs in Example 1—that is, at $150,000 for buyers and $50,000 for sellers. We then added a dynamic factor, where participation costs begin $40,000 lower (or higher) when the e-marketplace is empty and increase (or decrease) at a constant rate, achieving target levels when (if) the e-marketplace achieves 100 percent participation. The results are summarized in Figures 4 and 5.

As expected, when costs start low ($110,000 for buyers and $10,000 for sellers) and increase (Figure 4), equilibrium participation (89.15, 99.42) is higher than in the fixed-cost case (89.03, 99.33), since costs are always lower than target level, which would only be reached with 100 percent participation. Similarly, when costs start high ($190,000 for buyers and $90,000 for sellers) and decrease (Figure 5), equilibrium participation is lower (88.89, 99.32), since costs never fully decrease to the target level. In general, the fixed-cost model, with cost equal to the 100 percent participation

Table 5. Distribution Sensitivity Analysis—Equilibrium Participation Levels as a Percentage of Total Industry Volume (Buyer, Seller)

Seller Weibull shape parameter	Buyer Weibull shape parameter				
	1	2	3	4	5
1	71.11, 73.54	88.82, 73.72	95.80, 73.72	98.46, 73.72	99.45, 73.72
2	71.11, 90.68	89.03, 91.00	96.01, 91.12	98.57, 91.12	99.50, 91.12
3	71.11, 96.86	89.03, 97.03	96.12, 97.17	98.64, 97.21	99.53, 97.21
4	71.11, 98.97	89.03, 99.05	96.12, 99.11	98.66, 99.13	99.54, 99.14
5	71.11, 99.67	89.03, 99.70	96.12, 99.71	98.66, 99.73	99.54, 99.74

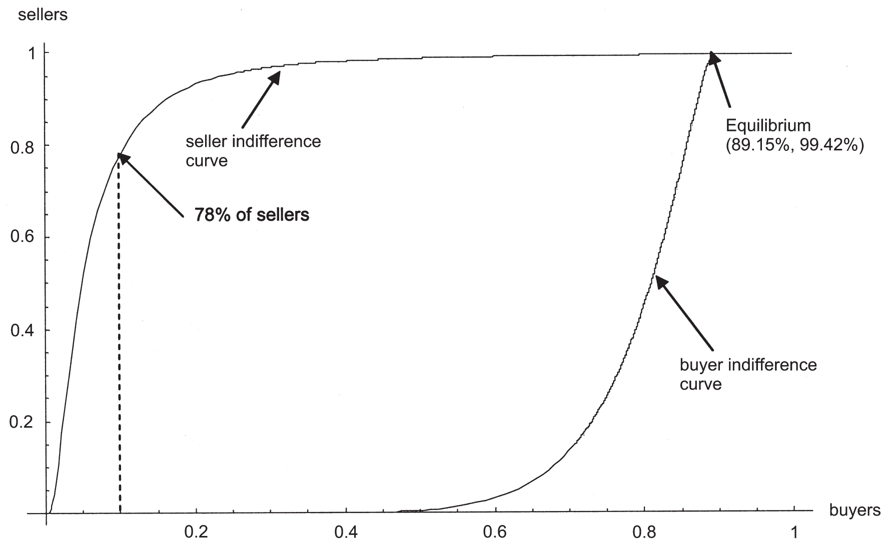

Figure 4. Dynamic Cost Example: Increasing Costs

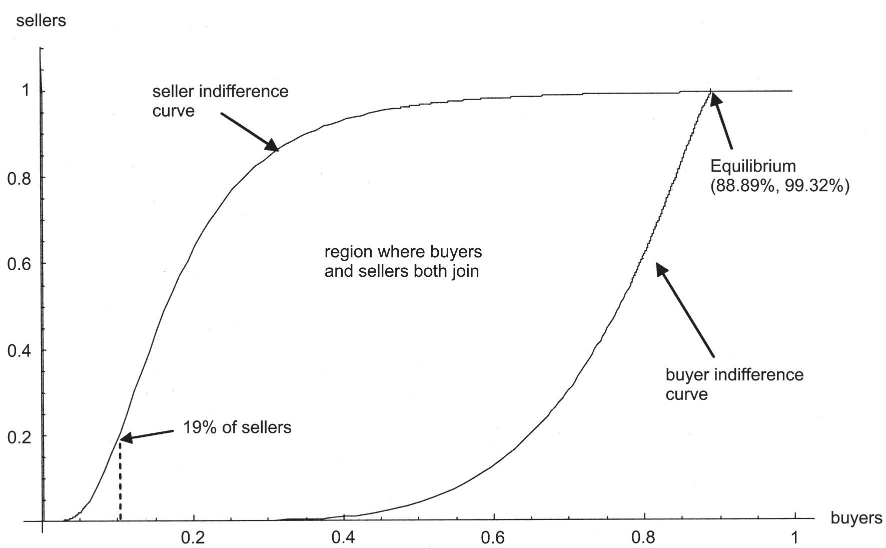

Figure 5. Dynamic Cost Example: Decreasing Costs

price of the dynamic model, provides a bound on equilibrium participation levels with the dynamic cost.

In this example, the equilibrium levels in the dynamic cases did not vary significantly from those in the fixed-cost model. This will not be the case in general, since e-marketplaces with much lower equilibrium participation levels in the fixed-cost model will not experience as strong a price movement toward the target level. The more significant implication of the dynamic-cost models can be observed in the slopes of the indifference curves. In the decreasing-cost case (Figure 5), the slope is less severe, indicating a slower movement toward the equilibrium—fewer potential participants are able to justify entry very early. The opposite effect—more steeply increasing indifference curves—is evident in the increasing case (Figure 4). The different shapes of these curves reflect different levels of interest from one side of the market, given a level of participation on the other. For example, if 10 percent of buyers are participating in an e-marketplace with increasing costs, then 78 percent of sellers can justify joining. However, the participation of 10 percent of buyers in the decreasing-cost case would only justify the entry of 19 percent of sellers. The dashed lines in Figures 4 and 5 show these levels. Similar effects can be seen in buyer interest based on seller participation.

The level of interest among buyers and sellers generated by the different participation-cost structures could affect the way in which the e-marketplace grows. E-marketplaces with a large percentage of potential participants able to justify joining earlier will create a positive sentiment about the prospects of the e-marketplace as a whole and potentially speed growth. In our example, the increasing-cost model can be expected to create considerably more positive sentiment in the early stages of growth. This might also be beneficial in encouraging potential participants to discount pessimistic views of e-marketplaces and follow rational expectations when considering participation.

Future Research

THIS STUDY HAS ESTABLISHED A BASIC game-theoretic model of e-marketplace participation growth that can serve as the foundation for a variety of future studies. In order to enable a more robust analysis, the following assumptions of the model could be relaxed:

- Switching costs—The switching-cost component of participation cost could vary widely by company. Yoo et al. [29] point out that firms lie on a continuum between very low and very high switching costs, driven by factors such as current level of purchasing technology. Riggins et al. [24] describe a situation in which “stalling” by sellers might occur unless their negative externalities were offset by some level of subsidizing of seller joining costs. The model could be extended to include variable switching costs and incentives, ideally based on empirical data from existing e-marketplaces.
- Linear relationship between the administrative cost of processing a transaction and the transaction amount—A more robust representation of this relationship, which, in practice, is unlikely to be truly linear, would strengthen the model.
- Homogenous goods with perfect substitution—Markets with heterogeneous goods could be modeled in this framework. In this study, we assumed that only one product exists in the market, and all buyers and sellers are indifferent. Therefore, a buyer might be able to conduct all of its purchasing in the e-marketplace, even though only 20 percent of its sellers were participating. In a heterogeneous

case, each seller would bring different products to market, and therefore low seller participation would necessarily translate into a low percentage of available goods for buyers. In this case, we might expect to see situations where buyer and seller participation are both so low that no additional participants have justification to join the marketplace. Only at higher levels of participation on either axis will the player on the opposing axis have incentive to join. After a point, the growth of the e-marketplace as a whole might become self-sustaining.

Beyond addressing these assumptions, additional research that could be conducted using this model includes:

- Consideration of the role of expectations in e-marketplace growth. Subramaniam and Shaw [26] have noted that potential players might not all perceive the same value from implementing a business-to-business (B2B) system, and that these perceptions play an important role in the success of a B2B system. We have pointed out the existence of an empty e-marketplace equilibrium at 0 percent of buyers and 0 percent of sellers participating. In our analysis, we assume that buyers and sellers make participation decisions based on expected transaction volume. If buyers and sellers are skeptical of the prospects of an e-marketplace, these expectations might be lowered. In effect, this could cause participation levels to move toward the empty e-marketplace equilibrium as opposed to the internal one. A simulation study could provide insight into the role of e-marketplace perception in e-marketplace growth. The general lack of confidence in Web-based initiatives in recent years could explain why many e-marketplaces failed to grow to the projected participation levels—when potential participants expect the e-marketplace to fail, it will.
- Determination of the parameter values that characterize an e-marketplace capable of sustaining its existence. E-marketplace intermediaries invest in the e-marketplace infrastructure and must have a sustainable business model. If the e-marketplace intermediary (1) makes the participation costs too high for either buyers or sellers, or (2) demands too high a sales discount, or (3) is unable to provide sufficient net cost savings for buyers and sellers, or (4) chooses a market with inappropriate buyer or seller volume distributions, then the equilibrium may not provide sufficient revenue for the intermediary.
- Given an e-market in disequilibrium, what are the effects of pricing decisions by sellers and offering decisions by buyers on the ability of the e-marketplace to reach equilibrium? This question is particularly interesting in an auction-based e-market. Excess seller availability may result in a reduction of prices driving sellers from the e-market just when the e-market needs additional sellers to attract the next buyer.

We believe that a game-theoretic approach can shed considerable light on such questions and concerns and enable buyers and sellers to make more intelligent policy decisions with respect to participation. It should also enable intermediaries to anticipate the effects on participation levels and develop more intelligent policies and incentives to enable their e-marketplaces to survive and thrive.

Discussion and Conclusions

Our analysis shows that game-theoretic economic modeling is an effective mechanism to represent the projected growth patterns of e-marketplace participation. In our examples, e-marketplaces reached their equilibria at the expected levels. These levels, where annual costs equal annual benefits, were easily confirmed in the simple cases analyzed. The model can, however, be used to examine more complex situations where the equilibria are less obvious, and where the e-marketplace might require a minimum critical mass of participants before sustained growth can occur. Our model enables potential e-marketplace participants to predict the maximum sustainable level of participation in an e-marketplace, determine the fraction of total purchasing activities that buyers and sellers can be expected to transact in the e-marketplace, and determine if participation for a specific company can be expected to be beneficial in the long run.

Another key advantage of this model is the strategy formulation and "what if" analysis that it enables for e-marketplace intermediaries. For example, seller incentives can boost the value of the e-marketplace for sellers. Intermediaries have direct control over the C_b and C_s parameters, and the model can be used to determine the effect of proposed parameter changes on equilibrium participation levels. The sensitivity analyses in Tables 3, 4, and 5 provide examples of the strategic initiatives or "what if" scenarios that could be examined using the model.

Recent e-commerce literature has identified the participation levels, adoption patterns, and benefits of Web-based systems as important research areas [9, 26]. Whereas prior studies have accurately categorized and analyzed e-marketplaces in general, this research presents a framework to quantify these characteristics of e-marketplaces. These have been described only conceptually in previous work. In this study, we model e-marketplace growth, incorporating the network effects inherent in such systems, and contribute to the understanding of the potential value that can be expected from an e-marketplace in practice. We have furthered knowledge in this area by providing a model that captures the complex buyer–seller network effects that characterize e-marketplace growth, and have contributed a new, powerful tool to help researchers and practitioners evaluate potential e-marketplace investments.

Acknowledgments: The authors thank the editors and reviewers for their helpful comments and suggestions.

Note

1. Many resources exist for obtaining industry data, including Mergent Online, Hoover's Online, Gale Group's Business and Company Resource Center, and Career Search Information Technologies (CSIT) CareerSearch database.

REFERENCES

1. Atkinson, B. Earning the return. *Purchasing, 130,* 13 (2001), 22–26.

2. Bloch, F. Group and network formation in industrial organization: A survey. In G. Demange and M. Wooders (eds.), *Group Formation in Economics: Networks, Clubs and Coalitions.* Cambridge: Cambridge University Press, 2005, pp. 335–353.

3. Boyer, K., and Olson, J. Drivers of Internet purchasing success. *Production and Operations Management, 11,* 4 (2000), 480–498.

4. Brynjolfsson, E. Information assets, technology, and organization. *Management Science, 40,* 12 (1994), 1645–1662.

5. Carabello, L. E-procurement can reduce expenses. *Healthcare Financial Management* (December 2001), 82–83.

6. Clemons, E.; Reddi, S.; and Row, M. The impact of information technology on the organization of economic activity: The "move to the middle" hypothesis. *Journal of Management Information Systems, 10,* 2 (Fall 1993), 9–35.

7. Croom, S. Restructuring supply chains through information channel innovation. *International Journal of Operations and Production Management, 21,* 4 (2001), 504–515.

8. Dai, Q., and Kauffman, R. To be or not to B2B? An evaluative model for e-procurement channel adoption. Working paper 00–09, Carlson School of Management, University of Minnesota, Minneapolis, 2000.

9. Dai, Q., and Kauffman, R. Business models for Internet-based B2B electronic models. *International Journal of Electronic Commerce, 6,* 4 (Summer 2002), 41–72.

10. Gonsalves, A. Health system lays out benefits, shortcomings of e-marketplaces. Internetweek.com (January 17, 2003) (available at www.internetweek.com/showArticle .jhtml?articleID=6400032).

11. Gurbaxani, V., and Whang, S. The impact of information systems on organizations and markets. *Communications of the ACM, 34,* 1 (1991), 59–73.

12. Guth, P. Purchase order contents, receiving, and accounts payable. *Hospital Materiel Management Quarterly, 10,* 2 (1988), 29–34.

13. Helper, S., and MacDuffie, J.P. Suppliers and Intermediaries. In B. Kogut (ed.), *The Global Internet Economy.* Cambridge, MA: MIT Press, 2003, 331–380.

14. Kaplan, S., and Sawhney, M. E-hubs: The new marketplaces. *Harvard Business Review, 78,* 3 (2000), 97–103.

15. Kauffman, R., and Mohtadi, H. Open versus proprietary systems in B2B e-procurement: A risk-adjusted transactions cost perspective. Working paper 03–05, Carlson School of Management, University of Minnesota, Minneapolis, 2003.

16. Katz, M., and Shapiro, C. Network externalities, competition, and compatibility. *American Economic Review, 75,* 3 (1985), 424–440.

17. Keskinocak, P., and Tayur, S. Quantitative analysis for Internet-enabled supply chains. *Interfaces, 31,* 2 (2001), 70–89.

18. Malone, T.; Yates, J.; and Benjamin, R. Electronic markets and electronic hierarchies: Effects of information technology on market structure and corporate strategies. *Communications of the ACM, 30,* 6 (1987), 484–497.

19. McKinsey & Company and CAPS Research. Coming in to focus: Using the lens of economic value to clarify the impact of B2B e-marketplaces. Tempe, AZ, 2000.

20. Mukhopadhyay, T.; Kekre, S.; and Kalathur, S. Business value of information technology: A study of electronic data interchange. *MIS Quarterly, 19,* 2 (1995), 137–156.

21. Ovans, A. E-procurement at Schlumberger. *Harvard Business Review, 78,* 3 (2000), 20–21.

22. Perez, K. E-procurement for hospitals. *Health Management Technology, 21,* 8 (2000), 28.

23. Riggins, F., and Mukhopadhyay, T. Interdependent benefits from interorganizational systems: Opportunities for business partner reengineering, *Journal of Management Information Systems, 11,* 2 (Fall 1994), 37–57.

24. Riggins, F.; Kriebel, C.; and Mukhopadhyay, T. The growth of interorganizational systems in the presence of network externalities. *Management Science, 40,* 8 (1994), 984–998.

25. Stone age thrives in many purchasing organizations. *Purchasing, 120,* 8 (1996), 27.

26. Subramaniam, C., and Shaw, M. A study of the value and impact of B2B e-commerce: The case of Web-based procurement. *International Journal of Electronic Commerce, 6,* 4 (Summer 2002), 19–40.

27. Wang, E., and Seidmann, A. Electronic data interchange: Competitive externalities and strategic implementation policies. *Management Science, 41,* 3 (1995), 401–418.

28. Yi, S-.S. Endogenous formation of joint ventures with efficiency gains. *RAND Journal of Economics, 29,* 3 (1998), 610–631.

29. Yoo, B.; Choudhary, V.; and Mukhopadhyay, T. A model of neutral B2B intermediaries. *Journal of Management Information Systems, 19,* 3 (Winter 2002–3), 43–68.