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Hope or Hype: On the Viability of Escrow Services as Trusted Third Parties in Online Auction Environments

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Internet fraud has been on the rise in online consumer-to-consumer (C2C) auction markets, posing serious challenges to people's trust in electronic markets. Among various remedies to promote trust and reduce trader's risk, online escrow service has been proposed as a trusted third party to protect online transactions from Internet fraud. However, whether an escrow service constitutes a viable business model for a trusted third party to effectively block Internet fraud remains an open question. This research proposes a dynamic game model for online traders and a profit maximization model for the escrow service provider. Through the investigation of the optimal strategies of online traders, we explore the relationships among traders' decision making, escrow service fee rates, and adoption rates. We reveal the demand for escrow services and establish the optimal pricing rule for the escrow service provider. A numerical study based on the theoretical analysis is conducted to provide detailed guidelines of the model application for an escrow service provider and to explore if the escrow service is a viable business model in C2C auction markets.

Key words: escrow service; trusted third party; online auction; fraud; dynamic game; numerical study; optimum pricing
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1. Introduction

Over the past several years, increasing commercial activity conducted on the World Wide Web has driven the development of new systems and tools for use in electronic commerce. One main form of this market, online auctions such as eBay, Yahoo Auctions, and Amazon Auctions have attracted the most attention in both the popular press and the research community.

An online auction is technically a two-phase process: an online contracting phase and a financial settlement/physical delivery phase.[1] In the first phase, a buyer and a seller match up in an auction market, reach an agreement about the merchandise offered, and settle on a price. In the second phase, payment is handled by the auction site's payment system (such as PayDirect at Yahoo Auctions), a third party payment processing system (such as PayPal[2]), or through traditional offline payment methods (such as check or money order). Shipment is handled offline if it is a physical product and online if it is a digital product. Either way, the second phase of an online auction involves implementation of the initial contract. These implementations directly affect auction participant satisfaction and combine to impact the general public's trust in online auction markets.

Most mainstream research on online auctions has focused on the first phase (e.g., Kauffman and Wood

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[1] In commercial transactions, financial settlement and physical delivery may or may not occur as one phase. Because the function of online escrow services covers both financial settlement and physical delivery, we treat them as one phase.

[2] PayPal was acquired by eBay in October 2002. However, it remains a third party for other e-commerce sites, including other online auction sites.

2000, Resnick and Zeckhauser 2002, Ba and Pavlou 2002, Melnik and Alm 2002, Dellarocas 2003a, Bolton et al. forthcoming). Few studies have been devoted to investigating the issues in the second phase or to the interrelationship between the two phases. However, the second phase of an auction is integral to the successful fulfillment of a transaction. In this paper, we concentrate on how to alleviate the serious problem of Internet fraud through the use of online escrow services in this critical second phase.

According to the Internet Fraud Watch (operated by the National Consumers League), online auction sales have remained the Number 1 source for Internet fraud for the past several years. In 2003, 37,183 complaints were reported to Internet Fraud Watch, up from 36,802 in 2002, and 89% of the total complaints were online auction related (Internet Fraud Watch 2003). Because online auction fraud can significantly deteriorate the still vulnerable consumer trust in electronic markets, building trust and securing online transactions are key to the future success of electronic commerce (Resnick et al. 2000, Friedman and Resnick 2001, Ba et al. 2003, Dellarocas 2003a).

The use of a trusted third party (TTP) to promote confidence in electronic markets has been extensively studied in academic literature (e.g., Kollock 1999, Ba and Pavlou 2002, Ba et al. 2003). Kollock (1999) explores endogenous solutions to the problems of risky trade in electronic markets, such as eBay's feedback system. Ba and Pavlou (2002) empirically explore the extent to which proper feedback mechanisms in electronic markets can induce trust. They find that feedback systems can generate price-premiums for reputable sellers. Ba et al. (2003) have designed a TTP that binds trading agents' reputations to their online identities.

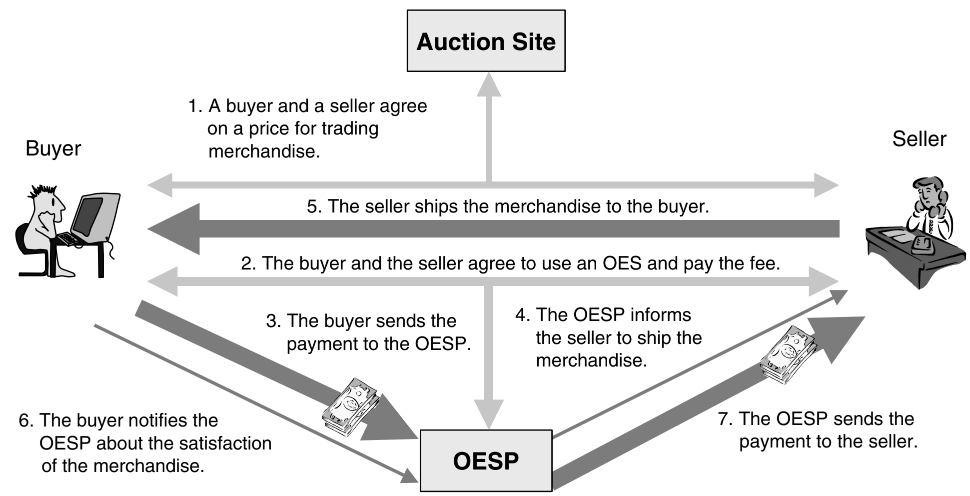
Recently, online escrow service (OES) providers, such as Escrow.com and Safebuyer.com, have emerged as a new type of TTP. OES providers secure the transfer of auction payments for both sellers and buyers. OES is one type of risk-relief service in electronic markets. Other risk-relief services include third-party debit account services, such as PayPal; proprietary account services, such as PayDirect at Yahoo Auction and ASAP™ at Fair Market; traditional credit card services; and insurance, such as is offered by eBay, Amazon, and MSN. OES distinguishes itself from these rivals through its secured transaction mechanism. Theoretically, online fraud will be completely eliminated if all online auctions adopt escrow services. In practice, however, the adoption rate of OES is surprisingly low.[3] This fact raises several interesting research questions. (1) Will OES be adopted by online auction traders, and if so, when? (2) Is the current OES fee rate optimal? (3) Will OES constitute a viable business model for a TTP in online consumer-to-consumer (C2C) auction markets? We seek to answer these questions.

This paper proposes a two-stage dynamic game with incomplete information to investigate the pure- and mixed-strategy Nash equilibrium (Fudenberg and Tirole 1991, Gibbons 1992, Kreps 1990) between honest and strategic traders. Moreover, we reveal the links among the optimal strategy of honest traders, the optimal strategy of strategic traders, and OES demand. We also present a profit maximization model for OES providers. Based on the theoretical analysis, we conduct a numerical study to reveal the dynamic relationships among OES fee rate, OES adoption rate, and OES provider's profit. We also provide detailed guidelines by which an OES provider can optimize its pricing schemes. Finally, we discuss the viability of OES as a business model in online C2C auction markets and uncover the necessary condition for the OES provider to prosper. This research sheds light on various aspects of escrow service practices in electronic markets, and (to the best of our knowledge) it is the first study of OES using game theory.

The remainder of this paper is organized as follows. Section 2 briefly describes how an OES functions. Section 3 proposes the game theoretic model of honest and strategic traders in online C2C auction markets and derives the optimal equilibrium strategies for these traders. Section 4 establishes the profit maximization problem for a monopolist OES provider and solves the optimal pricing scheme. Section 5 presents a numerical study and offers detailed guidelines for OES fee rate optimization. Section 6 concludes the paper with a discussion of our findings and points toward potential topics for future research.

[3] According to an online auction survey conducted by the National Consumers League, only 6% of online auction buyers have paid through an online escrow service (National Consumers League 2001). Wolverton (2002a) also confirms that very few online auction transactions involve the use of escrow services.

Figure 1 How an Online Escrow Service Works[7]



2. Online Escrow Services

All electronic markets—including online auction markets—share the problem of asymmetric information (Akerlof 1970). Two aspects of asymmetric information in electronic markets are closely related to online fraud: The uncertainty of the trader identity and the uncertainty of merchandise quality (Ba et al. 2003). In online C2C auction markets, traders can easily remain anonymous or change identities; it is nearly impossible to bind one identity to a trader. eBay recognizes this difficulty and effectively avoids all responsibility in its user agreement: "because user verification on the Internet is difficult, eBay cannot and does not confirm each user's purported identity."[4]

In the traditional face-to-face business environment, interpersonal interactions such as conversation and a handshake contribute to the basic sense of trust between vendors and customers. Customers are able to directly examine a product and evaluate its quality. Electronic markets preclude this opportunity. Online auction sites like eBay often claim that they "have no control over the quality, safety or legality of the items advertised, the truth or accuracy of the listings," which exposes traders to potentially fraudulent transactions.[5]

The problems highlighted above may lead to the failure of online auction markets. Recognizing the threat of online fraud enabled by asymmetric information, auction sites have begun to offer protective services such as feedback systems, insurance, and online escrow services. Currently, almost all the major online C2C auction sites either provide their own escrow services or have contracted with escrow service providers. For example, eBay has entered into an alliance with Escrow.com.

As a trusted third party, an OES provider protects both the buyer and the seller. The service operates by first receiving and holding a buyer's payment. Once payment is secured, the OES notifies the seller to ship the merchandise. When satisfactory merchandise is received by the buyer, the OES releases payment to the seller. If the merchandise is unsatisfactory, the buyer returns it, and the payment is credited back to the buyer by the OES provider.

Escrow service fees are usually based on the transaction value (purchase price) of the trade and the method of payment used by the trader.[6] In the case of fraud, OES users lose only the service fee. Figure 1 illustrates a successful online trade and shows how an OES can effectively protect online auctions from fraud.

[4] Quote from eBay's user agreement: http://pages.ebay.com/help/policies/user-agreement.html.

[5] Quote from eBay's user agreement: http://pages.ebay.com/help/policies/user-agreement.html.

[6] The OES service fee can be paid by either the buyer or the seller, or it may be split between them. For the detailed OES fee rates, please consult http://www.escrow.com/partners/companies/ebay/rates.asp.

[7] OESP stands for online escrow service provider.

3. Dynamic Game Model in Online C2C Auction Markets

To provide profit maximization guidelines for an OES provider, we first need to investigate online traders' optimal strategies and their OES adoption decision criteria. These strategies and criteria can directly reveal the demand for OES. To this end, we develop a two-stage dynamic game with an incomplete information setting.

3.1. Model Setup

First, we must define the basic nature of the players and establish the rules by which they play the game.[8]

The two types of players—honest players and strategic players—are distinguished by their moral behavior in the game. This categorization is consistent with Krep's "guile" and "without guile" classifications in the economics literature (Kreps 1990). Honest players will never cheat due to the high moral cost of cheating.[9] Therefore, playing honestly is the optimal strategy in any situation for honest players. Strategic players are motivated to cheat and will deceive their trading partners if given an opportunity. However, to achieve his best interest, a strategic player can either act honestly or cheat. Both types of traders can be buyers or sellers in any trade and are considered rational, risk-neutral players in this game.

We ignore the initial contracting phase of an online auction in our model. We assume a buyer and a seller have been successfully matched up and have reached an agreement prior to the two-stage dynamic game.

The first stage of the dynamic game is when the players simultaneously decide whether to adopt OES. During this stage neither player knows their trading partner's OES adoption decision.

The second stage of the game is a simultaneous move of bilateral exchange. In this stage, an honest player will trade honestly, and a strategic player might trade honestly or dishonestly. A strategic buyer cheats by forfeiting a payment, while a strategic seller cheats by sending an inferior substitute for the merchandise or by not sending anything at all. We do not consider differentiated degrees of cheating in our model. Thus, the result of cheating is assumed to be a total loss for the cheated player.[10]

Table 1 Notations for the Two-Stage Dynamic Game

M	The transaction value (purchase price) of a trade.
r	The escrow service fee rate, normally based on the percentage of the transaction value.
V^b	The buyer's valuation of the auctioned merchandise taking into account the shipping fee and other costs; $M < V^b$.
V^s	The seller's reservation value of the auctioned merchandise taking into account the shipping fee and other costs; $M > V^s$.
x	Trading surplus; we assume symmetric trading surplus x, where $x = V^b - M = M - V^s$.
k	Buyer's valuation/price ratio; $k = V^b/M$.
ε	The cost of cheating includes loss of ethical value (negative feeling), the cost of reputation damage, and the time of obtaining a new e-mail address and building another identity on the Internet, etc. It is normalized to be uniform among all strategic traders.
p	The probability of a trader being a strategic type; this probability is assumed to be a common knowledge among all traders and OES providers.
θ	The probability that an honest buyer adopts OES.
ω	The probability that an honest seller adopts OES.
α	The probability that a strategic buyer adopts OES.
β	The probability that a strategic seller adopts OES.

In addition, though "mutual mistake" and naïve "misrepresentation" exist between trading partners in online auction markets, we are not undertaking them in this paper. We deal only with intentional cheating and its resulting loss for the other party.

The notations used in the dynamic game that follows are listed in Table 1.

3.2. The Two-Stage Dynamic Game

Nature moves first to draw a pair of players according to a prior probability. There are four different combinations: honest buyer and honest seller, honest buyer and strategic seller, strategic buyer and honest seller, and strategic buyer and strategic seller. We denote the probability of a trader being strategic as p and the probability of a trader being honest as $1-p$.

A player's type is private information, and while he knows his own type, he does not know his trading partner's. Furthermore, each player has a prior belief about the probability of his trading partner being a strategic player. We assume that the prior belief of p

[8] Actually, the auctioneer (e.g., eBay) also has an interest in having escrow services in online auction markets (e.g., less hassle in dealing with dissatisfied auction participants). However, this is not within the scope of this paper.

[9] The cheating cost of an honest player can be viewed as a strong negative feeling (disutility) about the cheating behavior.

[10] When both players cheat, we assume they both only lose the cheating cost ε.

is common knowledge between the two players, and that it matches the prior probability set by nature. In other words, each player knows p and knows that the other player knows p, and so on ad infinitum.

A player needs to make a decision about OES adoption in the first stage of the game without knowing his trading partner's type. Both types of players have the same strategy profile {Adopt OES, Not adopt OES}, simply denoted as $\{A, N\}$. Adoption of OES means that the player is willing to pay for the service. If only one player adopts OES in a trade, then this player assumes the whole escrow service fee rM. If both players adopt OES, they evenly split the fee.

At the beginning of the second stage, the players learn the outcome of the first stage and, knowing the status of OES adoption, make their second-stage decisions accordingly. Honest and strategic players have differentiated action spaces in this stage. An honest player's action space contains only one strategy: {trade honestly}, denoted as {H}. A strategic player's action space contains two strategies: {trade honestly, cheat}, denoted as $\{H, C\}$, and he will choose a strategy that maximizes his payoffs.

Meanwhile, although a player's adoption of OES may provide some signal of his type, the Bayesian updating of trader type is not a necessary component of decision making in this game. As we show later, every player has a dominant second-stage strategy that is dependent only on the first-stage outcome and not on his opponent's type. Therefore, to compute each player's second-stage strategy, it is unnecessary to reassess each player's belief of his opponent's type after the first-stage game playing.[11]

A total of 36 possible combinations of player types and strategies are identified in Figure 2. We have marked all payoffs with regard to the different combinations at the end nodes of the game. The payoffs of the game are structured as follows: At the initial four nodes of the game, nature draws the four possible combinations of players, formatted as Player 1 and Player 2. At the end node with payoffs, the payoffs are formatted as (Player 1's payoff, Player 2's payoff). At this point, we can classify the game as a two-stage dynamic game with incomplete information.

[11] Therefore, the game is simplified without signaling and Bayesian updating.

3.3. Solving for the Two-Stage Dynamic Game

We use backward induction (Gibbons 1992, Fudenberg and Tirole 1991) to solve the equilibrium of the two-stage game. Given the history of the multistage game, if a player has a strictly dominant strategy in the last stage, we can generally replace the last-stage strategies with the dominant strategy. We can then consider the penultimate stage, apply the same reasoning, and so on. Therefore, we start to solve the game by comparing the payoffs of the second stage.

The honest player has a single strategy in the second stage, so the dominant strategy for an honest player in the second stage is simply "trade honestly." Therefore, the only task left is to analyze the payoffs for the strategic player and reveal his dominant strategies. We compare the payoffs of strategic players (buyer and seller) under two different scenarios, OES adopted and OES not adopted, and find the dominant strategies for strategic players.

Proposition 1. *For a strategic player, the second-stage optimal strategies in an online auction are: "trade honestly" when OES is adopted and "cheat" when OES is not adopted.*

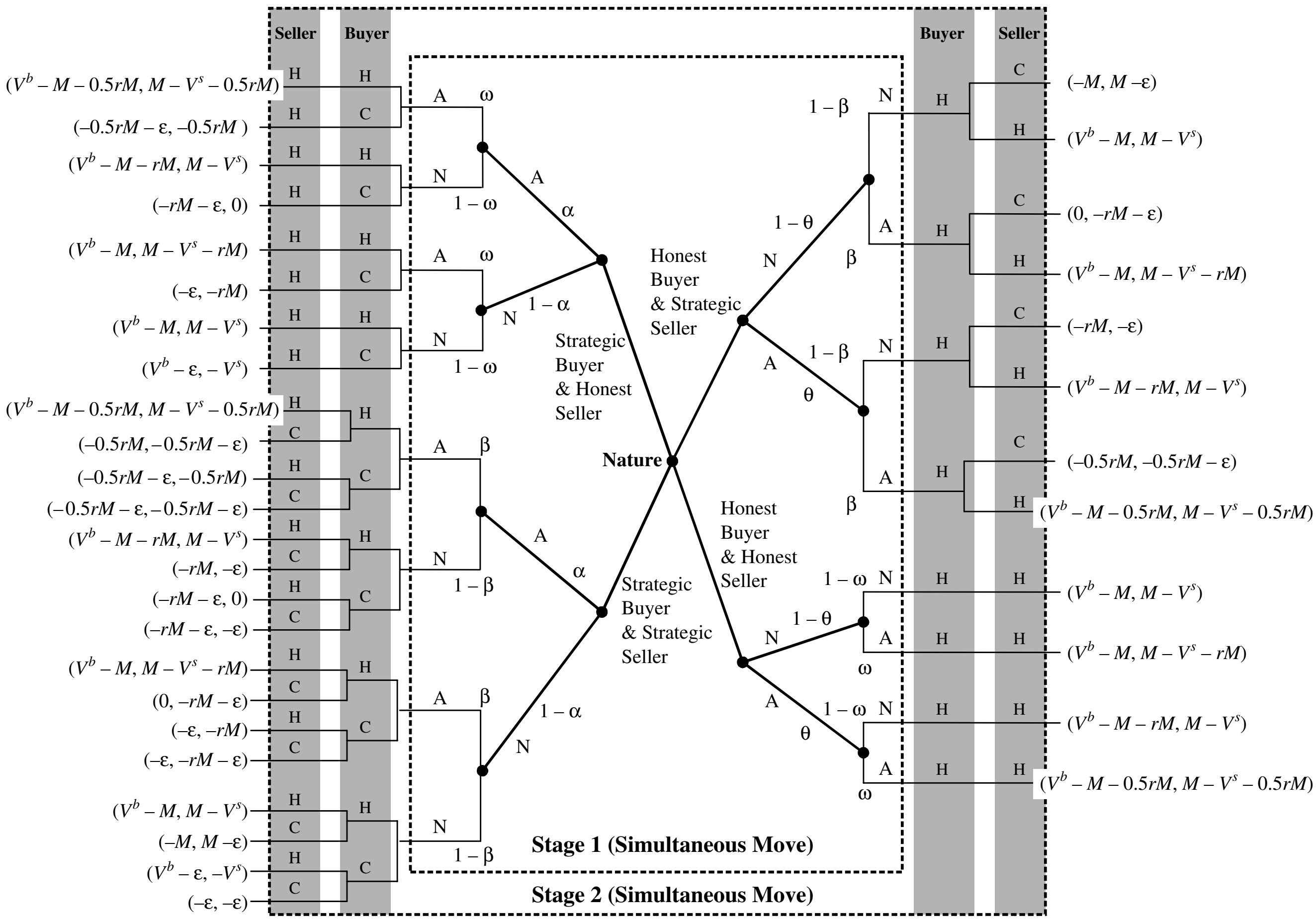
See Appendix 1 for the detailed proof.

Regardless of his trading partner's strategy, a strategic player (buyer or seller) always gains higher payoffs by playing "cheat" in the second stage of the game if no OES was adopted in the first stage. If OES was adopted in the first stage, he always gains higher payoffs by playing "trade honestly" in the second stage. Therefore, the two dominant strategies for a strategic trader are identified under two different scenarios.

This proposition shows that the adoption of OES cannot only block the strategic player's attempt to cheat, but can also induce him to trade honestly and ensure a successful trade for an honest player. In light of this, OES might be a viable business model to prevent fraud in electronic markets.

After identifying the dominant strategies for both types of players at the second stage, we eliminate all the strictly dominated strategies for strategic players. The original 36-node game is now reduced to a 16-node game, and the associated payoffs are shown in Table 2.

Figure 2 **Two-Stage Online Auction Dynamic Game**



3.4. Equilibrium Analysis

Now we return to the first stage to solve the equilibrium of the game. The equilibrium of the game can reveal the conditions under which OES will be adopted by the four groups of players—strategic buyers, strategic sellers, honest buyers, honest sellers—and provide guidelines for an OES provider to optimize fee rates.

Proposition 2. *A strategic player will not adopt OES as long as the common belief p is less than $rM/(2(x - rM/2 + \varepsilon))$.*

See Appendix 2 for the detailed proof.

We start to solve the mixed-strategy Nash equilibrium for the game by allowing both types of players to adopt OES. The internal solutions of the game

Table 2 **The Normal Form of the First-Stage Game**

	Honest seller ($1-p$) A (ω)	Honest seller ($1-p$) N ($1-\omega$)	Strategic seller (p) A (β)	Strategic seller (p) N ($1-\beta$)
Honest buyer ($1-p$)				
A (θ)	$V^b - M - 0.5rM$, $M - V^s - 0.5rM$	$V^b - M - rM$, $M - V^s$	$V^b - M - 0.5rM$, $M - V^s - 0.5rM$	$V^b - M - rM$, $M - V^s$
N ($1-\theta$)	$V^b - M$, $M - V^s - rM$	$V^b - M$, $M - V^s$	$V^b - M$, $M - V^s - rM$	$-M$, $M - \varepsilon$
Strategic buyer (p)				
A (α)	$V^b - M - 0.5rM$, $M - V^s - 0.5rM$	$V^b - M - rM$, $M - V^s$	$V^b - M - 0.5rM$, $M - V^s - 0.5rM$	$V^b - M - rM$, $M - V^s$
N ($1-\alpha$)	$V^b - M$, $M - V^s - rM$	$V^b - \varepsilon$, $-V^s$	$V^b - M$, $M - V^s - rM$	$-\varepsilon$, $-\varepsilon$

require more than 100% adoption rates for honest players to sustain the equilibrium. Therefore, we investigate corner solutions. We impose the maximum allowable OES adoption probabilities (100%) on the honest players, and find that for strategic players, the expected utility of adopting OES is always less than the expected utility of not adopting OES under a fair market assumption where p is lower than the following criteria: $rM/(2(x-rM/2+\varepsilon))$.

Strategic players only consider OES adoption when the electronic market is a dangerous place to trade and the chance of meeting another strategic player is high. Given a reasonable set of market parameters,[12] the criteria for p is about 2%, which is much higher than the estimated fraud rate that is between 0.01% and 0.1% (Wolverton 2002b). This implies that the chance a strategic player will adopt OES is negligible in reality. Because the current p level is projected as high as 0.1% (Wolverton 2002b), the above fair market condition can easily be satisfied. From now on we ignore the possibility that strategic traders adopt OES, and we concentrate on the case that only honest players consider OES adoption.

According to the result of Proposition 2, we can further remove the dominated strategies of OES adoption for a strategic buyer and strategic seller.

Proposition 3. *The Nash equilibrium for probability distribution of action space* $\{Adopt\ OES, Not\ Adopt\ OES\}$ *is* $\{\theta^*, 1-\theta^*\}$ *for an honest buyer,* $\{\omega^*, 1-\omega^*\}$ *for an honest seller, and* $\{0, 100\%\}$ *for a strategic buyer or a strategic seller*:

when $r \in [0, kp]$, $\theta^* = \omega^* = 100\%$;

when $r \in (kp, 2p/(1+p))$,

$\theta^* = 2(r-p)/((1-p)r)$ *and* $\omega^* = 2(r-kp)/((1-p)r)$;

when $r \in [2p/(1+p), 1]$, $\theta^* = \omega^* = 0$.

See Appendix 3 for the detailed proof.

A set of pure- and mixed-strategy Nash equilibrium is identified when only honest players consider OES adoption. If the OES fee rate r is lower than kp, a pure-strategy Nash equilibrium is found where honest buyers and honest sellers will adopt OES with 100% probability. This is due to the relatively low service fee rate versus the relatively high potential risk p, and encourages players to seek protection from OES. If the OES fee rate is higher than $2p/(1+p)$, another pure-strategy Nash equilibrium is found and neither honest buyers nor honest sellers will adopt OES. The relatively high fee rate versus the relatively low potential risk makes OES adoption less favorable. When the fee rate resides in the middle range, a mixed-strategy Nash equilibrium is obtained and both honest sellers and honest buyers need to adopt OES with a certain positive probability to sustain the equilibrium.

In addition, to ensure the above middle range of r is feasible, the ratio k needs to reside within the range of $1 < k < 2/(1+p)$. If k is beyond this range, the equilibrium conditions are bipolar, and only the two pure-strategy Nash equilibria stand.

According to these equilibrium conditions, the OES provider is facing a downward sloping demand. Lowering the fee rate can increase OES adoption, but at the cost of a lesser gain per trade. Raising the fee rate can generate more gain per trade, but may result in a lower adoption rate. Therefore, an OES provider needs to balance the gain per trade and the adoption rate to achieve the optimum profit level.

4. A Monopolist OES Provider's Optimum Pricing

Consider a risk-neutral monopolist OES provider in an online C2C market that charges a fee r, a percentage of transaction value (purchase price), for using its escrow services. The OES provider incurs a constant marginal cost η every time it provides the service. The goal of the OES provider is to find the fee rate level r that can maximize its total profit. OES providers usually charge a different fee rate according to different purchase price ranges, but without losing generality, we focus on the fee rate in one range in the following discussion. The theoretic outcomes from the following discussion can still apply to all transaction value ranges.

The profit maximization model for an OES provider in a given range of transaction value can be expressed as:

$$\operatorname*{Max}_r \pi(r) = \max_r [Irw(r) - IS(r)\eta].$$

Here I is the number of transactions in this transaction value range, $w(r)$ is the expected transaction

[12] $x = 0.5M$, $r = 2\%$, and $\varepsilon \ll rM$.

value under the protection of OES, and $S(r)$ is the OES adoption rate for all trades. $Irw(r)$ represents the total revenue of escrow services, and $IS(r)$ represents the demand for OES.

To find the expected transaction value $w(r)$ and the adoption rate $S(r)$, we need to first determine the demand for OES from the equilibrium conditions in Proposition 3. We can derive OES adoption probability $A(r,p,k)$ for each trade as the following:[13]

$$r\in[0,kp] \quad \text{or} \quad p\in[r/k,1]\colon\ A(r,p,k)=1-p^2$$

$$r\in(kp,2p/(1+p)) \quad \text{or} \quad p\in(r/(2-r),r/k)\colon$$

$$\begin{aligned} A(r,p,k) &= (1-p)(\theta+\omega)-(1-p)^2\theta\omega \\ &= 2p[(k+1)r-2kp]/r^2 \end{aligned}$$

$$r\in[2p/(1+p),1] \quad \text{or} \quad p\in[0,r/(2-r)]\colon\ A(r,p,k)=0.$$

Buyers and sellers evaluate the risks of a trade when they conduct business in an actual auction market. The risk is affected by factors such as transaction amount, product characteristics, trading partner's behavior, and trading partner's reputation. Therefore, from an OES provider's perspective, the potential risk p should be a distribution rather than a single, constant point. In this research, we introduce the transaction value M into the formation of p based on prior literature (Wolverton 2002b). Specifically, let p be a function of transaction value M, i.e., $p=p(M)$. M is assumed to be a random variable with a range from zero to infinity. According to Wolverton (2002b), the higher the M, the higher the potential p.

Thus, a general expression of the OES adoption rate $S(r)$, which is based on the traders' adoption probabilities $A(r,p,k)$, can be expressed as:

$$\begin{aligned} S(r) &= \int_1^\infty \left\{\int_0^1 [f(p)A(r,p,k)]\,dp\right\} g(k)\,dk \\ &= \int_1^\infty \left\{\int_{r/k}^1 [(1-p^2)f(p)]\,dp \right. \\ &\qquad \left. +\int_{r/(2-r)}^{r/k}\left[\frac{2p((k+1)r-2kp)}{r^2}f(p)\right]dp\right\} g(k)\,dk \end{aligned}$$

[13] Because k resides in the range of $(1, 2/(1+p))$ and can fulfill the most complete case analysis, we assume this range stands in the rest of the analysis. When k is beyond this range, the analysis is reduced to only one range.

where $f(p)$ is the density function of p, and $g(k)$ is the density function of k.

Denote $M(p)$ as the inverse function of $p(M)$. We can define *expected OES-protected transaction value* as:

$$\begin{aligned} w(r) &= \int_1^\infty \left\{\int_0^1 [M(p)f(p)A(r,p,k)]\,dp\right\} g(k)\,dk \\ &= \int_1^\infty \left\{\int_{r/k}^1 [(1-p^2)M(p)f(p)]\,dp \right. \\ &\qquad \left. +\int_{r/(2-r)}^{r/k}\left[\frac{2p((k+1)r-2kp)}{r^2}M(p)f(p)\right]dp\right\} g(k)\,dk. \end{aligned}$$

After plugging $w(r)$ and $S(r)$ into the original profit maximization problem, it is ready to be solved. From the integral with $f(p)$ and $g(k)$ we can derive that $w(r)$ and $S(r)$ are continuous on r. Then, to determine the optimal fee rate, we can maximize $\pi(r)$ by setting the first-order condition to equal zero. The following analyses assert that if there exists some r' with regard to a reasonable cost of η, such that $\pi(r') > 0$, there must exist at least an $r^* > 0$ within the interval of $[0, 1]$, which maximizes the profit as $\pi^* = \pi(r^*)$:

(1) when $r=0$, $\pi(r) = -IS(r)\eta < 0$;

(2) according to the *intermediate-value theorem*, $\exists r_0 \in (0, r')$, such that $\pi(r_0)=0$;

(3) when r is greater than a high rate r_m, $\pi(r)=0$ because no one will adopt OES at such a high fee rate.

In other words, when an OES provider chooses a fee rate, it inevitably affects the adoption rate and, thus, the OES provider's profit. Although a higher fee rate yields a higher gain per trade, a lower adoption rate follows and it is uncertain whether the OES provider's total profit is raised or lowered. Therefore, there must exist an optimal fee rate that balances these factors to achieve the highest profit level.

The first-order condition for the profit maximization model is:

$$\frac{d\pi(r)}{dr} = I\left[w(r) + r\frac{dw(r)}{dr} - \eta\frac{dS(r)}{dr}\right] = 0.$$

The complete derivation of the first-order condition can be found in Appendix 4. Theoretically, we can obtain the solution of the optimal fee rate r from this equation. The second-order condition of profit with respect to fee rate r must be negative to guarantee a maximization problem.

Table 3 **Outcomes of Numerical Study** ($M = \lambda \exp(200p)$, $\overline{M} = \$200$, $\eta = \$1$)

λ	E[p]	var(p)	r^* (%)	$\Delta(r^*)$ (%)	$W(r^*)$ (%)	$S(r^*)$ (%)
\$131.06	0.0019	0.0020^2	0.70	0.05	12.15	7.75
\$123.63	0.0022	0.0023^2	0.70	0.08	21.37	13.68
\$116.42	0.0024	0.0027^2	0.80	0.12	23.48	13.92
\$104.36	0.0028	0.0032^2	0.90	0.19	31.15	17.22
\$96.19	0.0031	0.0036^2	1.00	0.25	34.26	17.68
\$83.93	0.0036	0.0042^2	1.15	0.36	39.50	18.50
\$67.44	0.0043	0.0050^2	1.35	0.55	47.00	19.50
\$57.72	0.0048	0.0056^2	1.60	0.69	48.71	17.50
\$41.21	0.0058	0.0067^2	1.95	1.03	57.50	17.00

5. Numerical Study and Findings

Although the profit maximization model is a single-dimensional optimization problem, the distributions complicate the general solution. We conducted a numerical study to explore its properties.

First, we calibrate the distribution of M, p, and k. We assume the rationales of the relationship between M and p are: $dp/dM > 0$, the higher the M, the higher the p, and p is concave with regard to M, where $d^2p/dM^2 < 0$. The relationship between p and M is assumed to be $p = \ln(M/\lambda)/\tau$, or $M = \lambda \exp(\tau p)$.[14] When we adopt a lognormal distribution for M,[15] the distribution of p is normal (Aitchison and Brown 1969). According to Wolverton (2002b), we can reasonably assume that E[p], the mean of p, falls within the interval [0.0001, 0.005]. Accordingly, we assume E[M], the mean of M, is within the interval [100, 500]. k is assumed to be uniformly distributed in (1, 2) to support all the equilibrium ranges.

To better present the findings from the numerical study, we further introduce two definitions. (1) We define *OES adoption percentage regarding transaction value* $W(r)$, which equals $w(r)/\overline{M}$, where $\overline{M}$ is the estimate of E[M]. (2) We define *profit rate* $\Delta(r)$, which equals $\pi(r)/(I\overline{M})$.

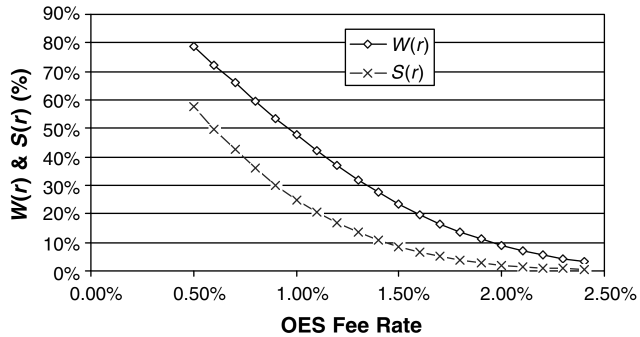
We conducted the numerical study by running the program with different sets of parameters constrained by the above calibrated value ranges. The results with $\tau = 200$, $\overline{M} = 200$, and $\eta = 1$ are shown in Table 3.

[14] The range of p is confined within the close interval of 0 and 1. When $\ln(M/\lambda)/\tau$ is less than zero, p is set to be zero; when $\ln(M/\lambda)/\tau$ is greater than 1, p is set to be 1.

[15] Lognormal distribution is described in the formula:

$$g(x, \mu, \sigma^2) = \frac{1}{\sigma x \sqrt{2\pi}} \exp\left(\frac{-[\ln(x) - \mu]^2}{2\sigma^2}\right).$$

Figure 3 $W(r)$ **vs.** $S(r)$



Notes. $M = 83.93 \exp(200p)$, $p \sim N(0.0036, 0.0042^2)$; $W(r)$ represents the percentage of the total value of transactions protected by OES, and $S(r)$ represents the percentage of the total number of transactions protected by OES.

We obtain the following findings from the numerical study.

(1) *OES does effectively prevent fraud.*

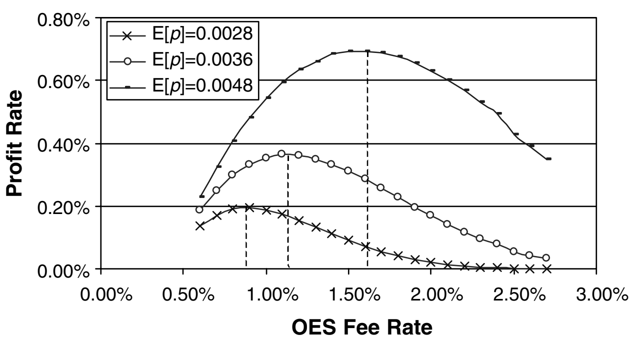
Figure 3 shows that the higher the OES fee rate r, the lower the OES adoption probability $S(r)$ and the OES adoption percentage regarding transaction value $W(r)$. Most importantly, $W(r)$ is always higher than $S(r)$ at any level of fee rate. This means a larger percentage of the trade (in terms of transaction value) is protected by OES than its adoption rate (in terms of number of trade). In other words, players trading merchandise with a high transaction value are more likely to adopt OES. As in the model, we assume higher risk p is associated with higher transaction value. The above result shows that the trades with higher risk are protected more often by OES than those with lower risks. Because of this, OES effectively services higher risk trades.

(2) *According to the numerical study, the current OES fee rate might be higher than is optimal.*

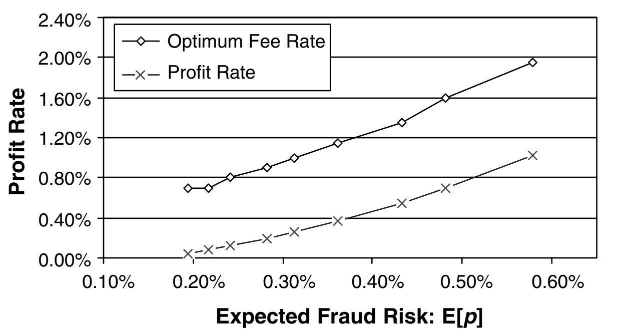
Figure 4a demonstrates the profit maximization problem: There exists an OES fee rate r that maximizes the OES profit. Figure 4b shows the optimal fee rate r with respect to different levels of expected fraud risk E[p]. According to our numerical study, the optimal fee rate is lower than 2%, which is below the current OES fee rate in this transaction value range. Therefore, if OES providers reduce their service fee rates in this range, they may experience higher profit.[16]

[16] The parameters calibrated for the numerical study are generated from sources such as the prior literature and industry reports. It is

Figure 4 **The Sensitivity of OES Provider's Profit to Fraud Risk**



(a) OES profit rate curves with different fee rates



(b) The effect of fraud risk on the optimum OES fee rate and profit rate

(3) *The OES profit is positively associated with the risk of fraud*.

Figure 4b reveals that when fraud risk p increases, optimum fee rates and OES profit rates also increase and vice versa. OES is a viable business model in high-risk marketplaces, and OES providers can earn a great profit. Conversely, when the expected fraud risk is low (approximately lower than 0.19%), OES providers' profit rates drop to zero, and OES as a stand-alone business may have difficulty surviving.

6. Conclusions and Future Research

Increasing fraud may cripple online auction markets, so there is an indisputable value in understanding how different types of traders and OES providers behave in electronic markets, whether and when an OES will be adopted by online traders, and under what conditions an OES constitutes a viable business model as a trusted third party. While many studies have been conducted on the role of other TTPs in electronic markets, online escrow services have never been fully explored. This study represents a pioneering effort to apply game theory to analyze online escrow services and provide a better understanding of OES markets and auction participants' behavior.

We have defined two types of traders, honest and strategic, in online C2C auction markets and proposed a two-stage dynamic game model to investigate their optimal strategies under the influence of an OES. Our results provide insights for understanding the general patterns of OES adoption in online auction markets. Moreover, we established a profit maximization model and proposed an optimal service fee scheme for monopolist OES providers. Our analysis demonstrates that the OES provider may reach the optimal profit level by choosing an optimal fee rate that balances the trade-off between single trade profit gain and a moderate adoption rate. Finally, we conducted a numerical study to further explore the OES profit maximization problem.

We conclude that an OES is currently an effective business model for blocking strategic traders from cheating in online C2C auction markets. However, according to our numerical study, the current OES fee rates charged by OES providers are higher than the rate for profit maximization.[17] The current high OES fee rates may explain the low OES adoption rate in online auction markets.

The OES fee rate is under the direct control of an OES provider. However, OES providers have no control over indirect factors that may also affect the OES adoption rate and profitability. These indirect factors can be classified into four categories.

The first category is associated with traders' general perceptions of e-markets. It includes the online auction fraud rate, loss rate, and past experiences of online traders. The adoption rate of OES will drop when the general perception of risk is low.

The second category is associated with a trader's perception of risk regarding a particular trade. It

possible that the true parameter settings are different from our calibration. Therefore, we encourage OES providers to calibrate their own parameters and use our paper as a guide for finding their optimal fee rates.

[17] For example, the major OES company, Escrow.com, charges 3% for items with a transaction value between $0 and $5,000 if using a check or money order, and 6% if using a credit card.

includes factors such as the purchase price, a trading partner's reputation, and the product type. If the trading partner has a good reputation, there is less possibility of OES adoption. In contrast, a high purchase price may lead to a higher possibility of OES adoption. Brand-name products have a higher perceived quality level, and buyers feel less uncertainty about them, which in turn lowers the OES adoption rate.

The third category is closely related to the distribution of transaction values in online C2C auction markets.[18] One remarkable aspect of OES is that while a service fee is usually a percentage of the transaction value, the cost of providing an escrow service is relatively independent of that value. Therefore, the profitability of OES depends in large part on the distribution of transaction values. The OES provider has a better chance of thriving in online C2C markets with more high-value transactions.

The fourth category involves other risk-relief services, which present competition. This category includes services such as PayDirect at Yahoo Auctions, ASAP™ at Fair Market, traditional credit card services, and insurance or guarantees offered by online auction sites (e.g., eBay's standard guarantees and eBay's PayPal buyer protection program).[19] These services offer a degree of Internet fraud protection. The quality and price of these services can directly affect OES demand. Risk-relief services that provide equal service quality and lower fee rates will be stiff competition for OES providers.

Finally, online reputation mechanisms, a special category of risk-relief services, may play a significant role in the viability of the OES model. Online reputation mechanisms are large-scale online communities in which individuals share opinions, comments, or evaluations on a wide range of topics, including companies, products, and services (Dellarocas 2003a). In an online auction site, the online reputation mechanism is the fundamental trust-building system. It collects, distributes, and compiles feedback in a system that helps participants decide who to trust. Prior literature (e.g., Kollock 1999, Ba et al. 2003, Dellarocas 2003b) has demonstrated that online reputation mechanisms are a viable system for promoting trust and fostering cooperation in electronic markets. For certain transactions, traders may decide to trust each other based solely on their reputation ratings. Therefore, the existence of online reputation mechanisms may further diminish the need for online escrow services.

All of the above indirect factors may affect the viability of OES as a TTP in online auction markets. Whether OES will be a profit-making business model in the near future—and how long it can remain so—is dependant on the security features of future online markets and on OES providers' fee rates. This conclusion may explain why the escrow service industry has been so unstable over the past few years. For instance, i-Escrow merged with Trade Direct in 1999 and acquired Tradenable in 2000, occupying 80% of OES market share in that year. However, this online escrow leader closed its business in 2001 and Escrow.com is now the major player in the market. Clearly, the OES market faces substantial uncertainties and challenges. OES providers may have to provide more value-added services in the future, or this business model may not survive.

Several avenues for future research emerge from the above discussion. First, changing the role of OES providers from profit maximizing to social planning can be modeled to explore the efficiency of OES. Second, the substitution effect between OES and other online risk-relief services can be studied to further examine the effectiveness of OES. Further exploration of these topics will answer questions about developing fraud-free online auction markets, and provide a better understanding of the nature of C2C online auction markets. In addition, as one anonymous reviewer pointed out, investigating the different degrees of cheating and allowing for cases of "mutual mistake" and "misrepresentation" between traders would also generate more insights.

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[18] We thank an anonymous reviewer for this insight.

[19] Currently, eBay's standard guarantees provide coverage up to \$200 (minus a \$25 processing fee), and eBay's PayPal Buyer Protection program provides up to \$500 at no additional cost.

Appendix 1. Proof of Proposition 1

We use a backward induction method to solve the strictly dominant strategies for a strategic player in the second stage.

First, we compare all the payoffs of the end nodes that involve a strategic trader and OES adoption. We found that when a strategic buyer plays "trade honestly," his payoff is either: $V^b - M - 0.5rM$, $V^b - M - rM$, or $V^b - M$. However, if he plays "cheat," his payoff is either: $-0.5rM - \varepsilon$, $-rM - \varepsilon$, or $-\varepsilon$ correspondingly. Therefore, the optimal strategy for a strategic buyer when OES is adopted is "trade honestly." We can also prove this result for a strategic seller.

Second, we compare all the payoffs of the end nodes that involve a strategic trader and no OES adoption. We found the following situations when a buyer is strategic. (1) When the strategic buyer plays "trade honestly" with a seller who plays "trade honestly," regardless of the type of the seller, his payoff is $V^b - M$. (2) When the strategic buyer plays "cheat" with a seller who plays "trade honestly," his payoff is $V^b - \varepsilon$. (3) When the strategic buyer plays "trade honestly" with a seller who plays "cheat," his payoff is $-M$. (4) When a strategic buyer plays "cheat" with a seller who plays "cheat" as well, his payoff is $-\varepsilon$. Because we know that M is assumed to be greater than ε, the payoff of (2) for a strategic buyer is always better than that of (1), and the payoff of (4) is always better than that of (3). Therefore, the optimal strategy for a strategic buyer when no OES is adopted is "cheat." We can also prove this result for a strategic seller.

It is worth noting that when no collusion is assumed and two strategic players match up in a trade, they will both deceive each other and yield a prisoner dilemma result (Table A1). Q.E.D.

Appendix 2. Proof of Proposition 2

To solve the mixed strategy for buyers and sellers of different types, we need to set the expected utility (EU) of adopting OES equal to the expected utility of not adopting OES:

EU(*an honest buyer adopts OES*) = EU(*an honest buyer does not adopt OES*)

$$\begin{aligned}&(1-p)\big[\omega\big(V^b - M - \tfrac{1}{2}rM\big) + (1-\omega)(V^b - M - rM)\big]\\&\quad + p\big[\beta\big(V^b - M - \tfrac{1}{2}rM\big) + (1-\beta)(V^b - M - rM)\big]\\&\quad = (1-p)[\omega(V^b - M) + (1-\omega)(V^b - M)]\\&\qquad + p[\beta(V^b - M) + (1-\beta)(-M)].\end{aligned}$$

Table A1 The Second-Stage Game Between Two Strategic Traders when OES Is Not Adopted

	Strategic seller	
	H	C
Strategic buyer		
H	$V^b - M,\quad M - V^s$	$-M,\quad M-\varepsilon$
C	$V^b - \varepsilon,\quad -V^s$	$-\varepsilon,\quad -\varepsilon$

EU(*a strategic buyer adopts OES*) = EU(*a strategic buyer does not adopt OES*)

$$\begin{aligned}&(1-p)\big[\omega\big(V^b - M - \tfrac{1}{2}rM\big) + (1-\omega)(V^b - M - rM)\big]\\&\quad + p\big[\beta\big(V^b - M - \tfrac{1}{2}rM\big) + (1-\beta)(V^b - M - rM)\big]\\&\quad = (1-p)[\omega(V^b - M) + (1-\omega)(V^b - \varepsilon)]\\&\qquad + p[\beta(V^b - M) + (1-\beta)(-\varepsilon)].\end{aligned}$$

EU(*an honest seller adopts OES*) = EU(*an honest seller does not adopt OES*)

$$\begin{aligned}&(1-p)\big[\theta\big(M - V^s - \tfrac{1}{2}rM\big) + (1-\theta)(M - V^s - rM)\big]\\&\quad + p\big[\alpha\big(M - V^s - \tfrac{1}{2}rM\big) + (1-\alpha)(M - V^s - rM)\big]\\&\quad = (1-p)[\theta(M - V^s) + (1-\theta)(M - V^s)]\\&\qquad + p[\alpha(M - V^s) + (1-\alpha)(-V^s)].\end{aligned}$$

EU(*a strategic seller adopts OES*) = EU(*a strategic seller does not adopt OES*)

$$\begin{aligned}&(1-p)\big[\theta\big(M - V^s - \tfrac{1}{2}rM\big) + (1-\theta)(M - V^s - rM)\big]\\&\quad + p\big[\alpha\big(M - V^s - \tfrac{1}{2}rM\big) + (1-\alpha)(M - V^s - rM)\big]\\&\quad = (1-p)[\theta(M - V^s) + (1-\theta)(M - \varepsilon)]\\&\qquad + p[\alpha(M - V^s) + (1-\alpha)(-\varepsilon)].\end{aligned}$$

Combining the above equations, we obtain the mixed-strategy Nash equilibrium:

$$\omega^* = 1 + \frac{rM}{2(1-p)V^b} \qquad \beta^* = 1 - \frac{rM}{2pV^b}$$

and

$$\theta^* = 1 + \frac{r}{2(1-p)} \qquad \alpha^* = 1 - \frac{r}{2p}.$$

However, because the requirements for ω^* and θ^* are greater than 100%, this internal solution is not sustainable. We re-establish the above equations by setting the maximum allowable adoption rate of 100% for honest traders[20] and find the following equilibrium results:

$$\omega^* = 1 \qquad \beta^* = 1 - \frac{rM}{2p(V^b - M - rM/2 + \varepsilon)}$$

and

$$\theta^* = 1 \qquad \alpha^* = 1 - \frac{rM}{2p(M - V^s - rM/2 + \varepsilon)}.$$

In the above equilibrium conditions, for honest traders the condition of $\omega^* = \theta^* = 1$ leads to the situation: EU(an

[20] From the above expected utility equations, we can claim that honest traders have more intention to adopt OES than strategic traders. Therefore, we disregard the case when ω and θ are equal to zero. We omit the case when $\omega = 1$ and $\theta \cong 1$ for the sake of simplicity.

honest trader adopts OES) > EU(an honest trader does not adopt OES). Meanwhile, for strategic traders we have: EU(a strategic trader adopts OES) = EU(a strategic trader does not adopt OES).

For this equilibrium to stand, α^* and β^* must be between 0 and 1, which leads to the requirement that the prior belief p must satisfy the following condition: $p > rM/(2(x - rM/2 + \varepsilon))$. Q.E.D.

Appendix 3. Proof of Proposition 3

To solve for the mixed strategy of honest traders, we need to set the expected utility of adopting OES equal to the expected utility of not adopting OES, given the condition that strategic traders will not adopt OES.

EU(*an honest buyer adopts OES*)=EU(*an honest buyer does not adopt OES*), i.e.,

$$\begin{aligned}(1-p)\omega\big(V^b - M - \tfrac{1}{2}rM\big) + (1-p)(1-\omega)(V^b - M - rM)\\ + p(V^b - M - rM) = (1-p)\omega(V^b - M)\\ + (1-p)(1-\omega)(V^b - M) + p(-M).\end{aligned}$$

EU(*an honest seller adopts OES*)=EU(*an honest seller does not adopt OES*), i.e.,

$$\begin{aligned}(1-p)\theta\big(M - V^s - \tfrac{1}{2}rM\big) + (1-p)(1-\theta)(M - V^s - rM)\\ + p(M - V^s - rM) = (1-p)\theta(M - V^s)\\ + (1-p)(1-\theta)(M - V^s) + p(-V^s).\end{aligned}$$

Solving the above equations led to

$$\omega^* = \frac{2(r-kp)}{(1-p)r} \quad \text{and} \quad \theta^* = \frac{2(r-p)}{(1-p)r}.$$

To ensure the above equilibrium probabilities fall within the open interval $(0, 1)$, the requirement for r becomes: $r \in (kp, 2p/(1+p))$. We have the internal solution for the mixed-strategy equilibrium only when the OES fee rate falls within this defined range. Otherwise, only corner solutions will stand.

To investigate the equilibrium conditions when r is outside $(kp,\ 2p/(1+p))$, we identify three critical points of r from the equilibrium requirements: p, kp, and $2p/(1+p)$.

(1) When the OES fee rate is significantly low (below the trader's belief of p) the optimal strategy for honest buyer and honest seller is to adopt OES, where the EU(an honest trader adopts OES) is always greater than the EU(an honest trader does not adopt OES) even if the trading partner will not adopt OES.

(2) When the fee rate rises from p to kp, an honest buyer still adopts OES even if his trading partner will not. Because an honest seller will always adopt OES, the optimal strategy for an honest buyer is also 100% OES adoption.

Therefore, the two lower bounds p and kp are reduced to one (kp) with a 100% optimal adoption probability for honest buyers and sellers.

(3) When the fee rate is raised above the level of $2p/(1+p)$, an honest seller's expected payoff with OES adoption is still lower than without even if an honest buyer will adopt OES. Therefore, an honest seller will not consider OES adoption when the fee rate falls in this range. In this fee rate range, an honest seller will never share the OES cost, so an honest buyer's expected utility with OES adoption is always less than the expected utility without OES adoption. Therefore, the equilibrium is 0% adoption from both honest buyers and honest sellers. Q.E.D.

Appendix 4. The First-Order Condition for OES Provider's Profit Maximization

A complete expression of the expected profit is

$$\begin{aligned}\pi(r) = I\bigg[\int_1^\infty \bigg\{\int_{r/k}^1 [(1-p^2)(rM(p)-\eta)f(p)]\,dp\\ + \frac{1}{r^2}\int_{r/(2-r)}^{r/k} [2p((k+1)r - 2kp)\\ \cdot (rM(p)-\eta)f(p)]\,dp\bigg\}g(k)\,dk\bigg].\end{aligned}$$

The first-order condition for the above is

$$\begin{aligned}&\int_1^\infty \bigg\{\int_{r/k}^1 [(1-p^2)M(p)f(p)]\,dp\bigg\}g(k)\,dk\\ &-\int_1^\infty \bigg[\frac{(r^2-k^2)}{k^3}\bigg(rM\bigg(\frac{r}{k}\bigg)-\eta\bigg)f\bigg(\frac{r}{k}\bigg)\bigg]g(k)\,dk\\ &+2\int_1^\infty \bigg[\frac{(k-1)}{k^2}\bigg(rM\bigg(\frac{r}{k}\bigg)-\eta\bigg)f\bigg(\frac{r}{k}\bigg)\bigg]g(k)\,dk\\ &-\frac{4}{(2-r)^4}\int_1^\infty \bigg[(2-rk-r)\bigg(rM\bigg(\frac{r}{2-r}\bigg)-\eta\bigg)\\ &\qquad \cdot f\bigg(\frac{r}{2-r}\bigg)\bigg]g(k)\,dk\\ &+\frac{1}{r^2}\int_1^\infty \bigg\{\int_{r/(2-r)}^{r/k} [4p(kr+r-kp)M(p)\\ &\qquad -2p(k+1)\eta]f(p)\,dp\bigg\}g(k)\,dk\\ &-\frac{2}{r^3}\int_1^\infty \bigg\{\int_{r/(2-r)}^{r/k} [2p(kr+r-2kp)\\ &\qquad \cdot (rM(p)-\eta)f(p)]\,dp\bigg\}g(k)\,dk = 0.\end{aligned}$$

References

Aitchison, J., J. A. C. Brown. 1969. *The Lognormal Distribution, with Special Reference to Its Uses in Economics*. The Cambridge University Press, Cambridge, U.K.

Akerlof, G. 1970. The market for lemons: Quality uncertainty and the market mechanism. *Quart. J. Econom.* **84**(3) 488–500.

Ba, S., Paul A. Pavlou. 2002. Evidence of the effect of trust building technology in electronic markets: Price premiums and buyer behavior. *MIS Quart.* **26**(3) 243–268.

Ba, S., A. B. Whinston, H. Zhang. 2003. Building trust in online auction markets through an economic incentive mechanism. *Decision Support Systems* **35**(3) 273–286.

Bolton, G., E. Katok, A. Ockenfels. How effective are online reputation mechanisms? An experimental investigation. *Management Sci.* Forthcoming.

Dellarocas, C. 2003a. The digitization of word-of-mouth: Promise and challenges of online feedback mechanisms. *Management Sci.* **49**(10) 1407–1424.

Dellarocas, C. 2003b. Efficiency and robustness of binary feedback mechanisms in trading environments with moral hazard. Working Paper 4297-03, Sloan School of Management, MIT, Cambridge, MA.

Friedman, E., P. Resnick. 2001. The social cost of cheap pseudonyms. *J. Econom. Management Strategy* **10**(2) 173–199.

Fudenberg, D., J. Tirole. 1991. *Game Theory*. The MIT Press, Cambridge, MA.

Gibbons, R. 1992. *Game Theory for Applied Economics*. Princeton University Press, Princeton, NJ.

Internet Fraud Watch. 2003. Fraud trends: January–December 2003. http://www.fraud.org/2003internetscams.pdf.

Kauffman, R., C. Wood. 2000. Running up the bid: Modeling seller opportunism in Internet auctions. *Proc. 2000 Amer. Conf. (AMCIS)*, Long Beach, CA.

Kollock, P. 1999. The production of trust in online markets. E. J. Lawler, M. Macy, S. Thyne, H. A. Walker, eds. *Advances in Group Processes*, Vol. 16. JAI Press, Greenwich, CT.

Kreps, D. M. 1990. *A Course in Microeconomic Theory*. Princeton University Press, Princeton, NJ.

Melnik, M. I., J. Alm. 2002. Does a seller's eCommerce reputation matter? Evidence from eBay auctions. *J. Indust. Econom.* **50**(3) 337–349.

National Consumers League (NCL). 2001. Online auction survey summary. January 31, 2001. http://www.natlconsumersleague.org/onlineauctions/auctionsurvey2001.htm.

Resnick, P., R. Zeckhauser. 2002. Trust among strangers in Internet transactions: Empirical analysis of eBay's reputation system. Michael R. Baye, ed. *The Economics of the Internet and E-Commerce. Advances in Applied Microeconomics*, Vol. 11. Elsevier Science, Amsterdam, The Netherlands.

Resnick, P., R. Zeckhauser, E. Friedman, K. Kuwabara. 2000. Reputation systems. *Comm. ACM* **43**(12) 45–48.

Wolverton, T. 2002a. eBay brings escrow aboard. http://news.com.com/2100-1017-898154.html.

Wolverton, T. 2002b. Auction service targets deadbeat bidders. http://news.com.com/2100-1017-961312.html.