Analysis of Supplier Competition in Electronic Marketplaces

Shantanu Biswas and Y. Narahari

Abstract— **The advent of e-business heralds new opportunities and challenges for buyers and sellers in business-to-business commerce. The electronic trading reduces transaction and search costs and reduces other market inefficiencies. The electronic trading also shortens supply chains and lowers inventory carrying costs. On the other hand e-business increases supplier competition, reduces prices, and lowers the profit margins. Our study shows the potential benefits that accrue for the suppliers can offset the shrinkage of profit margins.**

Keywords— **E-commerce, Procurement, Competition, Switching costs, Setup Costs, Equilibrium**

I. Introduction

E-business offers buyers and sellers new marketing strategies and opportunities to create innovative marketplaces taking advantages of advances in communication technologies.

An online seller needs only a small number of big warehouses from where the goods are packed and dispatched instead of a grid of physical selling outlets. Therefore e-commerce will reduce the distribution costs Automated transactions will reduce transaction costs for buyers and sellers. Operational efficiencies can be realized because of fewer stages in transaction process and a reduction in staff required for transaction processing ([1]). E-commerce can lead to shorter supply chains. Thus significant reductions on the cost side are possible due to reduction of inventory and carrying costs ([2]).

Several authors ([3], [4]) have argued that since modern computing and communication technologies reduce buyer search costs and other market inefficiencies, there should be intense price competition between sellers in electronic markets. The search cost represents the real and opportunity costs of identifying vendors, locating products, comparing offerings, and making purchasing decisions. These costs may be lower in electronic markets due to factors such as easier access to information, reduced waiting times, and elimination of travel time. The reduction in buyer search costs in electronic markets increases price competition amongst vendors, resulting in converging prices and ultimately eliminating any profits. However, it is well known that products with complex characteristics enable producers to avoid the outcome of pure price competition through product differentiation ([5]). By offering different products - either price-quality combinations or different non-quality attributes (colour, size) - firms can soften competition and increase their profits in markets where buyers have heterogeneous preferences. Retailers differentiate themselves in a variety of ways; such as the range of products they offer, their geographic locations, and choice of product or service quality. It is the ability to appeal to different tastes that enable vendors to segment their markets, to limit direct competition, and thus to charge a premium.

Prof. Y. Narahari (corresponding author), E-mail: hari@csa.iisc.ernet.in and Shantanu Biswas, E-mail: biswas@csa.iisc.ernet.in are with the Indian Institute of Science.

Many researchers, economists, and market analysts are studying the effects of e-commerce on the economy, especially on competition, price levels, and firm performance. Various studies ([6], [4]) have predicted that e-business will result in increase in competitive pressures, decrease in profit margins, lowering of prices, and more efficient supply chain management. These changes would not only affect the online buyers and sellers but also more traditional firms that do not transact online since the share of business partners and customers doing online trading is increasing rapidly.

This leads to the question whether e-commerce causes ruinous competition. We study the extreme (or pessimistic) scenario of competition amongst suppliers for a homogeneous product i.e. we have a pure price competition. Klemperer proposed a duopoly model ([7]) for markets with switching costs. Biswas and Hogendorn ([8]) extended this model to market with N players. We use this model to study the effect of e-commerce on the profit of a firm. The technical terminologies used in the paper are defined in the glossary given at the end of the paper.

II. Model Description

In many markets, buyers face substantial costs of switching between brands of homogeneous products. There are many different types of switching costs which a buyer may have to pay, such as: transaction costs, learning costs, and contractual costs. Klemperer assumes the switching costs are exogenous. The switching costs make each individual firm's demand more inelastic and segment the market into sub-markets. Each sub-market contains buyers who have previously bought from a particular firm and may in effect be monopolized by that firm. The resulting non-cooperative equilibrium may be the same as the collusive solution in an otherwise identical market with no switching costs.

Klemperer's model is a two period duopoly model of a market with switching costs. In the first period buyers have no ties with any particular firm. Any startup transaction or learning costs are assumed to be the same whichever firm a buyer buys from. The second period is the mature market after buyers' switching costs have been built up. Second period switching costs are created by first period sales. We emphasize the dynamics in the second period in this study. The model used here which is the extension of

Klemperer's model finds a symmetric equilibrium in an N player market of buyers with different switching costs.

A. Assumptions

In period 2, we assume switching costs and firms' previous period market shares are given. We consider N sellers producing functionally identical products and there many buyers for this product. We assume that the number of buyers and sellers do not change in the second period i.e. there are no new entrants in the market. Let
$h(r)$: the number of buyers whose reservation price is less than or equal to r i.e. those buyers who are willing to pay at most r for the product.
σ_i: market share of buyers already with seller i.
s: cost to switch vendors.
$\Gamma(s)$: CDF of switching costs i.e. proportion of a firm's buyers whose cost of switching to other firms' product is less than or equal to s. We assume $\Gamma(0) = 0$. This assumption is quite natural because $\Gamma(0) > 0$ means there are customers without switching costs.

Let firm i charge p_i, and all other sellers charge $\overline{p}$. We take this assumption because we are interested to study the symmetric equilibrium. Now we can have two two different cases for market equilibrium:
Case 1: If $p_i > \overline{p}$. In this case the firm i sells only to its own customers with reservation prices greater than or equal to $\overline{p}$ and switching costs greater than or equal to $p_i - \overline{p}$. Then demand for seller i is:

$$q_i = \sigma_i(1 - \Gamma(p_i - \overline{p}))h(p_i) \tag{1}$$

Case 2: If $p_i < \overline{p}$. In this case firm i sells to
– All its own customers with reservation prices greater than or equal to p_i
– Those of the competitors' customers with reservation prices greater and or equal to $\overline{p}$ and switching costs less than or equal to $\overline{p} - p_i$
– Those customers of the rival firms with reservation prices in the range $(p_i, \overline{p})$ and switching costs less than or equal to $r - p_i$, where r is the reservation price.
Then demand for seller i is:

$$\begin{aligned} q_i &= \sigma_i h(p_i) \quad + (1-\sigma_i)\Gamma(\overline{p} - p_i)h(\overline{p}) \\ &\quad + (1-\sigma_i)\int_{p_i}^{\overline{p}} (r - p_i)(-dh(r)) \end{aligned} \tag{2}$$

B. Non-cooperative Equilibrium

We use Equations 1 and 2 to solve a price-competition equilibrium. Seller i's (taking $\overline{p}$ as given) demand is given by $q_i(p_i|\overline{p})$, and marginal cost is given by $c(q_i(p_i|\overline{p}))$

Seller i's profits is price $\times$ quantity $-$ marginal cost i.e.

$$\Pi_i(p_i|\overline{p}) = p_i q_i(p_i|\overline{p}) - c(q_i(p_i|\overline{p})) \tag{3}$$

Firm i's first-order condition for equilibrium is

$$\frac{\partial \Pi_i}{\partial p_i} = 0 \tag{4}$$

$$q_i(p_i|\overline{p}) + p_i\frac{\partial q_i(p_i|\overline{p})}{\partial p_i} - \frac{\partial c(q_i(p_i|\overline{p}))}{\partial q_i}\frac{\partial q_i(p_i|\overline{p})}{\partial p_i} = 0 \tag{5}$$

Let

$$\frac{\partial c(q_i(p_i|\overline{p}))}{\partial q_i} = c'$$

Then we have

$$q_i(p_i|\overline{p}) + p_i\frac{\partial q_i(p_i|\overline{p})}{\partial p_i} - c'\frac{pi\partial q_i(p_i|\overline{p})}{\partial p_i} = 0 \tag{6}$$

For symmetric equilibrium (in pure strategies), let

$$\sigma_i = \frac{1}{N}, p_i = \overline{p} = p, \ \ and \ \ \Gamma(0) = 0,$$

then

$$h(p) + (p - c')(\frac{\partial h(p)}{\partial p} - (N-1)\gamma(0)h(p)) = 0 \tag{7}$$

Prices and profits decrease in N and in $\gamma(0)$.
If $\gamma(0) = 0$, then we can rewrite Equation 7 as

$$h(p) + (p - c')\frac{\partial h(p)}{\partial p} = 0 \tag{8}$$

This is the first order condition for a monopolist (or collusive oligopoly) in a market without switching cost ([9]).
If $\gamma(0) \to \infty$, then Equation 7 implies that $p - c' \to 0$, i.e. the market price approaches the competitive price (firms' marginal cost).

With $\gamma(0)$ between these extreme cases the equilibrium is between the competitive and collusive equilibria. We verify that the second order conditions are globally satisfied for the cases under consideration numerically in the next section and therefore a unique equilibrium in pure strategies exists for the cases we study.

III. Numerical Results

A. Effects of E-Commerce

Electronic trading lowers the switching costs for the buyers i.e. increased competition and hence reduction of profit margins for the sellers.

Electronic trading lowers the transaction costs and sales costs for the sellers, i.e. marginal cost 'c' falls. Lower costs equal higher seller profits which depends on demand elasticity. We shall call the transaction and sales costs of the seller as her setup costs. According to figures available from GoldmanSachs, AMR, and SAP ([10])

- the the switching costs of buyers are reduced by $20-30\%$.
- the setup costs of sellers are reduced by $30 - 70\%$.

By calibrating Klemperer's model and performing comparative statics, we can estimate which effect dominates.

B. Study of Various Scenarios

B.1 Calibration

Competition: We assume there are four sellers, $N = 4$
Demand: We assume constant price elasticity of demand, ϵ. Then we can write $h(r) = r^\epsilon$ or $h(p) = p^\epsilon$ Now the first order condition becomes

$$p^{-\epsilon} + (p - c')(-\epsilon p^{-\epsilon-1} - (N-1)\gamma(0)p^{-\epsilon}) = 0 \tag{9}$$

Marginal cost before electronic trading: This is unknown and we assume it to be constant, set $c = 1$. This is possible because we are comparing the marginal cost before and after electronic trading. Therefore only the percentage change of marginal cost matters.

Switching cost distribution: Switching costs percentages are with respect to the price the buyer has to pay for procuring the object. Switching costs will vary from industry to industry. We study three different mean switching costs ($25\%, 50\%$, and 75%)which should cover the range of switching costs encountered in various sectors. These are assumed to be distributed uniformly on $[0, u]$ We set u such that the mean switching cost is $\overline{s}$ percent of the equilibrium price in the model. We assume the reduction in switching costs in 20% and reduction is setup costs in 30% which are the lower ends of the data mentioned above.

The suppliers generally want to build long term relationships with the buyers. So the supplier tries to recover her setup costs of a period of time. This can be treated as a loan given by the supplier to the buyer.

- Let us assume setup costs are recovered over a period of two years.
- Assume constant interest rate of returns is 10%.
- Setup payback i.e. present value of the investment is 120% (this is a very low estimate).

C. Results

We need to show that the second order conditions are satisfied i.e. equilibrium is unique. Numerically if we can show that the graph between price and profit is concave then we are done. To show this we proceed in the following manner:

1. Fix $\overline{p}$. Assume $\overline{p} = 3$ (All the values are normalized w.r.t. the marginal cost).
2. Fix a mean switching cost percentage w.r.t. price. Assume $\overline{s} = 25\%$.
3. For a given price elasticity of demand vary prices and calculate the corresponding profits. We vary prices from 0 *to* $\overline{p}$. We calculate these values for price elasticity $\epsilon = -1.2, -1.5, -1.8$. We know that the demand is elastic only when $\epsilon < -1$. And if the demand is price inelastic then it can be shown that the market price will increase till it reaches the demand elastic region. Therefore we study only the cases when $\epsilon < -1$.
4. Plot the corresponding graphs.

All the three curves in Fig.1 are concave in the region under consideration. Thus we will have a unique equilibrium point.

Now we calculate the profits before and after electronic trading for various cases. The results are shown in Table I.

We observe the following trends in the table:

1. By definition in price elastic region as price elasticity goes down the quantity demanded also goes down. And the profits also reduce accordingly. This fact is verified by our results.
2. The equilibrium prices and profits go up with the increase in switching cost percentages. This confirms the hypothesis given by various authors that switching costs reduce competition and divide the market into segments of monopoly pricing ([7]).
3. The equilibrium prices after electronic trading are lower than the corresponding prices before electronic trading. This also confirms the hypothesis that electronic commerce reduces prices and hence benefits buyers ([3], [4], [11]).
4. The increase in profit after electronic trading increases as the price elasticity goes down. To confirm this we study the effect of price elasticity on profits in detail for one of the mean switching percentages, 25%. The difference of profits before and after electronic trading is obviously higher for mean switching percentages more than 25% as observed earlier.

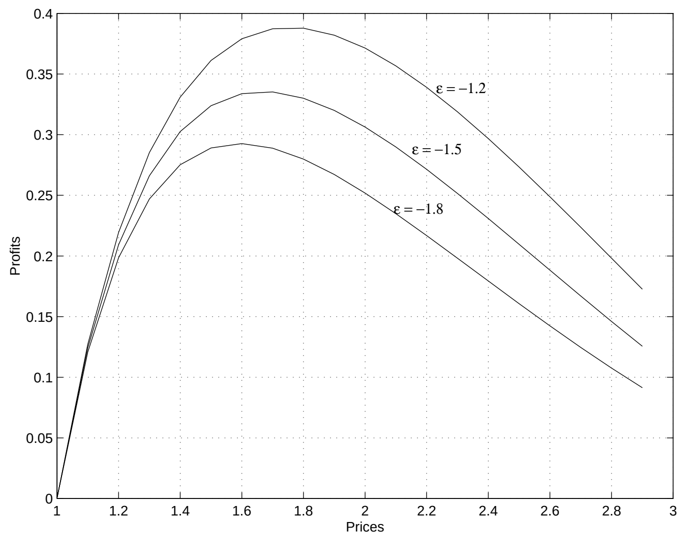

Fig. 1. Profits plotted against Prices

ϵ	$\overline{s}$	Before Electronic Trading			After Electronic Trading		
		Price	Quantity	Profit	Price	Quantity	Profit
-1.2	25%	1.1613	0.8357	0.1348	0.8265	1.2569	0.1590
	50%	1.3125	0.7216	0.2255	0.9421	1.0742	0.2601
	75%	1.4545	0.6379	0.2899	1.0494	0.9438	0.3298
-1.5	25%	1.1539	0.8068	0.1242	0.8201	1.3465	0.1617
	50%	1.2857	0.6859	0.1960	0.9199	1.1334	0.2492
	75%	1.4000	0.6037	0.2415	1.0051	0.9924	0.3028
-1.8	25%	1.1471	0.7811	0.1149	0.8143	1.4474	0.1654
	50%	1.2632	0.6567	0.1728	0.9014	1.2054	0.2428
	75%	1.3571	0.5772	0.2061	0.9705	1.0554	0.2855

TABLE I
COMPARISON BEFORE AND AFTER ELECTRONIC TRADING

We plot the line of zero profit difference ($\pi = 0$) while varying the %age reduction in setup costs and %age reduction in switching costs for elasticity = -1.2, -1.5, -1.8 (Fig 2,3,4).

The area above the line $\pi = 0$ represents the area of positive profits. The region of positive profits increase with the the rise of switching cost percentages. Thus from these graphs it is clear that the benefits of electronic trading for the seller is more when the price elasticity of demand is higher.

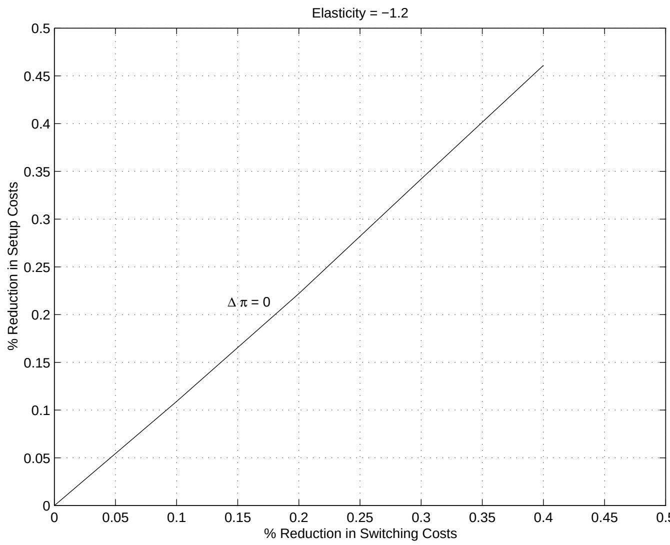

Fig. 2. $\pi = 0$ for $\epsilon = -1.2$

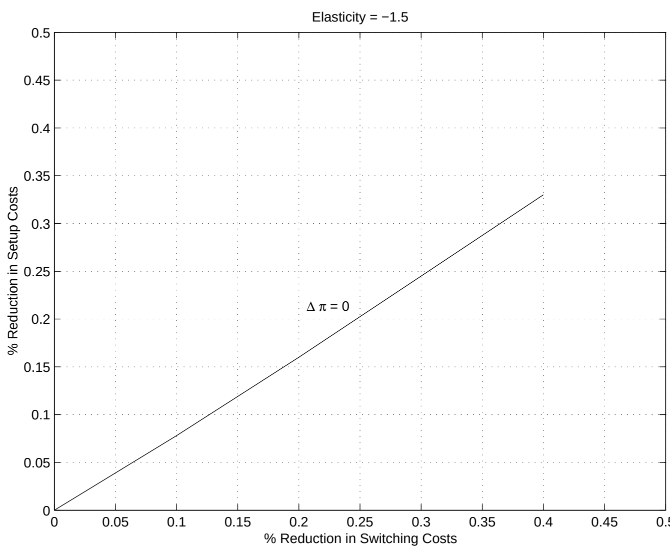

Fig. 3. $\pi = 0$ for $\epsilon = -1.5$

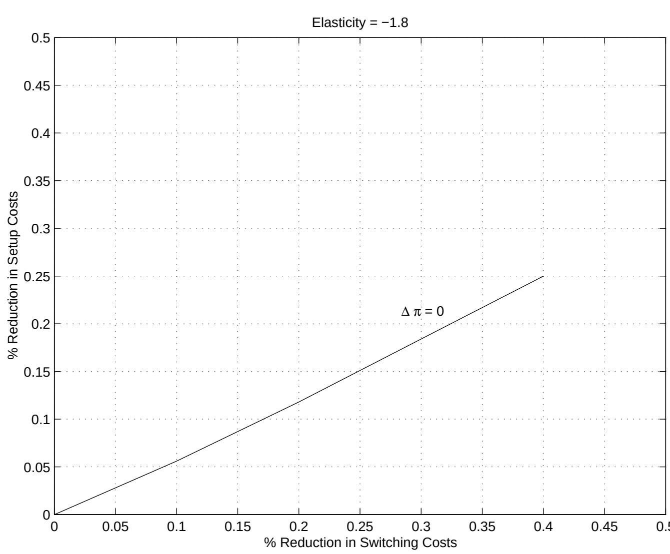

Fig. 4. $\pi = 0$ for $\epsilon = -1.8$

IV. Conclusions and Future Work

We have shown using a static switching cost model and cost estimates from GoldmanSachs, AMR, and SAP that e-commerce will increase the sellers' profits even in the extreme case of pure price competition. Thus in most cases when we don't have pure price competition the benefits will be much more than this extreme case. We have also shown that e-commerce is likely to benefit the sellers more when price elasticity of demand is higher. Also as the percentage of B2B trading done electronically increases, the sellers who do not participate in electronic trading will lose the benefits of lowered setup costs. Thus switching cost models can address sellers' concerns about electronic trading.

The model we have used is a static model. These static models give an aggregate level estimate. More advanced dynamic models e.g. churn models [12], continuous flow models with viscosity ([13]), evolutionary learning models ([14], etc. can be developed to study the effects of electronic trading at more detailed levels.

V. Glossary

Elasticity : Price elasticity of demand at a point A ($\epsilon(A)$) measures the percentage change in quantity demanded resulting from a 1% change in the price i.e.

$$\epsilon(A) = \frac{\%Change(q)}{\%Change(p)} = \frac{\Delta q/q(A)}{\Delta p/p(A)} = \frac{dq}{dp}\frac{p_A}{q_A}$$

We can have the following cases:

1. If elasticity is less than -1 then demand is elastic. The demand at a point is elastic if if the percentage change in quantity demanded is greater in magnitude than the percentage change in price.
2. If elasticity is greater than -1, then demand is inelastic. We say that the demand at a point A is inelastic if the percentage change in quantity demanded is smaller in magnitude than the percentage change in price.
3. If elasticity is equal to -1 then demand has unit elasticity, i.e. the percentage change in quantity demanded is equal in magnitude than the percentage change in price.
4. A perfectly inelastic demand curve has elasticity 0, i.e. the quantity demanded does not respond to price change at all. If elasticity is greater than 0 it means that the demand increases with the increase in price. Both this cases never happens, so price elasticities are always negative.

Monopoly : A market where there is a single seller and many buyers is called a monopoly. In a monopoly the decisions of the monopolist have a noticeable impact on the buyers but no single buyer's decisions have any effect on the monopolist.

Oligopoly : Markets where more than one but not many sellers offers a similar or identical product to the buyers. There are some entry barriers for sellers to enter the market.The firms in an oligopoly are mutually aware and mutually interdependent.

Duopoly : Oligopoly with only two sellers is called a duopoly.

Collusive Oligopoly : The oligopolists could try to reduce uncertainties of competing with each other by jointly setting a price for their mutual benefit, or to collude. These formal collusive arrangements are called cartels. If collusion is informal, it is called a tacit understanding. When two collusive oligopolists have identical costs, they act like a monopoly, but divide the market equally between them. *Equilibrium* By equilibrium we mean *Nash Equilibrium* i.e. a situation in which each economic agent choose their best strategy given the strategies of others. No agent has an incentive to deviate from the the equilibrium point. *First Order Condition*: In our oligopoly market, each player's best strategy is to maximize her profit given the prices of other players. If the profit function ($\pi(x)$)is differentiable then the first order condition is

$$\frac{\partial \pi(x)}{\partial x} = 0.$$

Non-cooperative Equilibrium : A non-cooperative equilibrium is an equilibrium is an equilibrium at which the firms are doing well for them individually as they can and each firm makes its decisions independently of every other. Independently does not mean that a firm ignores the interactions present in the market. It means there is no collusion in the market. In case there is collision or binding agreements we will have *collusive equilibrium.*

Price-Competition Equilibrium : This is a non-cooperative equilibrium which arises in an oligopoly market of homogeneous good where we have

- Each firm chooses an observable price.
- Each firm chooses unobservable capacity.

Symmetric Equilibrium : Symmetric equilibrium is an equilibrium where the strategies of the players are symmetric. In the oligopoly market scenario we have considered this means the players have identical equilibrium prices, symmetric costs and market shares.

Comparative Statics : The examination of a change in outcomes in response to a change in underlying economic parameters is known as comparative statics analysis.

Pure Strategies : A strategy is a complete contingent plan, or decision rule that specifies how the player will act in every possible distinguishable circumstance in which she might be called upon to move. A pure strategy specifies a deterministic choice at each of such circumstances.

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