

Welfare Implications of Secondary Electronic Markets

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Abstract

We develop a game-theoretical framework to investigate the competitive implications of Consumer-to-Consumer electronic marketplaces, which promote concurrent selling of new and used goods. In many e-marketplaces, where suppliers cannot directly use second-hand goods for practicing inter-temporal price discrimination, the threat of cannibalization of new goods by used goods become significant. We examine conditions under when it is optimal for suppliers to operate in such markets, explaining why used goods markets may not be detrimental for them. While a monopolist supplier is worse off in the presence of a secondary market, competition can in fact make it better off. The presence of used good markets provides an active outlet for some consumers to sell their second-hand goods. This leads to two countervailing effects and the net result for suppliers is contingent upon different parameters. Overall, for a wide range of parameters, there is an increase in social welfare from establishing such secondary markets.

Keywords: *Used Goods Resale, Quality Degradation, Supplier Competition, Budget Constraint, Game Theory, Electronic Markets*

1. Introduction

“Amazon's Used-Book Sales Upset Authors” - *New York Times*, April 10, 2002

“Guild Recommends De-Linking from Amazon” - *The Author's Guild*, May 2002.

The recent attempts of some online retailers to sell used books using their C2C e-marketplace mechanisms has elicited a considerable amount of attention. Judging from the headlines quoted above, it is clear that this practice of online used book sales by both merchants and individuals has not gone done well with the publishers. E-tailing giant Amazon.com is fuelling the trend much to the dismay of publishers and suppliers of other goods. According to publishers, Amazon's high-profile dissemination of used copies eats into their often limited royalties and shortens how long they have to generate new-book sales. This has prompted fears that publishers and suppliers will be forced to boost the prices of new products, in order to extract as high a price as they can, during the one-time sale of their product. Amazon however welcomes the traffic that's generated and the commissions it earns. A recent Wall Street Journal article (July 22, 2002) reports that the roughly equivalent amount of raw profit in each case is why Amazon says it doesn't really care whether it sells a good from its warehouses or through independent merchants. In fact, secondhand goods are proving to be a

money-spinner for Amazon, and the e-commerce site is expanding its policy of paying commissions to its affiliate Web sites to include the sale of used goods. No longer restricted to books, this matchmaking has spread to CDs and even DVDs.

A salient feature of some of these products is that once bought, many consumers derive only a limited utility from keeping them and are willing to resell them, if the transaction costs are negligible. The used good e-market provides access to those consumers who cannot afford to buy the new goods while it offers current owners an outlet to dispose used goods which still have market value and from which they have already derived their utility. Because of such concurrent selling of new and used goods on the Internet, a fundamental issue here is the strong possibility that used goods can cannibalize the sales of new goods. Conventional wisdom and prior research (Miller 1974) suggests that when suppliers do not draw any royalties from the used good sales, the opening of secondary markets will force them to increase the new good prices in order to extract the maximum possible profit from the onetime sale of a new good. In this paper we attempt to provide some alternate rationale to show that new good prices need not increase in the presence of second-hand markets.

1.1 Research Question and Prior Literature

Does the sale of used goods hurt or benefit suppliers when they cannot accrue any direct profits from secondary market sales? What is the impact of the quality of used goods on new good prices, suppliers' profits and consumer surplus? How does the strategic variable of used good commission impact profits and prices?

The nature of durable goods markets has long been an active research subject in Economics. The difficulty of maintaining the monopoly power on durable goods is due in part

to the problem of time-inconsistency, first pointed out by Coase (1972). However, after the early confirmations of the conjecture, other situations were described in which the Coase conjecture does not hold, such as in Kahn (1986). Rust(1986) solves for consumer behavior and prices for used goods in a durable-goods market, with stochastic depreciation. Anderson and Ginsburgh (1994) study how adverse selection would affect the equilibrium in the used- goods market. Waldman(1997) shows how the monopolist could benefit from explicitly interfering with the used-goods market, e.g., through imposing a variable transaction fee on buyers of used goods. Porter and Sattler (1999) introduce a transaction cost for private sellers of used goods, although the manufacturer in their model does not incur a disposal cost. Huang et al, (2001) highlight how consumers also need to worry about time-consistency in their own decision making.

The success of used goods e-marketplaces such as that promoted by Amazon, motivates the need to go beyond the existing models. Constructing, a comprehensive model that can simultaneously accommodate commonly observed phenomena such as active secondary markets, heterogeneity in consumer preferences, endogenous demand functions, quality depreciation and the element of product substitutability is the focus of this paper.

2 Model

The model consists of two suppliers, S_A and S_B , selling goods A & B respectively, through one common retailer, to a unit mass of consumers. The product i , ($i \in A, B$) that is marketed by each supplier is a durable that provides two periods of service. The good is new when it is marketed in period 1 and the same good is classified as used in period 2. In period 1, only new goods are available. In period 2, the retailer opens a used

good market where consumers can buy and sell used goods with minimal transaction costs, set to zero without loss of generality. The retailer sells both the goods, A and B, supplied by each of the respective suppliers. Whenever a consumer sells the used good, the retailer gets a commission k_u per used good sold while the remaining $(1 - k_u)$ goes to the consumer. Similarly it gets k_N per new good sold, with $(1 - k_N)$ going to the supplier. Without loss of generality, we also assume that the marginal cost of each good for the suppliers is symmetric and set to zero.

Consumers are modeled as utility maximizers. Let θ be a consumer's valuation for a good, where θ in $[0, 1]$. The type parameter θ indicates the heterogeneity in a consumer's marginal valuation for quality. For any given quality, a consumer with a higher θ is willing to pay more for the product than one with a lower θ . This type of consumer heterogeneity has been widely employed in marketing and economics literature (Moorthy 1988). Let 1 denote the quality of the new good and q denote the quality of used good in period 2, where $0 < q < 1$. Thus q can be interpreted as the degree of inter-temporal quality degradation of the new good over two periods. If a consumer purchases a product of quality q at price p , his utility is $U(\theta) = \theta q - p$.

In our model there are two types of consumers, within the continuum of valuations in each market. Type A consumers have θ valuation for good A and $\alpha\theta$ evaluation for good B where $\alpha \in [0, 1]$. Similarly, type B consumers have θ valuation for good B and $\alpha\theta$ valuation for good A. α is the degree of consumers' affinity for the other product such that higher the value of α more intense is the competition between the two suppliers for inducing the consumers to buy their goods. When $\alpha = 0$, consumers strictly prefer the specific good i in (A,B) according to their respective types, $i \in (A,B)$. However, when $\alpha > 0$, consumers would have an incentive to buy both the goods as long

as it gives them a positive surplus. We also impose an implicit budget constraint BC for the consumers in the form of disposable income for goods. Having bought a new good in period 1, consumers can either hold on to a used good or sell it in the market place in the second period. Intuitively, we would expect that for the same used good, a consumer holding the good will derive less utility than a used good buyer. Therefore, we assume that while the buyer of a used good derives a utility of q from consuming the good the holder of the used good derives a utility of h , where $h < q$. To motivate this discussion, consider a good such as a DVD or a fiction novel. Once a consumer has seen the movie or read the novel, her utility from the content per se, of the product might reduce considerably. As such she will derive a reduced utility from holding the good. Conversely, a buyer of the same used DVD or novel, can derive a much higher utility from the content of the good.

The game is modeled as a multi-stage process across two periods. We consider a Subgame perfect equilibrium of this game using backward induction. First suppliers choose optimal new good prices simultaneously. Then two events occur simultaneously. Market forces determine the optimal price of used goods from clearance conditions. At the same time, consumers choose a combination of strategies to maximize their surplus over two periods and demand is realized.

3 No Secondary E-Marketplace

We begin with modeling the case when used goods are absent. Note, that we have a duopoly market structure. Therefore, both suppliers can compete in prices to induce some consumers in each of their respective markets to buy both the goods. We proceed to show that this game has two equilibria: a standard non-competitive

monopoly equilibrium in which only one good is sold and a competitive equilibrium such that there exists a segment of consumers in each supplier's market who buy both new goods, despite the absence of a used good market.

3.1 Non-competitive equilibrium

Since there is no "used good market", consumers buy the good in first period and hold it in the second period. Let's denote the price of the new good in the absence of a used good market as p_n . This ensures that when the supplier sells their goods at monopoly prices, buyers have enough income to buy it. From the Incentive Compatibility (IC) and Individual Rationality (IR) constraints, consumers of both types in both markets, buy a good as long as $\theta(1+h) - P_N > 0$.

Hence the demand for a new good (both A and B) is $D(P_N, q) = 1 - \frac{P_N}{1+h}$. The profit for each

supplier, $\pi_s = (1 - \frac{P_N}{1+h})(1 - k_N) P_N$ from which

the optimal price is $P^*_N = \frac{1+h}{2}$. At this price,

each supplier makes a profit of $\pi_s = (\frac{1+h}{4})(1 - k_N)$

) while the total profit of the retailer from both

the markets is of $\pi_r = (\frac{1+h}{2})(k_N)$.

Lemma 1 : *For all $\alpha \in (0,0.61)$, there exists a symmetric pure strategy Nash equilibrium such that both suppliers offer the monopoly price (P^*_N, P^*_N) . In this equilibrium, consumers buy only one good.*

In the case of new goods, the profit maximizing price for the retailer and suppliers is the same. In case of used goods, as we show later, strategies for the retailer and suppliers change because while the retailer still gets a commission for each used good sold, the suppliers do not. It is this differential incentive for used good sales between suppliers and retailers and the consequent implications for equilibrium profits that we explore in this paper.

3.2 Competitive Equilibrium

In the previous equilibrium, we showed that both the suppliers simultaneously offer monopoly prices and consumers only buy 1 good. Suppose both suppliers decide to deviate from their monopoly prices p_m and get some of the type i (j) users to buy good j (i) and vice-versa. Supposing S_A (S_B) offers price P_A^{low} (P_B^{low}) $< P_N$ such that in type B (A) market, some consumers find it incentive compatible to buy both good A and B at lower prices as long as it satisfies their Individual Rationality (IR) constraint. Hence the type B (A) market gets split into two segments, such that the higher willingness to pay consumers buy their preferred good B (A) and good A (B) while the remaining buyers buy only good B (A). As is immediate, all type B consumers between 1 and θ_1 also buy from S_A . This situation is depicted in the figure below.

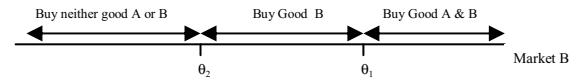


Figure 1: Market Segmentation in Accordance with Consumer Buying Strategies

Lemma 2: *When suppliers can sell two goods to some consumers, the optimal price and supplier*

profits are given by $\frac{(1+h)\alpha}{1+\alpha}$ and $(1-k_N)\frac{(1+h)\alpha}{1+\alpha}$ respectively.

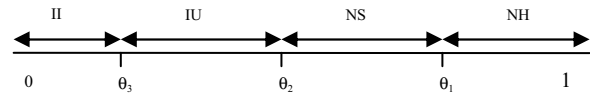
Note that in order for consumers to buy both goods they should have a disposable budget constraint (BC) equal to $2\frac{(1+h)\alpha}{1+\alpha}$. We proceed to show that this budget constraint is significantly lowered due to the establishment of secondary electronic markets and in the long term, it is this feature this will in lead to an increase in supplier profits in the presence of used good markets.

4 Retailer establishes a Secondary E-Marketplace

One major goal of the paper is show that for a finite budget constraint, users can buy only one good in the absence of a used good market. But in the presence of used good market, for the same budget constraint, some users can buy both goods. Further, when transaction costs are low like on the Internet, the budget constraint for which this behavior holds will be milder than when there are significant transaction costs as in the offline world. At the beginning of each period, when consumers evaluate their needs over the two period horizon, they can follow one of the five independent strategies laid out below. Let N^i , H, S, U and I denote a single period action, corresponding to buying a new good of type i , holding onto a used good, selling a used good, buying a used good and remaining inactive by not buying any good.

4.1 Monopoly Revisited

In the absence of competition, that is, when $\alpha = 0$, consumers always buy their preferred good according to the type of the market to which they belong. That is consumers of type A(B) buy only good A(B). The figure below describes the segmentation of the market based on the consumer action strategies. Let P_N and P_S denote the new good and used good prices, respectively. Hence the corresponding utilities derived from various action strategies are as follows:



1. (NH) Buy new good in period 1 and hold onto it in period 2 : $\theta(1+h) - P_N$
2. (NS) Buy new good in period 1 and sell it in period 2 : $\theta - P_N + (1 - k_u) P_S$
3. (IU) Remain inactive in period 1 and buy used good in period 2 : $\theta q - P_S$
4. (II) Remain inactive in both periods : 0

By equating the IR and IC constraints based on these 4 strategies, we derive the three indifferent points θ_1 , θ_2 , θ_3 which define the consumer market segments. It is important to recognize that in our model, based on suppliers' pricing strategies, the number of consumers in these groups will emerge endogenously. Since the used good market is competitive, the price of used goods, P_S will also be endogenously determined. This ensures that clearance conditions will equalize demand and supply of used goods at all times. By equating the demand of used goods with the supply of used goods, we get the market clearing second period price. Hence the supplier's profit equation is given by

$$\pi_S = (1 - \theta_1 + \theta_1 - \theta_2)(1 - k_N)P_N$$

We find that the suppliers' profits decrease with the establishment of an used goods market while the retailer's profits increases. The presence of an active used goods market creates competition for new goods because the option of buying used goods is now incentive compatible for some consumers who would have bought new goods before. This enhanced competition forces suppliers to decrease the new good prices in order to remain competitive with used goods. Recall that the supplier cannot derive any benefit from the sale of used goods, since all the proceedings from the sale of used goods (i.e. the commission fees) are shared between the retailer and the consumers. The price of new goods p_n decreases from the case when there is no used good market. With market share remaining unchanged this leads to lower profits for the supplier. On the other hand, if we were to compare the profits of the retailer, we observe that the retailer's profits increase by opening up of the secondary electronic market. The loss from the reduced profits from the NH and NS segments is more than offset by the gain from used good sales in the IU segment. Therefore, it is immediately clear that Amazon always has had an incentive to establish a used good market because it is always better-off. Interestingly we observe that for a monopoly supplier the quality of used goods does not influence the number of new goods sold. This is because the "implicit quality degradation cost" borne by consumers is proportional to the valuation of the consumers for the original good, θ and hence the new good price adjusts endogenously. This leads consumers to self-select in such a way that although the supplier loses some new good sales in the NH segment, it makes up for those lost sales in the NS segment and thus the total segment of new good buyers remains at one-half.

Proposition 1 *(i) The optimal new good price and supplier profits always decrease with used*

good quality q but increase with used good holding utility h . (ii) The optimal used good price increases monotonically with both the used good attributes, q and h . (iii) The optimal new good and used good price increases monotonically with an increase in the used good commission, k_u . (iv) The establishment of a secondary used-good marketplace leads to an increase in Consumer Surplus. (v) Supplier profits decrease with used good commission k_u .

When the used good price increases due to an increase in quality q , then the supplier's best response is to decrease p_n to compete head-to-head with used goods. But when the used good price increases due to supply considerations like changes in k_u or h , then the supplier's best response is to increase P_N . Our model suggests that suppliers gain if consumers derive a higher value from holding the new good. The intuition behind this is that, with an epsilon change in h , although there is no change in the total number of new goods sold (NH+NS), there is a reallocation of consumers between the NH and NS segments. Since the utility of the NH segment increases with h , the supply of used goods decreases due to the larger NH and smaller NS segment. Since the demand of used goods does not change, the reduced supply of used goods leads to an upward thrust on the used good prices which in turn causes the new good price to increase as well. The increase in prices, with an unchanged total new good demand, results in an increase in supplier's overall profits with increasing h .

We show that ex-post consumer welfare increases with the establishment of used goods e-markets since there is a new segment of used good buyers who are a pure addition to the total number of existing new good buyers. These consumers could not afford to buy

new goods earlier but are now able to at least afford used goods. Additionally new good buyers gain from reduced new good prices and this increases their surplus. As k_u increases, consumers get less utility from selling the used good, compared to holding it. Hence the NH segment increases in size while the NS segment shrinks in size. While the supply of used goods shrinks, the demand remains unchanged. This causes the used good price to increase, with k_u . However with an increase in P_S, P_N also increases which puts a downward thrust on demand for new goods. Consequently this leads to a decrease in supplier profits with increasing k_u .

4.2 Duopoly : Inter - Supplier Competition

Will the suppliers gain or lose if the captive consumers in their own markets, also desire to buy the goods of the other supplier that is, from their competitors? In this section, we proceed to answer this question by introducing the element of competition. Since $\alpha > 0$ now, there will always be some consumers who will buy one good each from both the suppliers, as long as it gives them a positive surplus. This leads to the creation of a new segment which we term as NSN. The dominant consumer strategies and corresponding utilities are as follows :

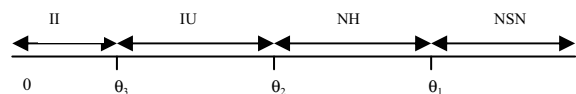


Figure 3: Consumption classes by Consumer type θ in Market $i, i \in (A, B)$

Proposition 2 *Consumers in $(1, \theta_1)$ will follow N^iSN^i , consumers in (θ_1, θ_2) will follow N^iH , consumers in (θ_2, θ_3) will follow IU^i and those in $(\theta_3, 0)$ will follow II .*

All consumers from 1 to θ_1 create the supply 'S' of used goods. All consumers from (θ_2, θ_3) create the demand 'D' for used goods. Therefore,

by equating D and S, we get the market clearing used good price P_S^* . The optimal new good price P_N^* can be derived from the supplier's profit equation, after substituting for P_S^* . Note that the new good sales occur in first two segments, that is, in the NSN and NH segments. Also since the NSN segment in both the consumer markets, i and j , buys from both the respective suppliers, each supplier gets twice the NSN segment of the market. Hence, the supplier's profit equation is

$$\pi(S) = 2(1-\theta_1)(1-k_N)P_N + (\theta_1 - \theta_2)(1-k_N)P_N$$

Whether, monopoly or competition benefits suppliers, is determined by α . There exists a critical value of α_c such that compared to the monopoly regime, supplier profits increase with the introduction of inter-supplier competition, for any $\alpha > \alpha_c$. Thus for any α which exceeds the critical value, suppliers make higher profits despite having to implicitly compete with each other. The NSN segment thus plays a critical role in this scenario. The existence of this segment leads to 2 countervailing effects for the suppliers. In order to incentivise consumers in the other market j , to buy their less preferred good, supplier i will need to lower its price. This causes profits to fall. However, it is precisely this reduction in price that leads to additional sales from the NSN segment of supplier j , since these consumers can afford to buy both the goods. This is the "market expansion effect" which puts an upward thrust on the profits. These two countervailing forces, lead to a situation wherein, depending on the value of α , suppliers end up making higher profits than in the monopoly case.

Proposition 3 *If consumers have an implicit budget constraint BC such that, $2P_N^* - (1-k_u)P_S < BC < 2P_N^*$, then suppliers' profits increase with the establishment of an used*

goods market, compared to the no used good market scenario.

The intuition for this is that offering a market for used goods provides some consumers an incentive to sell their good. This increases their disposable income, thereby allowing them to buy an additional new good. In particular, the NSN segment is now able to buy the second (less preferred) good from the other supplier as well. This behavior is reinforced by the fact that due to the two effects outlined earlier, the price of the new good also decreases in comparison to the scenario in which the used good market was absent, thereby enabling a larger mass of consumers to buy new goods.

Thus, the important economic effect of the C2C electronic exchanges is that it creates a segment of consumers, NSN which is able to buy the second new good by virtue of the extra income through sales of their used good. In effect the used good option is like a rebate coupon which reduces the net price that consumers actually pay for the new good. That is, the selling price of the new good P_N in period 2 effectively becomes equal to, the sum of the new good price in period 1 minus the expected used good price in period 2. This intuition is corroborated by the fact that as used goods commission charged by the retailer k_u decreases, supplier profits increase because consumers in the NSN segment then have a higher disposable income, enabling them to buy both the new goods.

5 Conclusion and Implications

Information technology facilitates the delivery of many products and services over newly emerging secondary electronic networks. As these electronic networks develop and mature, it will be important to quantify their impact on supplier & retailer profits and consumer welfare. There has been a lot of strife between suppliers and

retailers in the recent past, over the damage which such secondary electronic markets are supposedly causing to the profits of suppliers. The general consensus is that since used good sales cannibalize new good sales, secondary e-markets established by brokers like Amazon and E-bay are necessarily a bane for suppliers. Using a game-theoretic model, we investigate the competitive implications of these newly emerging e-marketplaces on consumer surplus, suppliers' prices and profits. The purpose of our work is to highlight some of the important economic properties of secondary C2C e-marketplaces which are cropping up on the Internet, and causing a furor amongst suppliers in many industries such as book publishers and music companies. The insights from this model help to explain several interesting market phenomena including (i) the profitability of concurrent sales of new and used goods i.e., why used goods markets may not be detrimental for suppliers, (ii) why an increase in the used goods quality may not necessarily be a cannibalization threat for new goods and (iii) the overall increase in social welfare that accrues from establishing such secondary electronic markets.

We show that the major motivation of the retailer to establish a used good market is to capture additional surplus from those consumers who were shut out of the new good market. This enables it to effectively practice price discrimination. Our model also highlights that compared to a monopolistic market, inter-supplier competition can be beneficial to suppliers in the presence of a secondary market, rather than being harmful. Thus, we show that contrary to popular perceptions, the presence of a used good market is beneficial for suppliers too, under a relatively wide range of conditions. When merchandized as a deep discount option for a new good, secondary electronic markets offer an extremely attractive option to increase

the disposable income and thereby stimulate more new goods sales.

Our analysis has implications for durable goods in which suppliers sell through intermediaries but cannot accrue any direct gains from secondary markets. As long as there is more than one supplier, and consumers are willing to buy another new good, a secondary market can be useful for suppliers. In the light of the ruckus created by publishers over Amazon's practice of using their marketplace mechanism to sell used goods and a call for government intervention in such markets, this result can have some public policy and managerial implications. Based on the result that total welfare increases, our model suggests the strong possibility of a win-win situation for suppliers, retailers and consumers alike from the establishment of used-goods marketplaces.

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6. Appendix

Proof of Lemma 1

Suppose S_A (selling book A) decides to deviate from its monopoly price P_N and offers price $P_1 < P_N$. Then in its own market A, demand D_1^A for good A from type A users at P_1 is $1 - \theta^A =$

$$1 - \frac{P_1}{1+h}. \text{ In the type B market, some consumers}$$

will find it incentive compatible to buy their less preferred good A at lower price as long as it satisfies their (IR) constraint. Therefore we have,

$$\theta^B (1+h) - P_N > \alpha \theta^B (1+h) - P_1 \text{ and } \alpha \theta^B (1+h) - P_1 > 0. \text{ Hence demand } D_1^B \text{ for good A from type}$$

$$\text{B users at } P_1 \text{ is } = \theta^B - \theta^A = \frac{\alpha P_N - P_1}{\alpha(1+h)(1-\alpha)}.$$

Thus total demand $D(P_1) = D_1^A + D_1^B$. Hence the profit equation is

$$\pi_S = P_1(1 - k_N) \left[\left(\frac{1}{1+h} \right) \left(\frac{\alpha P_N - P_1}{\alpha(1-\alpha)} - P_1 \right) + 1 \right].$$

Optimizing the profit equation after substituting the monopoly price P_N gives us the optimal price

P_1^* . Substituting P_1^* in we get the optimal supplier profit equation as $\pi_S(P_1) = \frac{(1-k_N)(2-\alpha)(1+h)}{(16-\alpha)}$. Comparing this to the

monopoly profits equation and solving for positive values of α provides the critical value of $\alpha = 0.61$ beyond which S_A finds it profitable to offer P_1^* .

Proof of Proposition 1

The first derivative of new good prices with respect to quality q and α , are given by $\frac{\partial P_N}{\partial q} < 0$ and $\frac{\partial P_N}{\partial \alpha} > 0$. The optimal supplier profit

equation is

$$\pi_S(P_N, P_S) = (1-k_S) \frac{(1-k_U)(1-q) + h(1+(3-2k_U)q)}{(h+q-k_Uq)}$$

and retailer's profits

$$\pi_R(P_N, P_S) = \frac{k_S \pi_S}{1-k_S} + \frac{hk_U q((1-k_U)q-h)}{2(h+q-k_Uq)}.$$

Comparing with the no used good market supplier profit with consumers buying only one good, the difference in retailer's profits is > 0 and that in supplier's profits is < 0 . (iii) Consumer Surplus (CS) in the absence of used goods is

$$\text{given by } CS_N = \int_{1/2}^1 \theta + \theta h - P_N = \frac{1+h}{8}. \text{ Total}$$

Consumer Surplus (CS_T) from the NH, NS & IU segments is given respectively by

$$\int_{\theta_{12}}^1 \theta(1+h) - P_S + \int_{\theta_2}^{\theta_{12}} (\theta - P_N + P_S(1-k_U)) + \int_{\theta_3}^{\theta_2} (\theta q - P_S).$$

We find that the difference $CS_T - CS_N =$

$$\frac{((1-k_U)q-h)(3(1-k_U)q^2-3h^2+hk_U(5q-4k_U))q}{8(h+q-k_Uq)^2} > 0.$$

Proof of Proposition 2

Apart from the four strategies stated in the Proposition, consumers could adopt any of the 2 following strategies: NSU and IN. We shall now proceed to eliminate these two strategies.

- (i) Utility from following a NSU strategy $U^{NSU} = \theta(1+\alpha h) - P_N - P_S + (1-k_U)P_S$
- (ii) Utility from following a IN strategy $U^{IN} = \theta(1+h) - P_N$

Comparing NH and NSU, we find that $U^{NH} - U^{NSU} = \theta(h - \alpha h) + k_U P_S > 0$. Hence NSU $<$ NH is proved. Also utility from IN = $\theta(1+h) - P_N$, which is the same as that from NH. This leads to the 5 possible strategies as stated in the Proposition.

Proof of Proposition 3

From the demand supply clearance condition for used goods, we get $P_S(P_N)$. Plugging this back in equation (9) and maximizing it w.r.t. price P_N , we get $P_N \{\alpha^*\}$. This in turn gives us $P_S \{\alpha^*\}$. Taking the second derivative of the supplier's profit equation, we find that

$$\frac{\partial^2 \pi_S}{\partial P_N^2} = -(1-k_N) \frac{2(1+\alpha+h\alpha) - k_U q}{(1-k_U)(1-q)q + \alpha - h^2(1-\alpha) - h(1+k_U q - q - 2\alpha)}$$

. Since $k_U < 1$, it is immediate to show that the equation < 0 . This proves that $P_N \{\alpha^*\}$ is a maxima and hence $BC^U < BC^N$.