# Inequality, Product Durability and the Adoption of New Technology Products.[1]

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**Abstract**

The analysis highlights how inequality and the cost of producing durability influence the degree to which new technology products are adopted in an economy. It is shown that redistribution may both increase and lower technology dispersion. If inequality is large at the outset, redistribution may lower technology dispersion. On the other hand, if inequality is low at the outset, more redistribution will be beneficial for the adoptation of new technology products. For intermediate cases the effect from redistribution is ambigious.

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# 1 Introduction

The last few decades have developed a vast literature on how inequality affects economic growth.[1] While theory seems to suggest that inequality benefits growth[2], this is largely not supported by empirical studies. Instead, many recent empirical studies find a positive correlation between equality and economic growth.[3] In theory, the standard approach was that inequality is good for incentives and therefore also good for growth. Newer theoretical contributions has focused on the role of inequality on investments (both in physical and human capital) and thereby economic growth.

Also it has long been recognized that increases in technical efficiency play a critical role in long-term growth. This has lead researchers to focus a lot of attention on the determinants of R&D activities, and the ability that an economy has to develop new technology products. Substantial attention has been devoted to the determinants of the adoption of already existing new technology products. It seems like an undisputed fact that even if high technology products are readily available to most national economies through international trade, there are huge differences in the degree to which national economies are able to adopt new technology products. Many explanations for this phenomenon have been proposed in the literature. The literature has focused on factors such as differences in levels of human capital, trade openness vis-a-vis the OECD, property rights protection, rates of investment per worker, shares of agriculture and manufacturing in GDP, and the size of government[4]. This paper aims at adding to the existing theoretical literature on technology adoption by analyzing the potential effect that inequality has on the ability to adopt new technology products.

[1] See Aghion et al. (2001) for an excellent survey of this literature.

[2] See for example Bourguignon (1981) and Rebelo (1991).

[3] For a review of this literature, see Benabou (1996). Alesina and Rodrik (1994) and Persson and Tabellini (1994) offers possible explanations for the empirical findings.

[4] See Caselli and Coleman II (2001) for a case study concerning computer adoption.

We know that wage inequality is on the rise in most rich countries[5], but why should really inequality matter for the degree of technology adoption in an economy? Certainly a country's average income may matter, and many empirical studies confirm this. Higher average income (e.g. as measured by GDP per worker) tends to increase the rate of technology adoption (Caselli and Coleman II, 2001). One obvious explanation for this is that higher income potentially increases the profitability of distributing and selling high technology products. If so, inequality should affect technology adoption as well, because the distribution of wealth or income among consumers could affect the optimal pricing policy of the sellers of high technology products. Behind a certain measure of average national income, incomes may be more or less evenly distributed. If income distribution is fairly even, sellers of new technology products may pursue a low price strategy for the 'mass market', whereas if incomes are fairly uneven distributed, the same sellers may find it more profitable to pursue a high price strategy for the high-end of the market. Hence, inequality may have important effects on how new technology is dispersed in an economy.

In addition, the pricing strategy of sellers may be influenced by whether or not consumers have access to imperfect substitutes at the time of the potential introduction of a new technology product. For instance, it might be that some consumers own a perfectly functional old technology product that is an imperfect substitute to the new technology product. Whether or not consumers have access to an imperfect substitute may in turn depend on choices made my earlier generations of producers regarding quality (durability),[6] and the sellers' pricing policy. If some consumers

[5] See the Economist, September 11th-17th 1999, p. 95.

[6] The issue of product durability in itself has received some attention in the literature, although the question is controversial. For instance, uneconomical short durability (planned obsolescence) is sometimes claimed to be a strategy intended to make consumers repurchase too frequently. Also, as pointed out by Coase (1972) wastefully short durability may be the result of a monopolist wanting to escape from the time inconsistency problem arising when he produces a durable and consumers are patient (see Stokey (1981), Bulow (1982,1986), Gul et. al. (1986) and Olsen (1992)). Also, as pointed out by Fishman et al. (1993) producing long durability products may be a strategy to prevent entry of potential newcomers with a new technology. Here we abtract from these

already have access to an imperfect substitute to a new technology product, this will per se tend to lower their willingness to pay for the new technology. For instance, whether or not you already have a functioning personal computer may affect your willingness to pay for the latest state-of-the-art technology product. If, on the other hand, it is possible for these consumers to dispose old technology products in a second-hand market at a reasonable price, this might increase their willingness to pay for the new technology. Finally, whether or not a second-hand market for old technology products will arise, may depend on the income distribution in the economy.

Inequality and redistribution thus, may affect new technology adoption in a non-trivial way and in this paper mainly through two channels; i) the pricing policy of the sellers of new (and old) technology products, and ii) the emergence of efficient 'second-hand markets' for old technology products.

We analyze a simple two-period model with two types of consumers where one group have potentially higher income (or wealth) than the other. In the first period, there are incumbent firms that produce and sell 'old' technology products and that make choices of pricing policy and product durability. In period two, new firms arrive that may either continue to sell the old technology or decide to market and sell a new technology product. Evidently, firms' choices on durability and technology are linked to their profit opportunities. These, in turn, are linked to the cost of producing durable products versus more short-lived products, the size of the innovation of the new technology and the income distribution in the economy.

We show that from a given level of inequality, redistribution may both increase or lower the incentives to disperse the new technology. There are mainly two opposing forces at play. The crucial factors are whether inequality is high or low at the outset and the costs of producing durable products. If the cost of durability is high, incumbent firms will produce relatively short-lived products. This is per se

considerations.

beneficial to newcomers selling new technology products. In this case if inequality is high, redistribution will hurt the incentives to sell the new technology and vice versa if inequality is low. The reason is that if inequality is high, all firms will sell to high demand consumers only, and redistribution will lower these customers' willingness to pay for the new technology. Similarly, if inequality is low, all firms will wish to sell to all consumers, and redistribution will increase the low demand consumers willingness to pay.

In contrast, when the costs of durability is relatively low, incumbent firms will produce long-lived products. Hence, when introducing a new technology, some or all consumers may posses an imperfect substitute. In this case, when inequality is high a market for old technology products may arise. If only high demand consumers have access to the substitute and the new firm will sell to these customers only, an efficient market for old technology products will indeed arise. Due to this, the introducing firm is able to extract the high demand consumers full valuation for the new technology. If so, redistribution is bad for the incentives to introduce the new technology, because it will lower the high demand customers' willingness to pay. When inequality is intermediate, a situation may arise in which incumbent firms have sold durables to the high demand consumers only, but that the new firms may want to try to attract the low demand consumers as well. If so, the sellers of the new technology must introduce the product at a very low price in order to discourage the consumers to trade the old technology. Consequently, the new firm is now only able to charge a price equal to the low-demand consumers incremental valuation for the new technology. With redistribution the incremental valuation of low-demand customers is increasing, hence redistribution is beneficial to the incentives to introduce the new technology. Finally, when inequality is low, all firms will choose to sell to all customers. Hence, to the firms selling the new technology, there is no second-hand market to worry about. The new firms can now extract the incremental valuation of the low-demand customer from all customers

and in this case redistribution is beneficial.

# 2 The model

Consider two (groups of) consumers having identical tastes and (potentially) different income levels[7]. There are two periods, $t = 1, 2$. Let $V_i^t$ be consumer $i$'s per period willingness to pay for a product with a given technology, and let $p^t$ be the corresponding price. The per period surplus for a consumer purchasing the product then is:

$$U^t \equiv \begin{cases} V_i^t - p^t \text{ from buying the technology in period t} \\ 0 \text{ otherwise} \end{cases}$$

For simplicity we will assume that there are only two firms. In period 1 only firm 1 is present.[8] Firm 1 can produce and sell an 'old technology' (O) product, but can choose between producing a durable (D) or a nondurable (ND). A nondurable lasts in one period only, whereas a durable lasts in two periods. The maximum per period willingness to pay for old technology is $\alpha v^O$ for consumer 1 and $(1-\alpha)v^O$ for consumer 2. I assume that $0 < \alpha \leq \frac{1}{2}$, meaning that consumer 1 (potentially) has the lowest willingness to pay. It is assumed that willingness to pay reflects the consumers' net income or wealth levels.[9] From now on I therefore denote consumer 1 as the low income consumer (LO), and consumer 2 as the high income consumer (HI). The lower $\alpha$, the larger income disparity (less wage compression, more inequality) there is in the economy. The constant marginal production cost of a nondurable is $c^{ND}$ (which I for simplicity normalize to zero) and of a durable $c^D > 0$. I assume that $c^D < v^O$, implying that the consumers' willingness to pay for a durable old

[7] For the sake of the argument it could also be a question of differences in wealth.

[8] The implicit assumption is that a producer of a given technology has monopoly in one period after which the technology is copied by rivals.

[9] The net income level can of course be influenced by taxes, hence redistributive tax policy will affect consumers' willingness to pay.

technology product under perfect equality ($\alpha = \frac{1}{2}$) is sufficiently high to cover its production cost.

In period 2, a second firm arrives that potentially can sell a new technology product (N). Even if new technology products can readily be imported and sold by wholesalers and retailers in almost any country, there may be various reasons why sellers choose not to introduce a new technology product in a market. First there may be investments needed in order to manage sales of the new technology, there may be a need for market analysis, upgrading technical skills of the sales force, and changes in distribution systems may be needed. I therefore assume that selling the new technology product will require an investment $I$ for the seller.[10] The new firm is assumed to sell a nondurable (since the world ends after period 2), but can decide whether to sell the old technology product (at no investment) or start distributing the new technology product. If firm 2 chooses to sell the new technology this is worth $\alpha v^N$ to the LO-consumer and $(1-\alpha)v^N$ to the HI-consumer. I assume that $v^N > v^O$. When the difference $v^N - v^O$ is large, I will characterize the technology step from the old to the new technology product as a 'major' innovation, and when the difference is small the innovation is 'minor'.

If firm 1 could be active in both periods, it would when producing a durable in period 1 face the traditional intertemporal pricing problem (Coase (1972)). I wish to abstract from this issue, and therefore consider a situation where firm 1 disappears at the end of the first period. The sequence of moves is as follows: In period 1 firm 1 chooses between producing a durable or a nondurable and sets a price $p_1$. In the second period firm 2 chooses whether to sell the old or the new technology and sets its price $p_2$.[11] I assume that firms are not able to price discriminate between the

[10] Note that this assumption is not crucial. If there were no investment associated with selling new technology, all results would be the same. The incentive to market and sell the new technology is measured by the profit the seller can earn. A positive investment cost would only scale down this profit by a fixed amount..

[11] Obviously, when firm 1 is only active in period 1 this game is void of strategic interaction

consumers.[12]

The next subsections look at period 2 equilibria for every actions chosen by firm 1 and the consumers in the first period. Then I look at firm 1's optimal decisions in period 1.

## 2.1 Firm 1 has produced a nondurable

If firm 1 has chosen to produce a nondurable in period 1, firm 2 can choose to sell the old technology or the new technology (by investing $I$). If it chooses to sell the old product it can choose either to sell it to the HI-consumer exclusively (who has the highest willingness to pay) or to both consumers. If it sells to the HI-consumer it charges $p_2 = (1-\alpha)v^O$ and earns $\pi_2 = (1-\alpha)v^O$, and if it sells to both consumers it charges $p_2 = \alpha v^O$ and earns $\pi_2 = 2\alpha v^O$. If firm 2 chooses to invest and sell the new technology product, it has the same options. If firm 2 chooses to sell to the HI-consumer he will charge $p_2 = (1-\alpha)v^N$ and earns $\pi_2 = (1-\alpha)v^N - I$, and if he sells to both he will charge $p_2 = \alpha v^N$ and earns $\pi_2 = 2\alpha v^N - I$. By comparing these payoffs it follows:

**Proposition 1** *Assume that firm 1 has chosen to produce a nondurable in period 1. Then, if $\alpha < \frac{1}{3}$ firm 2 sells to the HI-consumer exclusively and sells the new technology if $I \leq (1-\alpha)(v^N - v^O)$. If $\alpha \geq \frac{1}{3}$ firm 2 sells to all consumers and chooses the new technology if $I \leq 2\alpha(v^N - v^O)$.*

**Proof.** It follows from the comparison of the payoffs in the text that when firm 2 sells the old product it will supply both consumers when $2\alpha v^O \geq (1-\alpha)v^O \Longrightarrow \alpha \in [\frac{1}{3}, \frac{1}{2}]$. If it chooses to sell the new technology it will sell to both consumers when

between firms 1 and 2.

[12] Second degree price discrimination would either involve som kind of non-linear pricing schemes or introducing different product qualities of the product. Non-linear pricing schemes are not very realistic in market for conumer durables, and I wish to abstract from quality issues in this paper.

$2\alpha v^N - I \geq (1-\alpha)v^N - I \Longrightarrow \alpha \in [\frac{1}{3}, \frac{1}{2}]$. It follows that for $\alpha < \frac{1}{3}$ firm 2 sells the new technology when $(1-\alpha)v^N - I \geq (1-\alpha)v^O$ or when $I \leq (1-\alpha)(v^N - v^O)$. When $\alpha \in [\frac{1}{3}, \frac{1}{2}]$ firm 2 supplies both consumers and sells the new technology when $2\alpha v^N - I \geq 2\alpha v^O$ or when $I \leq 2\alpha(v^N - v^O)$. ■

Firm 2 will sell to both consumers provided that the inequality is not too large. The reason is that when income disparity is large, firm 2 must set a very low price to induce the LO-consumer to purchase the product. Then it may be better to give up this consumer and sell only to the HI-consumer. Notice that in either case diffusion of the new technology is more likely to take place, for a given $I$ , the larger the innovation is. When there is relatively little income dispersion ($\alpha \geq \frac{1}{3}$), redistribution and larger innovations will make it more likely that firm 2 will invest and sell the new technology product. To see this it suffices to look at the critical value for the investment cost in this case. The reason why more equality benefits introduction of the new technology in this case is that it will increase the LO-consumer's willingness to pay for the new technology and therefore the price the firm can charge when selling to both consumers. When income dispersion is large ($\alpha < \frac{1}{3}$), the critical value of $I$ is decreasing in $\alpha$, meaning that redistribution will reduce the incentives to introduce the new technology. The reason is that less income disparity will reduce the HI-consumer's willingness to pay and hence the price that firm 2 can charge.

## 2.2 Firm 1 has produced a durable

Assume then that firm 1 has chosen to produce a durable in period 1. It now matters whether firm 1 has sold its product to only the HI-consumer or both consumers. When only the HI-consumer has purchased a durable a second-hand market for old technology may emerge following the introduction of the new technology.

### 2.2.1 Only the HI-consumer has a durable

When entering into period 2 the HI-consumer has the old technology yielding him $(1-\alpha)v^O$. In this case there are several options for firm 2. If firm 2 introduces the new technology there is a potential for a development of a second-hand market. Thus, one option is that firm 2 tries to attract both consumers to the new technology. To do so he must charge a low price ($p_2^L$) in order to destroy the incentive that the consumers have to trade in a second-hand market (HI can sell his old technology product to LO). Alternative, firm 2 can accept the existence of a second-hand market, charge a high price ($p_2^H$) and sell the new technology to the HI-consumer only. The third option, of course, is to not introduce the new technology and sell the old technology to the LO-consumer only.

If so, he sells the old technology to the LO-consumer at the price $p_2 = \alpha v^O$ and earns $\pi_2 = \alpha v^O$. If he invests, let $q$ denoted the second-hand price of the old technology that can be sold by HI to LO. Notice that we must have that $q \leq \alpha v^O$ for trade to take place. If HI sticks with the old technology he gets $(1-\alpha)v^O$ and if he sells the old technology at price $q$ and purchases the new technology he will get $(1-\alpha)v^N - p_2 + q$. Therefore, HI will sell his old product and purchase the new technology if $p_2 \leq (1-\alpha)(v^N - v^O) + q$. The LO-consumer can either purchase the second-hand old technology and get $\alpha v^O - q$ or buy the new technology and get $\alpha v^N - p_2$. Firm 2 can destroy the second-hand market by charging a price so that the LO-consumer is better off by buying the new product instead of trading in the second-hand market, i.e. $\alpha v^N - p_2 \geq \alpha v^O - q$, or $p_2 \leq \alpha(v^N - v^O) + q$. From this it follows that the maximum price firm 2 can charge and at the same time destroy the second-hand market is $p_2^L = \alpha(v^N - v^O)$. By charging this price, for any $q \geq 0$, LO will prefer the new technology. Therefore, at this price both consumers will buy the new technology and HI discards the old technology at $q = 0$. Firm 2 then earns $\pi_2 = 2\alpha(v^N - v^O) - I$.

At $p_2 \in (\alpha(v^N - v^O), (1-\alpha)v^N]$ trade will take place in the second-hand market at

price $q = p_2 - \alpha(v^N - v^O) > 0$. To maximize profits firm 2 charges $p_2^H = (1-\alpha)v^N$, HI sells the old technology product to LO at $q = \alpha v^O$ and purchase the new technology. Firm 2 earns $\pi_2 = (1-\alpha)v^N - I$. Then we have:

**Proposition 2** *Assume that firm 1 has produced a durable in period 1 and sold the product to the HI-consumer only. Then, in period 2 firm 2 introduces the new technology if* $I \leq max\left\{2\alpha\left(v^N - v^O\right), (1-\alpha)v^N\right\} - \alpha v^O$. *In this case, i) if* $v^N(3\alpha - 1) - 2\alpha v^O \geq 0$, *firm 2 sells the new technology to both consumers, and ii) if* $v^N(3\alpha - 1) - 2\alpha v^O < 0$, *firm 2 sells the new technology to the HI-consumer only.*

**Proof.** The critical investment cost follows from comparing the profit expressions in the text. Comparing firm 2's payoffs when he introduces the new technology yields that he will serve both consumers when $2\alpha(v^N - v^O) - I \geq (1-\alpha)v^N - I$, or when rearranging $v^N(3\alpha - 1) - 2\alpha v^O \geq 0$ which proves part i). Part ii) then follows immediately. ■

This result states that when the investment cost is sufficiently low, introduction of the new technology occurs. Whether or not a market for old technology will arise, depends on the price charged by firm 2. This in turn depends on the size of the innovation and the income disparity in the economy. When there is little income disparity, the innovation has to be very large to avoid the emergence of a market for old technology. Notice that when incomes are almost equal ($\alpha$ is close to $\frac{1}{2}$), it follows that firm 2 will sell the new technology to both consumers only if $v^N \geq 2v^O$. The reason is that when the size of the innovation is less, the HI-consumer that has the old technology is only willing to pay a small amount to acquire the new technology. Furthermore, the price firm 2 must offer for the new technology must be very small to destroy the incentive for trade in the second-hand market. In this case, it might be better to let the consumers trade, which will increase the HI-consumer's willingness to pay for the new technology product. Therefore, both consumers will acquire the new technology when income disparities are low ($\alpha$ is

close to $\frac{1}{2}$) and the innovation is major ($v^N - v^O >> 0$ ). We see that a necessary condition for being in this case is that $\alpha > \frac{1}{3}$, and the less income disparities are in this interval the smaller the innovation has to be. Necessary conditions for the dispersion of the new technology to both consumers are that $\alpha > \frac{1}{3}$ and $v^N \geq 2v^O$.

Trade in the second-hand market will arise when income disparity is large enough. A sufficient condition for being in this case is that $\alpha \leq \frac{1}{3}$. Notice, however, that the larger the innovation is the more inequality is needed to be in this case. Figure 1 below illustrates when firm 2 will sell to both or to HI only given that the new technology is introduced under the assumption of Proposition 2 ($v^O = 1$).

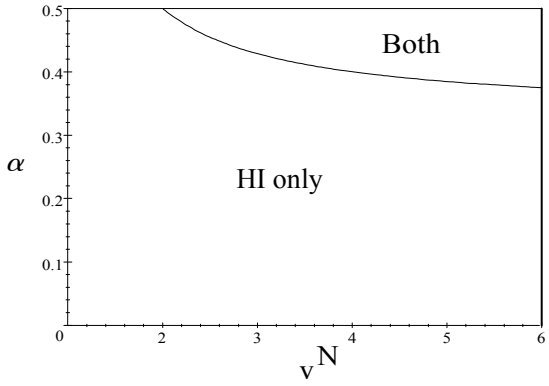


Figure 1: Who to sell to, size of innovation and inequlity.

We are now able to explore in more detail how redistribution influences the equilibrium choice of firm 2 in period 2 given that firm 1 has produced a durable and sold it to the HI-consumer only.

**Proposition 3** *Assume that firm 1 has produced a durable in period 1 and sold to the HI-consumer only. Then, redistribution may make introduction of new technology more or less likely. i) If the parameters are such that firm 2 would sell the new technology to both consumers, then redistribution increases the incentive to introduce the new technology. ii) If firm 2 would sell the new technology only to the HI-consumer, then redistribution will reduce the incentive to introduce the new*

*technology.*

**Proof.** >From Proposition 2 we have that firm 2 invests when

$$I \leq max\left\{2\alpha\left(v^N - v^O\right), (1-\alpha)v^N\right\} - \alpha v^O.$$

Suppose that $max\left\{2\alpha\left(v^N - v^O\right), (1-\alpha)v^N\right\} = 2\alpha\left(v^N - v^O\right)$, which implies that the critical investment cost is $\widetilde{I} = \alpha\left(2v^N - 3v^O\right)$. Differentiating this with respect to $\alpha$ yields $\frac{\partial \widetilde{I}}{\partial \alpha} = 2v^N - 3v^O$. From the text we know that to be in this case we must have that $v^N \geq 2v^O$, hence $\frac{\partial \widetilde{I}}{\partial \alpha} > 0$. Less income disparity makes introduction of the new technology more likely, which proves part i). If $max\left\{2\alpha\left(v^N - v^O\right), (1-\alpha)v^N\right\} = (1-\alpha)v^N \Longleftrightarrow \widetilde{I} = (1-\alpha)v^N - \alpha v^O = v^N - \alpha\left(v^N - v^O\right)$. This critical investment cost is clearly negative in $\alpha$,which proves part ii). ■

The essence of Proposition 3 is that major innovations will benefit from redistribution only when income disparity is small from the outset. The intuition is that redistribution increases firm 2's price when he sells to both consumers, but lowers his price when he sells to one consumer only. A firm that sells the new technology will therefore be more willing to sell to both consumers the less income disparity and the larger the innovation is. Increasing income disparity in such a situation will hurt the payoff from the firm's investment because he will have to lower his price in order to destroy the second-hand market.

We know that a firm introducing the new technology will be more likely to exclude low income consumers the smaller the innovation is and the higher income disparity in the economy. The price to attract both consumers in such a situation would have to be very low. Increasing income disparity from such a situation increases the price of the new technology to the high income consumer and reduces the price of the old technology, hence selling the new technology becomes more attractive both in absolute and relative terms.

The most interesting results so far is that more redistribution is good for large

innovations when incomes are fairly equal from the outset. If incomes at the outset is unequal, we have seen that redistribution may actually hurt the incentives to introduce the new technology.

### 2.2.2 All consumers have a durable

When both consumers have a durable from period 1, there is no incentive for the new firm to sell the old technology product. The open options for firm 2 are to introduce the new technology, and then either offer a low price to attract both consumers or to attract the high income consumer only. Notice also, that in this case there is no scope for a second-hand market, since all consumers already have the old technology. Intuitively, one should think that this will increase the penetration of the new technology. First, this will make exclusion of low income consumers relatively less attractive, because firm 2 need not worry about lowering his price to destroy the second-hand market when wanting to attract both consumers. Second, there is not any second-hand market effect on the HI-consumer's willingness to pay under exclusion of the LO-consumer.

Then we can show:

**Proposition 4** *Assume that firm 1 has sold a durable to both consumers in period 1. Firm 2 will introduce the new technology when:*

$$I \leq max \left\{ 2\alpha \left( v^N - v^O \right), (1-\alpha)(v^N - v^O) \right\}$$

*In this case, firm 2 will sell to both consumers when income disparity is low* ($\alpha \in [\frac{1}{3}, \frac{1}{2}]$) *and sell to the HI-consumer otherwise.*

**Proof.** The HI-consumer has $(1-\alpha)v^O$ and are willing to buy the new technology product iff $(1-\alpha)v^N - p_2 \geq (1-\alpha)v^O$, or when $p_2 \leq (1-\alpha)(v^N - v^O)$. Similarly, the LO-consumer purchases the new technology iff $\alpha v^N - p_2 \geq \alpha v^O$, or when $p_2 \leq$

$\alpha(v^N - v^O)$. Therefore, since $\alpha \leq \frac{1}{2}$ and if firm chooses to sell to only one consumer, this will be the HI-consumer, and firm 2 earns $\pi_2 = (1-\alpha)(v^N - v^O) - I$. If firm 2 decides to sell to both consumers he earns $\pi_2 = 2\alpha(v^N - v^O) - I$. Then the condition in the proposition follows directly. Provided that this condition is met, firm 2 will prefer selling to both consumers when $2\alpha\left(v^N - v^O\right) \geq (1-\alpha)(v^N - v^O)$, or when solving for $\alpha$ when $\alpha \geq \frac{1}{3}$. Since by assumption $\alpha \in [0, \frac{1}{2}]$, the result follows. ■

Whether or not firm 2 supplies the HI-consumer only or both consumers with the new technology hinges solely on the income distribution in the economy. When incomes are equally distributed, the firm supplies both consumers, and when incomes are unequally distributed only the HI-consumer purchases the new technology. Recall that when only the HI-consumer had the old technology we needed the innovation to be major in order to induce the firm to supply both consumers. This difference is the effect from the second-hand market. When all consumers has the old technology, the firm need not lower its price to destroy the second-hand market when he sells to both consumers. Therefore the only concern when considering to supply all consumers with the new technology is whether incomes are equal enough. When only some consumers have the old technology it is in a sense more costly to supply all consumers with the new product. The reason is that now the price must be lowered more in order to destroy the second-hand market, which in turn calls for major innovations to make it worthwhile. It is also interesting to find out whether the incentive to introduce the new technology is larger when both consumers have a durable or when only the HI-consumer has a durable from period 1. Then we have:

**Proposition 5** *Assume that firm 1 has produced a durable in period 1. If a firm would choose to provide both consumers with the new technology, the fact that both consumers have the durable makes introduction of the new technology more likely. If the firm would supply the HI-consumer only with the new technology, then it is more likely that introduction of the new technology occurs when only the HI-consumer posses the old technology durable.*

**Proof.** To see this, compare the critical investment cost from Proposition 2 (only the HI-consumer has a durable) with the critical investment cost from Proposition 4 (both consumers posses a durable). By inspection it is easy to see that the critical investment cost when firm 2 sells the new technology to both consumers is larger in Proposition 4 than in Proposition 2. Hence, introduction of the new technology is more likely when both consumers have a durable in this case. When exclusion of the LO-consumer occurs, by the same comparison as above, we have that the critical $I$ is lowest when both consumers have a durable when $(1-\alpha)(v^N-v^O) < (1-\alpha)v^N-\alpha v^O$ or when $\alpha < \frac{1}{2}$, which is always true. Hence, in this case introduction of new technology is more likely to take place when only the HI-consumer posses a durable old technology product. ■

Firm 2 will supply both consumers with new technology provided that income disparities are low and the innovation is sufficiently large. When both consumers posses a durable of the old technology, there is no need to worry about the appearance of a second-hand market. The only reason for why firm 2 must lower its price is because he must induce the LO-consumer to purchase. When only the HI-consumer has a durable, there is an extra effect on the price that firm 2 can charge. Firm 2 must now also ensure that his price is low enough to make trade in the second-hand market unattractive for the consumers. Therefore his price must be lower in this case which reduces the profitability of introducing the new technology. When firm 2 excludes the LO-consumer from the new technology, there is no effect on firm 2's price from inducing the LO-consumer to purchase. In this case the profitability of introduction hinges solely on the HI-consumer's willingness to pay for the new technology product, which is highest when he can sell the old technology in the second-hand market.

## 2.3 The first-period choice

Now we turn to firm 1's period 1 choice. Firm 1 either chooses to produce a durable or a nondurable. If it produces a nondurable it sells to the HI-consumer in period 1 it charges $p_1 = (1-\alpha)v^O$ and earns $\pi_1 = (1-\alpha)v^O$, and when selling to both consumers firm 1 charges $p_1 = \alpha v^O$ and earns $\pi_1 = 2\alpha v^O$. If firm 1 produces a durable and supplies the HI-consumer exclusively at price $p_1 = 2(1-\alpha)v^O$ it earns $\pi_1 = 2(1-\alpha)v^O - c^D$, whereas supplying both consumers at price $p_1 = 2\alpha v^O$ yields firm 1 the profit $\pi_1 = 4\alpha v^O - 2c^D$. Then we have:

**Proposition 6** *Whether firm 1 produces a durable or a nondurable and supplies either both consumers or the HI-consumer exclusively depends on the costs of producing a durable and the income disparity.*

1. *When i)* $c^D \leq (1-\alpha)v^O$*, ii)* $c^D \leq 2v^O(1-2\alpha)$*, and iii)* $c^D > 6v^O(\alpha - \frac{1}{3})$ *firm 1 produces a durable and supplies the HI-consumer exclusively.*

2. *When i)* $c^D > (1-\alpha)v^O$ *and ii)* $\alpha < \frac{1}{3}$ *firm 1 produces a nondurable and supplies the HI-consumer exclusively.*

3. *When i)* $\alpha \geq \frac{1}{3}$*, ii)* $c^D > 2v^O(1-2\alpha)$ *and iii)* $c^D > \alpha v^O$ *firm 1 produces a nondurable and sells to both consumers.*

4. *When i)* $c^D \leq 6v^O(\alpha - \frac{1}{3})$ *and ii)* $c^D \leq \alpha v^O$ *firm 1 produces a durable and supplies both consumers.*

**Proof.** Comparing firm 1's payoff from producing a nondurable when supplying one or both consumers yields that he will serve both consumers when $\alpha \geq \frac{1}{3}$ and HI otherwise (parts 2 ii) and 3 i)). Similarly, making the same comparison with a durable yields that in this case firm 1 will supply both consumers when $\alpha \geq \frac{c^D}{6v^O} + \frac{1}{3}$ or when $c^D \leq 6v^O(\alpha - \frac{1}{3})$ and HI only otherwise (parts 1 iii) and 4 i)). Then it is clear that firm 1 will serve HI exclusively when $\alpha < \frac{1}{3}$ and serve both

consumers when $\alpha \geq \frac{c^D}{6v^O} + \frac{1}{3}$. In the former case firm 1 will produce a durable when $2(1-\alpha)v^O - c^D \geq (1-\alpha)v^O$ or when $c^D \leq (1-\alpha)v^O$, which proves parts 1 i) and 2 i). When $\alpha \geq \frac{c^D}{6v^O} + \frac{1}{3}$ firm 1 will supply both consumers. In this case he will produce a durable when $4\alpha v^O - 2c^D \geq 2\alpha v^O$ or when $c^D \leq \alpha v^O$ proving parts 3 iii) and 4 ii). From this it is clear that when $\alpha \in [\frac{1}{3}, \frac{c^D}{6v^O} + \frac{1}{3})$ firm 1 supplies both if he produces a nondurable and HI only if he produces a durable. By comparing these payoffs we see that firm 1 will produce a durable and supply HI exclusively when $2(1-\alpha)v^O - c^D \geq 2\alpha v^O$ or when $c^D \leq 2v^O(1-2\alpha)$ (parts 1 ii) and 3 ii)). ■

The results from Proposition 6 is illustrated in Figure 2 below.

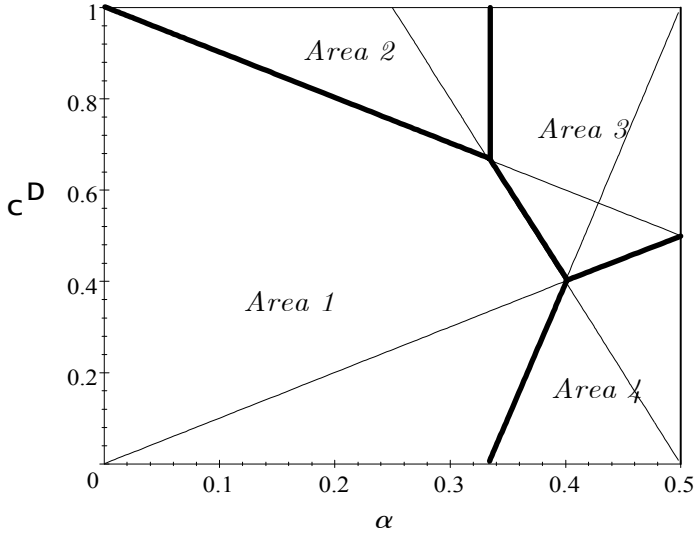


Figure 2: Firm 1's optimal choice of durability and pricing strategy ($v^O = 1$).

Firm 1 will serve the HI-consumer exclusively with a durable when income disparities are large and the costs of producing a durable are relatively low. The parameter range is illustrated in Figure 2 as area 1, corresponding to part 1of proposition 6. The larger the income disparity the higher the cost of a durable can be to be in this case. If the costs of durable becomes too high and income disparities are large, firm 1 supplies the HI-consumer with a nondurable (area 2). When incomes are fairly equal and the costs of a durable are high, firm 1 produces a nondurable and sells

to both consumers (area 3). Finally if income disparities are low and the costs of producing a durable is low, both consumers are supplied with a durable (area 4).

Then we are able to sum up our analysis. Our main focus will be on how income disparities affects the incentives to introduce the new technology. Incumbent firms' decisions on durability are solely governed by the costs of producing durables. Therefore, when durability costs are sufficiently low, incumbent firms will produce durable goods. Their pricing policy however, depends on the existing income distribution in the economy. More inequality may either reduce or increase the incentives to introduce the new technology. First, when existing wage inequality is high, incumbents will set high prices and sell to the high demand segment only. An firm that can sell the new technology will choose the same pricing strategy, and due to the appearance of an efficient second-hand market, the firm selling the new technology will be able to extract the full valuation of the new technology from the high demand consumers. Hence, more inequality will, in this case, increase the incentives to introduce the new product.

Second, for intermediate levels of wage dispersion a firm that introduces the new technology may want to destroy the second-hand market by pursuing a low price strategy and sell to all consumers. The cost of this strategy is that the new firm only can extract the difference in valuation of the new and old technology from the *low demand customers*. The reason for this is that these customers can now get the old technology from high demand consumers for free. On the other hand, the benefit is that the seller can increase sales by selling to all customers. When the innovation is big enough and incomes are not too unequal, this is an optimal strategy. Clearly, more inequality will hurt the incentives to introduce the new technology in this case, because it reduces the profitability of selling the new product at a low price.

Third, if the existing income distribution is even, incumbent firms will sell durable old technology to all consumers, and the firm introducing the new technology will pursue the same strategy. Because all customer have a durable old

technology product, the new firm can only extract the low demand consumers' difference in valuation for the old and new product. Increasing inequality from such a point will reduce the profitability of introducing the new technology because low demand customers' willingness to pay will be reduced.

Finally, when durability costs are high, incumbent firms will produce nondurables. A firm introducing the new technology will sell to all consumers when wage inequality is low and vice versa when inequality is high. In the former case more inequality will lower the incentives to introduce the new technology and in the latter more inequality will stimulate introduction of new technology products.

# 3 Concluding remarks

The analysis above highlights the roles of inequality, the costs of durability and the size of innovations on the incentives to sell and adopt new technology products in an economy. We started off this paper by posing the question whether redistribution would stimulate or reduce the firms' incentives to introduce new technology products in the market? The answer from the present analysis is: It depends. The answer is linked to two crucial factors; the degree inequality at the outset, and whether and to which extent the consumers are equipped with well-functioning old technology products.

A fairly robust result seems to be that the larger the innovation, the more likely it is that the new technology will be adopted. More interesting perhaps is the effect that inequality has on the incentives to introduce new technology products. The results derived above indicate that redistribution may actually hurt the adoption of new technology if inequality is large at the outset. The reason is that redistribution will reduce the high income consumers willingness to pay without making it worthwhile to supply the low income consumers with the new technology. For intermediate levels of inequality the effect from redistribution is ambiguous. On

one hand redistribution may induce low demand consumers to purchase the new technology, and if the innovation is large enough it may be worthwhile for firms to supply these customers with the new technology. However, if the innovation is small it may too costly for a firm to attract the low demand consumers to the new technology, in which case redistribution will hurt adoption. Last, if inequality is very low, more redistribution is beneficial for the adoption of the new technology. The reason is that because the firms are unable to price discriminate, more redistribution will increase the low demand consumers' willingness to pay for the new technology product.

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