# Durable Goods and Moral Hazard: An Option to implement the First Best

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### Abstract

A monopolist selling a durable good cannot extract the whole amount of monopoly rents from consumers each period. This inefficiency is due to the incompleteness of contracts: The monopolist cannot credibly commit not to lower the price in future periods. By using leasing contracts however the monopolist can solve this credibility problem, but then he is exposed to inefficiencies due to moral hazard. This leads many authors in the Durable Goods Literature to rule out leasing contracts. This paper's contribution is to show the invalidity of the moral hazard argument by using leasing contracts that include an option to buy the good. The kind of contract we propose has neither been considered in the durable goods literature, nor in the Incomplete Contracts Approach so far.

JEL-classification code: D42, L11, L12, M31

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# 1 Introduction

The literature on durable goods, originated by Bulow (1982) focuses primarily on sales contracts. This contract cannot solve the credibility problem, this strand of literature builds on: A durable goods monopolist cannot credibly commit not to lower the price in future periods. This improves consumers' outside option, because they can postpone their consumption decision to future periods. So the monopolist must leave all consumers with some rents, which in turn means that the supplier does not receive the entire monopoly profit each period.

Leasing contracts however can solve this credibility problem. In order for the Durable Goods literature to remain interesting, leasing contracts have to be ruled out. The standard argument by which this is achieved, is moral hazard[1].

This paper's contribution is to show the invalidity of the moral hazard argument by using slightly more complex contracts. We show that leasing contracts that include an option to buy the good, solve the durable goods problem, as well as the moral hazard problem and implement the First Best. By First Best we mean that the monopolist can extract the same amount of rents as under the marginal-revenues-equals-marginal-cost rule.

We interpret the durable goods problem as a problem that is due to the incompleteness of contracts. Obviously, if contracts were complete then even under sales contracting, a commitment not to lower the price in future periods is easy to achieve by simply fixing a sufficiently high penalty ex ante for price cuts. In the Incomplete Contracts Approach the only contracts that can be written are contracts on ownership rights and the price at which these rights can be acquired. Contracts can neither be written contingent on actions taken by the involved parties, nor on the generated surplus of the relationship. Both things cannot be verified by the Court. In the case of Durable Goods this means that no contract can be written contingent on the prices of goods which have not been produced yet.

Sales contracts can be interpreted as consumer ownership, leasing contracts

[1] see for example Fudenberg and Tirole (1998), Waldman (1996), or Achter (1999)

as supplier ownership. In our analysis, we show that neither contracts are able to achieve the First Best. Sales contracts cannot solve the durable goods problem, but at least partially solve the moral hazard problem. Leasing contracts on the other hand circumvent the durable goods problem, but the supplier is exposed to the inefficiencies due to the moral hazard problem.

Leasing contracts that include an option to buy the good combine features of both simple (unconditional) ownership structures. Note that the leasing plus option contract remains within the contractual restrictions of the Incomplete Contracts Approach. All this contract specifies, is who owns the good initially, at what date a change in ownership can occur, who has the right to exercise the option and at which price this can be done. This contract relies neither on the ex post surplus generated by both parties, nor on their future actions.

The benefit from using options is twofold: First the revenues from exercising the option reward the supplier for not lowering the price and this solves the durable goods problem. Second if consumer exercise the option in equilibrium, then they take care of the goods they will own in the future and this solves the moral hazard problem.

We are by no means the first who found that option contracts can help solving problems that are due to the incompleteness of contracts. Edlin and Hermalin (1997) as well as Nöldeke and Schmidt (1999) consider games in which two agents have to invest sequentially in effort in order to generate surplus. In both articles it is shown that at least in the case in which effort levels are strategic substitutes, the First Best can be achieved by using option contracts.

It turns out that, in our framework, a contract similar to the one these papers analyze, is a sales contract combined with an option for the supplier to buy back the good. We will denote this contract as the NöS-contract. This contract also implements the First Best in our setting, but it is not the kind of contract used in the market for consumer durables, e.g. the market for cars. There consumers have to decide whether or not to use the car further on. We provide an argument why the buy back contract cannot be adopted in our setting, but the leasing plus option contract.

Asymmetric information between the supplier and the consumers concerning the quality of the good after one period of consumption prevents the supplier to decide for the buy-back contract. Given our informational assumptions, the uninformed party has to decide whether or not to exercise the option in the case of the buy-back contract. This causes inefficiencies that can be avoided by using the leasing plus option contract, because in this case the informed party decides to exercise the option, or not.
The leasing plus option to buy contract only works for the two period case. In a multi-period setting consumers must not acquire ownership rights after the first period, but in the last period. We will see that in a three period setting the First Best can be achieved by using leasing contracts that include an option for a leasing plus option-to-buy contract.
The paper is organized as follows: In section 2 we outline the basic model, in section 3 we compare leasing and sales contracts. Then we turn to conditional ownership structures in section 4, where we consider the NÄS-contract and the leasing plus option contract. We extend our model to the case of asymmetric information in section 5 and finally to the three period case in section 6 while section 7 concludes.

## 2 The model

We consider a two-period model, in which a monopolist produces a durable good at constant marginal cost k. On the demand side there is a continuum of consumers of mass 1. The fraction $\lambda$ of consumers receive a gross benefit of $\bar{\theta}$ per period of consumption. The fraction $1 - \lambda$ only has a marginal willingness to pay of $\underline{\theta} < \bar{\theta}$ per period of consumption. Consuming more than one unit of the durable good per period does not generate additional utility. A consumer who decides not to consume, receives a utility level of 0. In each period a representative consumer has the following utility function:

$$u_t^i = \begin{cases} \theta^i - p_t - c(e_t^i) & \text{if consumption} \\ 0 & \text{else} \end{cases} \tag{1}$$

with $\theta^i \in \{\underline{\theta}, \bar{\theta}\}$.

In order to take into account the potential moral hazards, we assume that goods are not perfectly durable. With probability $1 - q(e^i)$ the good consumed by individual i is of no use to the consumers after one period of consumption. With probability $1 > q(e^i) > 0$ the good survives the first period and is of the same quality as a new good. The survival probability $q(e^i)$ depends on the effort level consumers choose. During consumption in the first period consumers decide how much effort $e^i \geq 0$ they invest in maintenance. If consumers take care of the good they use, then $e^i$ is high and vice versa. The effort level influences the survival probability in the following way: $q'(e^i) > 0$, with $\lim_{e^i \to 0} q'(e^i) = \infty$, $\lim_{e^i \to \infty} q'(e^i) = 0$ and $q''(e^i) < 0$. Taking care comes with a cost, denoted by $c(e^i)$ with $c'(e^i) \geq 0$, $\lim_{e^i \to 0} c'(e^i) = 0$, $\lim_{e^i \to \infty} c'(e^i) = \infty$ and $c''(e^i) > 0$.

Without loss of generality we assume that the common discount factor $\delta$ equals 1. The sequence of events is summarized in Figure 1.

First the parties sign a contract, then production in the first period takes

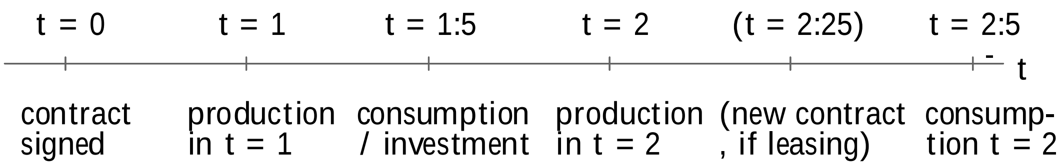


Figure 1: sequence of events

place. While consuming in the first period, consumers can take more or less care of their units. At the beginning of the second period the monopolist can produce additional units.

In order to compare our analysis with the work of Nöldeke and Schmidt, or Edlin and Hermalin, one can interprete the level of production in the second period as an investment. High levels of production are associated with low investment levels as we will see later.

# 3 Unconditional ownership structures and the First Best

To illustrate the main idea, we start with unconditional ownership structures and show that standard leasing or sales contracts can either solve the durable goods problem only, or at least partially the moral hazard problem.

As a point of reference, we start by determining the First Best. By First Best we mean the situation in which the monopolist can extract the maximum amount of rents from the consumers. We do not allow the monopolist to discriminate among consumers, because otherwise the durable goods problem does not occur[2].

In order to have a durable goods problem we assume $\underline{\theta} > k$. This condition alone however does not guarantee the existence of a durable goods problem. We assume that in a static setting it is favorable for the monopolist to produce only for $\bar{\theta}$-consumers.

$$\Delta\pi = \lambda(\bar{\theta} - k) - (\underline{\theta} - k) > 0 \tag{2}$$

In order for the monopolist to maximize profits in both periods, he should charge a price that extracts all rents from $\bar{\theta}$-consumers. Given our assumption on the durability of goods, not all units survive the first period. The fraction $1 - q(e)$ of goods produced in $t = 1$ have to be replaced for the second period[3]. Thus the over all profit depending on the effort choice is given by:

$$\pi^*(e) = \lambda(2\bar{\theta} - c(e) - k - (1 - q(e))k) \tag{3}$$

Differentiating (3) with respect to $e$ yield the first best effort levels. This effort level equates the marginal cost of effort and the saved marginals production cost due to higher maintenance:

$$c'(e^*) = q'(e^*)k \tag{4}$$

[2] We restrict attention to the anonymous case: Neither in the first period nor in the second period, we allow the monopolist to price discriminate. One can think of a second hand market, where arbitrage trades could take place.

[3] We apply the Law of large numbers. Note that we assume that all consumers invest the same amount of effort, but since we are interested in the First Best, we do not have to worry about Nash equilibria.

So the first best profit for the monopolist is given by:

$$\Pi^{*} = \lambda(2\bar{\theta} - c(e^{*}) - k - (1 - q(e^{*}))k) \tag{5}$$

Let us now consider sales contracts. Sales contracts specify a price at which ownership rights are transferred to consumers. Consumers who bought the good use it as long as they can, without making additional payments to the supplier. If the good bought by a consumer does not survive the first period, then the consumer is free either not to consume in $t = 2$ or to consume, but then he has to pay for this new good.

Suppose the monopolist sold $\lambda$ units in $t = 1$ to $\bar{\theta}$-consumers at a price $p_1^s$. At least a fraction $\bar{q}^s$ of these consumers can use their units in $t = 2$, without paying an additional amount of money to the monopolist. So the monopolist faces a residual demand of $\lambda(1 - \bar{q}^s)$ $\bar{\theta}$-consumers and $1 - \lambda$ $\underline{\theta}$-consumers that is potentially worthwhile to be satisfied. We have to distinguish two cases.

First let us assume that it is profitable for the monopolist to satisfy the residual demand completely at a price $p_2^s = \underline{\theta}$. This is true if

$$\Delta\Pi < \frac{\bar{q}^s}{1 - \bar{q}^s}(1 - \lambda)(\underline{\theta} - k): \tag{6}$$

This condition is certainly fulfilled, if survival probability $q(0)$ is sufficiently high. Given (6) holds, the maximum price the monopolist can charge to $\bar{\theta}$-consumers in the first period $p_1^s$ must satisfy the following incentive constraint.

$$2\bar{\theta} - c(e^i) - p_1^s - (1 - q(e^i))\underline{\theta} \geq \bar{\theta} - \underline{\theta} \Leftrightarrow p_1^s \leq \bar{\theta} + \underline{\theta} - c(e) - (1 - q(e^i))\underline{\theta} \tag{7}$$

In order for consumers not to postpone their consumption decision the monopolist must leave all $\bar{\theta}$-consumers with some rents of at least $\bar{\theta} - \underline{\theta}$, which is their outside option if they only consume in $t = 2$.

Consumer decide on their effort choice according to:

$$\max_{e^i} \bar{\theta} - c(e^i) - (1 - q(e^i))\underline{\theta} \tag{8}$$

From the perspective of the first period consumers receive a gross benefit of $\bar{\theta}$ for sure. With probability $q(e^i)$ they do not have to pay for consumption in the second period, but with $1 - q(e^i)$ they have to replace the good at $\underline{\theta}$. In order to improve the chance that their good survives the first period, they have to bear a cost of taking care of $c(e^i)$. Differentiating (8) with respect to $e^i$ yields:

$$c'(e^s) = q'(e^s)\underline{\theta} \tag{9}$$

The equilibrium investment level under sales contracting equates marginal cost of effort and the marginal reduction in replacement spendings. Since $\underline{\theta} > k$ consumer ownership leads to overinvestment $e^s > e^*$.
The over all profit is given by[4]

$$\Pi^s = \lambda[\bar{\theta} + \underline{\theta} - c(e) - k) - (1 - q(e^i))k] + (1 - \lambda)(\underline{\theta} - k) \tag{10}$$

Compared to the First Best payoff level, the monopolist looses some profits due to two sources of inefficiencies. First consumers overinvest. This reduces the cost of re-production, but consumers have to be compensated for their cost of effort and so the monopolist cannot extract as much rents from consumers as in the First Best. The second inefficiency stems from the credibility problem. The monopolist cannot extract all rents from the $\bar{\theta}$-consumers, because otherwise they would postpone their consumption decision. The monopolist must leave buyers in the first period with some rents which must be as least as high as $\bar{\theta} - \underline{\theta}$, which is the level of utility from consuming only in $t = 2$.
For the sake of completeness we consider now the second case, in which only $\bar{\theta}$-consumers are served in $t = 2$ under sales contracting[5].

$$\Delta\Pi < \frac{\bar{q}^s}{1 - \bar{q}^s}(1 - \lambda)(\underline{\theta} - k) \tag{11}$$

Here the monopolist decides for a price $p_2^s = \bar{\theta}$. Unlike the previous case the monopolist does not have to leave rents for consumers in the first period,

[4] In order for the monopolist not to serve $\underline{\theta}$-consumers in the first period we have to assume $\lambda\bar{\theta} > \underline{\theta}$. This guarantees that $\Pi^s > 2\underline{\theta} - k - (1 - q^s)k - c(e)$.

[5] This is the case if the minimum survival probability $q(0)$ is sufficiently low. But in this case the durable goods problem vanishes.

because postponing consumption yields zero rents. Thus the price in the first period is $p^s_2 = 2\bar{\theta} - (1 - q(e^i))\bar{\theta} - c(e^i)$. Similar to the previous case consumers choose their effort levels according to the following rule:

$$q'(e^i_b)\bar{\theta} = c'(e^i_b) \tag{12}$$

We denote all variables in this case by the subscript $b$. Since replacement is more expensive in this case, consumers take even more care than in the previous case. The overinvestment problem is even more severe. The overall profit is given by:

$$\Pi^s_b = \lambda[2\bar{\theta} - c(e^s_b) - k - (1 - q(e^s_b))k] \tag{13}$$

In both cases the First Best cannot be achieved by consumer ownership. In the first case we have seen that the overinvestment as well as the durable goods problem causes inefficiencies. In the second case there is no durability problem but the overinvestment problem is even more severe.

We now turn to Leasing Contracts. Here the monopolist remains the owner of the good. The contract specifies a price at which consumers can use the good for one period. A leasing contract is thus a short-term contract. After one period of consumption consumers have to give back the units to the monopolist[6].

What ever pricing strategy the monopolist adopted in the first period, consumers have to give back the units they used at the end of period one. At the beginning of the second period the monopolist is free to reoffer those units which survives the first period at any price in the second period, because there is no remaining contractual relationship from $t = 1$. The monopolist faces the same problem as in the static setting. He faces the whole demand "function" and not only a residual demand as in the case of sales contracts. Since $\Delta\Pi > 0$, he will charge a price $p^l_2 = \bar{\theta}$. Obviously in the first period the monopolist charges the price of $p^l_1 = \bar{\theta}$, too. The pricing strategy seems to generate high profits, but how much effort consumers will invest?

Consumers do not invest at all. Consider a representative $\bar{\theta}$-consumer in

[6] A long-term leasing contract would yield similar results as the sales contract.

$t = 1$. Independent of his investment level he will consume a good of given quality at a price $p_2^l = \theta_1$. But if the consumers does not exert effort, he saves cost of taking care of $c(e^l)$. Thus the monopoly profit under leasing takes the following form:

$$\Pi^l = \lambda(2\theta_1 - k - (1 - q(0))k) \quad (14)$$

Leasing contracts are inefficient, because they do not provide proper incentives for consumers to take care of the rented good. This leads to inefficiently high re-production cost for the monopolist. Proposition 1 summarizes the main findings of this section.

**Proposition 1** Neither sales nor leasing contracts achieve the first best.

Comparing monopoly profits under sales contracting and Leasing contracting leads to the second result[7].

**Proposition 2** Sales contracts outperform leasing contracts if and only if:

$$\Delta\Pi < \lambda\{(1 - q(0))k - [c(e^s) + (1 - q(e^s))k]\} > 0 \quad (15)$$

If the benefits from the solution to the durable goods problem $\Delta\Pi$ are smaller than the saved cost due to the partial solution to the moral hazard problem, then leasing contracts can be ruled out because of moral hazard. This is the scenario the Durable Goods Literature builds on.

# 4 Conditional ownership structures: Option Contracts

In this section we want to compare two kinds of contingent control allocations, namely a contract similar to the one Nöldeke and Schmidt proposed with the Leasing plus option contract. Both contracts include an option, but the contracts differ with respect to who holds ownership rights initially and who can acquire these rights later on. We preceed by comparing both contracts under symmetric information and in next section we show that only

[7]We only consider the case in which sales contracting leads to the durable goods problem

the leasing plus option contract still implements the First Best under asymmetric information.

By contingent control we mean that the initial contract speci¯es rules at which ownership rights can be transferred between the parties during the relationship.

NÄldeke and Schmidt consider a scenario in which two parties have to engage in e®ort sequentially in order to generate surplus. Party 1 has to exert e®ort ¯rst. After party 2 invested in e®ort, both parties negotiate over the division of surplus. The outcome of this bargaining is determined by the nature of their investment (either in physical or in human capital), the exogenously given bargaining power and the ownership structure. The authors ¯nd that the First Best can be implemented by the following contract: Initially party 1 owns the asset. After both parties having invested, but before the beginning of the bargaining stage, party 2 can exercise the option to buy the asset at a predetermined price that gives party 2 its reservation utility level if both invested e±ciently. The contract, signed before the parties invest, speci¯es the initial ownership, when and at which price the party without ownership rights can acquire those rights.

The rational behind this contract is simple. The option price is chosen such that party 2 exercises the option and invest e±ciently only if party 1 invested e±ciently. Note that not exercising the option leaves party 2 with at most his outside option, because party 1 owns the asset. Exercising the option and investing e±ciently is no worse for party 2. Party 1 receives the entire surplus if its investment is at the e±cient level even though party one is no longer the owner, because 2 exercised the option.

Applied to our durable goods problem we have to make several adjustments. Unlike NÄldeke ans Schmidt we are not interested in a socially optimal outcome, but to shift as much rents as possible to the monopolist. So we cannot adopt the NÄS-contract literally. Next in our speci¯cation only consumers exert e®ort, but one can interprete the monopolist's price-output decision in the second period as e®ort too. The action taken by the monopolist in $t = 2$ (either high, or low prices) determines the amount of "exractable" surplus generated by this relationship. Third, in the end consumers must use the

good in order for any surplus to be generated in $t = 2$. This implies that ownership rights have to be transferred before consumption in the second period takes place. But note that the efficiency properties of the NöS-contract rely only on the fact that party 2 can acquire ownership rights after party 1 invested. Since party 1 (consumers) owns the good initially and party 2 holds the optin, the NöS-contract translates to a sales contract with a buy-back option in our problem.
A contract similar to the one Nöldeke and Schmidt proposed that gives the monopolist first best profits is described in Proposition 3.

**Proposition 3** The monopolist can achieve the first best outcome with the following contract:

Consumers buy the good in t=1 at a price: $p_1 = \bar{\theta} + k - c(e^*)$,

The monopolist owns the option to buy back these goods at the beginning of $t = 2$ at a price: $\hat{p}_2 = k$,

After the production stage in $t = 2$ the monopolist charges a price of: $p_2 = \bar{\theta}$

proof:
If the monopolist does not exercise any of his options, then his second period profit is either:

$$\Pi_2^{no}(p_2 = \underline{\theta}) = (1 - \lambda)(\underline{\theta} - k) + \lambda(1 - q)(\underline{\theta} - k) \tag{16}$$

or

$$\Pi_2^{no}(p_2 = \bar{\theta}) = \lambda(1 - q)(\bar{\theta} - k) > \Pi_2^{no}(p_2 = \underline{\theta}) \tag{17}$$

with $q$ is the realized proportion of goods that survived. Exercising the option only makes sense if these units generate utility to consumers in the second period. Exercising all these options and re-producing all those units that did not survive the first period, yields

$$\Pi_2^{bb} = \lambda[q(\bar{\theta} - \hat{p}_2) + (1 - q)(\bar{\theta} - k)] = \lambda(\bar{\theta} - k) \tag{18}$$

Following this strategy gives the monopolist the maximum amout of profit in $t = 2$.

Consumers in $t = 1$ have proper incentives to invest, since

$$e^* \in \arg\max_e \bar\theta - c(e) + q(e)(p_2^o - \bar\theta) - (1 - q(e))\bar\theta$$

Thus the monopolist can charge a price of $p_1 = \bar\theta + k - c(e^*)$ in the first period. Adding up all cash-flows shows that the monopolist achieves the First Best:

$$\Pi^{bb} = \Pi^* = \lambda(2\bar\theta - c(e^*) - k - (1 - q(e^*))k) \qquad (19)$$

Q.E.D.

The contract characterized in Proposition 3 solves the durable goods problem as well as the moral hazard problem. The option price is chosen such that the monopolist faces the same problem as in the static stettig. Whether he produces new units or buys back old ones, his cost is k. But restricting profits to $\bar\theta$-consumer yields higher profits. Consumers on the other hand have the right incentive to invest, because independent of their investment decision, they pay $\bar\theta$ in $t = 2$. Taking care of the good in $t = 1$ is rewarded by the monopolist through the option price. This price reflects only the opportunity cost of re-production and not the cost for replacement for consumers under sales contracting $\bar\theta$. This solves the overinvestment problem.

Next we consider Leasing contracts that include an option to buy the good. This contract specifies a price $p_1^o$ at which consumers can use the good for the first period, but the supplier remains the owner. After production in the second period takes place, the initial contract specifies a price $p_2^o$ at which those consumers who already consumed in $t = 1$ can acquire these units. Those goods for which consumers did not exercise their options are given back to the supplier. He can resell these units together with new units at a price $p_2^o$, as long as these units are of value to consumers. Those units that did not survive the first period cannot be sold. Figure 2 summarizes the sequence of events under leasing plus option contracting.

**Proposition 4** The following leasing plus option contract implements the First Best:

The leasing fee in the first period is: $p_1^o = \bar\theta - c(e^*) + k$

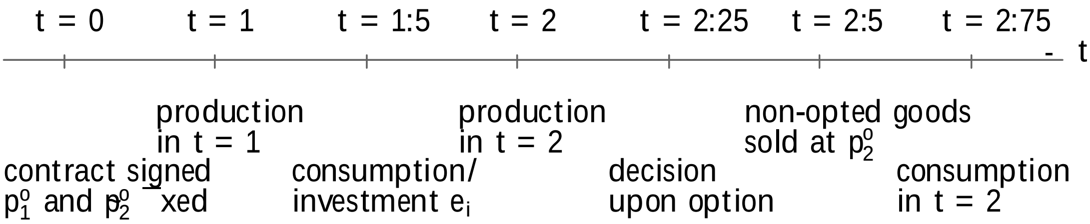


Figure 2: sequence of events

The option price at which consumers can acquire ownership in the second period is: $p_2^o = \bar{\theta} - k$

After the production stage in $t = 2$ the monopolist charges a price of: $p_2^o = \bar{\theta}$

if the following conditions hold:

$$\Delta\Pi \geq \lambda q(e^*)k \tag{20}$$

$$\underline{\theta} < \bar{\theta} - k \tag{21}$$

proof:
All consumers whose goods survived the first period exercise their option if $p_2^o = \bar{\theta}$, but do not exercise their options if $p_2^o = \underline{\theta}$, as long as $\bar{\theta} - k > \underline{\theta}$
Suppose the monopolist chooses $p_2^o = \underline{\theta}$, then his profit in the second period is:

$$\Pi_2 = (1 - \lambda)(\underline{\theta} - k) + \lambda Q\underline{\theta} + \lambda(1 - Q)(\underline{\theta} - k) \tag{22}$$

$Q$ denotes the fraction of goods that survived the first period. If on the other hand the monopolist charges a price $p_2^o = \bar{\theta}$, then his profit is:

$$\Pi_2 = \lambda(\bar{\theta} - k) \tag{23}$$

If $\Delta\Pi > \lambda Qk$ holds, then the revenues from options are sufficiently high in order to prevent the monopolist from lowering the price in $t = 2$.
Let us now consider consumers' investement decision in $t = 1$: Suppose all consumers, but $i$ invested efficiently $e^*$, what is consumer $i$'s best response?

Since we have assumed that each individual's contribution to monopoly profits is negligible, consumer i cannot in°uence the price decision of the monopolist in $t = 2$. So consumer i will invest e±ciently too.

$$e^* \in \arg\max_e \bar{\theta} - c(e) - q(e)p_2 - (1 - q(e))\bar{\theta}$$

Q.E.D.

The leasing plus option contract implements the First Best, too. But this contract is slightly more restrictive concerning the range of parameters in which the First Best can be achieved. The ¯rst restriction (20) is due to the fact that under leasing plus option contracting the supplier holds ownership rights and thus has an improved outside option. If he chooses a price of $p_2^o = \underline{\theta}$ in $t = 2$, then he receives an additional pro¯t from those consumers whose goods survived the ¯rst period of $\lambda q \underline{\theta}$, compared to the buy-back contract.
The second restriction stems from the fact that consumers have to reward high prices in the second period by exercising the option and to punish low prices by not exercising the option. The option price must be chosen such that exercising the option is favourable to consumers only if the price in $t = 2$ is equal to $\bar{\theta}$. But given both restrictions, the revenue created by exercising the option is su±ciently high in order to prevent the monopolist from lowering the price in $t = 2$.
Consumers invest e±ciently, because they have to pay $\bar{\theta}$ independent of their investment level, but receive a discount of k, if their unit survived. This discount re°ects the opprtunity cost of re-production.
Some might argue that the leasing plus option contract is not realistic, because the expiration date of these options is after the production stage in $t = 2$. First as Nöldeke and Schmidt argue one can think of American Opions and second the simple leasing contract without option only solves the durable goods problem if no further production is possible after consumers signed the leasing contract for that certain period.

# 5 Asymmetric information

In the case of symmetric information we have seen that both kinds of contracts can implement the First Best. The question now is why do we observe almost exclusively the leasing plus option contract, for instance in the market for car?

For this purpose let us consider what happens to the both contingent control allocations if only consumers who already used the good in $t = 1$ can observe whether or not the good will generate utility to consumers in $t = 2$. This is the classical lemons problem. First we consider the buy-back contract.

**Proposition 5** The buy-back-option contract does not work if there is asymmetric information concerning the quality between consumers and the monopolist.

proof:

If the monopolist cannot observe the quality before exercising the option, then he can either buy back every good, or non, or he randomizes.

If he buys back non of the goods in equilibrium, then the allocation is equivalent to the one under sales contracting.

If he buys back all units, then consumers free-ride other consumers' investment choice. This is a situation equivalent to the leasing case.

If the monopolist randomizes, both problems, the durable goods as well as the moral hazard problem are present but less severe than in the previous cases.

Q.E.D.

For the leasing plus option contract we receive the opposite result.

**Proposition 6** Even though there is asymmetric information concerning the quality, the monopolist can achieve the First Best by using the following leasing plus option contract:

- The leasing fee in the first period is: $p_1^o = \mu^1 - c(e^*) + k$
- The option price at which consumers can acquire ownership in the second period: $p_2^o = \mu^1 - k$

After the production stage in $t = 2$ the monopolist charges a price of: $p_2^o = \bar{\theta}$ if the following conditions hold:

$$\Delta \geq \lambda \lambda q(e^{*})k \tag{24}$$

$$\underline{\theta} < \bar{\theta} - k \tag{25}$$

proof: This proof is very similar to the one of proposition 4.
Asymmetric information does not play a role under leasing plus option contracting, because the informed party decides upon exercising the option or not[8]. Only consumers whose goods generate the same level of utility in the second period will exercise their options. Revealing their information is beneficial for consumers, because they can consume more cheap in the second period if their units survived, than consumers who do not use their option in the case their units survived. Revealing the private information if the good is of no use to consumers in the second period, does not hurt consumers since they receive zero rents in this case independent of what they report.

# 6 Extension

In the previous sections we have shown that a leasing plus option to buy contract can implement the First Best in the two-period case. Obviously this contract cannot implement the First Best in a multi-period setting, because giving consumers unconditional ownership rights in the second period leads to the same inefficiencies in the following periods as sales contracts in $t = 2$ in the two-period case. We restrict attention only to the three-period case in order to indicate that conditional ownership structures can implement the First Best in a multi-period setting. We do not consider the general case, because our analysis provides us with the same insights and the presentation is much clearer.
In order to analyze the three-period case we simply add another "second"

[8]We assume that every consumer in the second period knows when the offered good was produced. This implies that all old units that are offered by the monopolist in the second period under leasing plus option contracting must be of low quality.

period to the sequence of events in Figure 2. We assume that the survival probabilities are independent. A good that was produced in $t = 1$ and survived the first period, also survives the second period with the same probability $q()$ as a good that was produced in $t = 2$.[9]

In this section we restrict attention to the leasing plus option contract. In the last section we have shown that the sales contract with a buy-back-option cannot implement the First Best under asymmetric information. But the efficiency properties of the leasing plus option contract are unaffected by asymmetric information. The kind of contract we consider is a leasing contract that includes an option not for a sales contract, but for a second leasing contract with an option to use the good in $t = 3$. One can interprete this as a short-term leasing contract with several options to prolong.

**Proposition 7** The following double-option contract generates a subgame perfect Nash Equilibrium, in which the monopolist receives the first best payoff: $p_3 = \bar{\theta}$, $\tilde{p}_3^O = \bar{\theta} - k$, $p_2 = \bar{\theta} + q(e_2^*)k - c(e_2^*)$, $\tilde{p}_2^O = \bar{\theta} - (1 - q(e_2^*))k - c(e_2^*)$ and $p_1 = \bar{\theta} + q(e_1^*)k - c(e_1^*)$, if

$$\Delta\Pi \geq \lambda q(e^*)k \tag{26}$$

$$\underline{\theta} < \bar{\theta} - k \tag{27}$$

proof:

$p_3^o$, $\tilde{p}_3^o$ and $p_2^o$ are simply the same prices as in proposition 4. We have seen that these prices establish the First Best from period 2 on. These prices gives zero rents to consumers whose goods did not survive the first period.

We have to show that price cuts in the second period do not lead to higher profits from the point of view of the second period. The profit from the double-option contract is:

$$\Pi_{2+3}^{loo} = \lambda[q_1\tilde{p}_2^o + (1 - q_1)(p_2^o - k) + q(e_2^*)\tilde{p}_3^o + (1 - q(e_2^*))(p_3^o - k)] \tag{28}$$

$$= \lambda[\bar{\theta} - (1 - q(e_2^*))k - c(e_2^*) + \bar{\theta} - k] \tag{29}$$

[9]This assumption rules out strategic replacement decisions by consumers.

Cutting the price in $t = 2$, the monopolist can receive a maximum profit of:

$$
\begin{aligned}
&\Pi_{2+3}(p_2 = \underline{\theta} - c(e_2^*); p_3 = \bar{\theta}) \\
&= \underline{\theta} - c(e_2^*) - k + \lambda q_1 k + \lambda(\bar{\theta} - (1 - q(e_2^*))k)
\end{aligned} \tag{30}
$$

If the monopolist decides for price cuts in $t = 2$, then in $t = 3$ he will charge a price of $p_3 = \bar{\theta}$. Equation (30) determines an upper bound for profits in the case of price cuts in $t = 2$, since we assume that consumers invested efficiently. Note that the monopolist leases the goods in $t = 2$.

Comparing both profits (29) and (30), price cuts lower the monopolist's profit from the point of view of the second period, if

$$\Delta \Pi \quad \lambda \quad \lambda q_1 k - (1 - \lambda) c(e_2^*) \tag{31}$$

This is certainly true as long as condition () holds.

The last thing to check is whether consumers invest efficiently in $t = 1$. If the good does not survive the first period, then consumers lease a new good in $t = 2$ with an option to prolong this contract. In this case their utility levels after period one take the following form:

$$u^{replace}(e_1) = -c(e_1) \tag{32}$$

If on the other hand the good survives, then:

$$u^{survival}(e_1) = k - c(e_1) \tag{33}$$

The decision on investment in $t = 1$ is made according to:

$$e_1^* \in \arg\max_{e_1} q(e_1)k - c(e_1) \tag{34}$$

Q.E.D.

The double-option contract implements the First Best in a three-period setting. The reason for this result is almost the same as in the former case. The option revenue rewards high prices and low prices are punished by not exercising the option.

The restrictions of proposition 6 are the same as those of proposition 4.

These restrictions ensure that the monopolist has no incentive to lower the price in the last period. Preventing the monopolist from lowering the price in the second period is easier to achieve than in the last period, because not only $\bar{\mu}$-consumers, but also $\underline{\mu}$-consumers (if they invest after the price cut) have to be compensated for their effort. In the last period for both groups of consumers this is not necessary.

# 7 Conclusion

In the literature on durable goods it is well known that leasing contracts can solve the credibility problem this literature builds on. This kind of contract reduces the durable goods problem to a repeated standard monopoly problem in which the monopolist sets his prices according to the marginal-revenues-equal-marginal-cost rule. In order for the durable goods problem to remain interesting this strand of literature rules out leasing contracts because of moral hazard.

In our analysis it turns out that option contracts can solve the durable goods problem, taking into account the potential moral hazards. By either using sales contracts with a buy-back option for the supplier, or by using leasing contracts that include an option to buy for consumers, the monopolist can extract the whole amount of monopoly rents from consumers each period. Even though we took into account the standard counterargument against solutions to the durable goods problem, we are back to the point where the durable goods problem is just a repeated version of the monopoly problem.

In the Incomplete Contracts Approach, option contracts are used in order to solve hold-up problems. Authors in this strand of literature disagree with respect to whether these contracts are robust to the possibility of renegotiation. Thus renegotiation could play the same role as the moral hazard argument and could possibly break down our solution. Edlin and Hermalin (1997) argue that in the case of sales contracts with an option to buy back, the monopolist has the incentive to let his option expire in order to buy back these units at a lower price. Since in our model the option price is lower than the benefit consumers receive from consuming the good, there is no scope for renegotiation. In the case of leasing contracts that include an option to buy for consumers, consumers cannot win by letting their options expire.

Since both contracts, the sales contract with a buy-back option and the leasing plus option contract implement the First Best, we have to provide an argument, why we almost exclusively observe the leasing plus option contract in the markets for durable goods, e.g. in the market for cars. We believe that asymmetric information concerning the quality of the good after one period of consumption can explain this observation. Even though we assume asymmetric information, under leasing plus option contracting the informed party decides whether to exercise the option or not. Since the price of acquiring the good is predetermined revealing information is bene¯cial to consumers, without incurring any ine±ciencies due to informational structure.

We do not only restrict attention to the two-period case, but indicate that in a multi-period setting a leasing contract with multiple options to prolong the relationship can implement the First Best.

While our analysis may ¯t to some observations on the market for durable goods, we were not able to explain why manufacturers of cars simultaneously use sales and leasing contracts. Another unanswered question is how option contracts perform in a competitive setting? Can option contracts be used as an instrument of collusion like best price clauses?[10] My conjecture in this respect is that option contracts can sustain collusion by using put options (options to sell).

[10]see Schnitzer (1994) for example.

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