

A Theory of Contractual Provisions in Leasing

Thomas Chemmanur*

Yawen Jiao**

and

An Yan***

Current Version: December 2007

* Professor of Finance, Carroll School of Management, Boston College, Chestnut Hill, MA 02467, Tel: (617) 552-3980, Fax: (617) 552-0431, email: chemmanu@bc.edu.

** Assistant Professor of Finance, Lally School of Management and Technology, Rensselaer Polytechnic Institute, 110 8th St., Troy, NY 12180. Tel: (518) 276-2612. Fax: (518) 276-8661, email: jiaoy@rpi.edu.

*** Assistant Professor, Finance Area, School of Business, Fordham University, 113 West 60th Street, New York, NY 10023, Tel: (212) 636-7401, Fax: (212) 765-5573, email: ayan@fordham.edu.

Thomas Chemmanur acknowledges support from Boston College Faculty Research Grant, and An Yan acknowledges support from Fordham University Faculty Research Summer Grant. For helpful comments or discussions, we thank Ingela Alger, Richard Arnott, Paolo Fulghieri, James Schallheim, and Fabio Schiantarelli, as well as participants at the Western Finance Association meetings, the Financial Management Association meetings, and seminars at Boston College and Fordham University. We alone are responsible for any errors or omissions.

A Theory of Contractual Provisions in Leasing

Abstract

We develop a non-tax rationale for leasing in a double-sided asymmetric information setting, and analyze how various contractual provisions in leasing contracts arise in equilibrium. In our model, a manufacturer of capital goods has private information about their quality; entrepreneurs (users of these capital goods) come to learn this quality only by using them over a period of time. Each unit of the capital goods requires a certain level of maintenance in each period. Entrepreneurs differ in their cost of providing this maintenance; this maintenance cost is information private to each entrepreneur. Leasing emerges as an equilibrium solution to this double-sided asymmetric information problem. Various contractual provisions in leasing contracts (e.g., short-term versus long-term leases with non-cancellation provisions, option to buy at lease termination, and service leases) also emerge as equilibrium solutions under alternative settings. Leases with metering provisions emerge in equilibrium when, in addition to the maintenance cost, entrepreneurs differ in other dimensions, such as their intensity of usage of the capital good. Our model has implications for the lease versus sell decision, the situations under which various leasing contract provisions will be used, and for the relative magnitudes of sales prices and leasing costs (for leases with different contractual provisions).

1 Introduction

Leasing is an important source of external financing for U.S. corporations. It has been estimated that a third of the capital equipment used by U.S. corporations is leased. However, the motivations for leasing are still not completely understood. While the finance literature has analyzed corporate leasing policy extensively, much of the discussion has been confined to tax-related incentives to lease or buy (see, e.g., Miller and Upton (1976), or Lewellen, Long, and McConnell (1976)). These and other papers assume that the real operating cash flows associated with leasing or owning are invariant to the financial contract chosen, thus assuming that it is primarily tax-related incentives which drive the lease or buy decision.

More recently, however, financial economists have come to recognize that, while taxes are important in determining the identity of the lessor and the lessee, they may be less crucial in identifying the specific assets to be leased. The co-existence of both leased and purchased assets suggests that the net benefits of leasing may be neither uniformly positive nor negative. The predominance of leasing in certain industries and for certain assets implies wide variations in the benefits from leasing. Equally important is the variety of contractual provisions observed in practice, based on service provisions, option to cancel the lease before the maturity of the contract or to renew it for additional periods, option to buy the asset at the termination date of the lease, metering, etc. To illustrate, consider the example of a hospital leasing medical equipment (e.g., MRI or CT systems). When the equipment's lease has ended, the hospital has several options: return the equipment to the lessor, and replace it with newer equipment that better meets the hospital's needs; renew the lease for an additional period; or buy the equipment as used equipment at its fair market value. Clearly, tax considerations offer little explanation for the inclusion of such contractual provisions in the above and similar situations.

The objective of this paper is two-fold. First, we develop a non-tax rationale for leasing in an asymmetric information framework and analyze the lease-versus-buy decision in such a setting. Second, we develop a theory of contractual provisions in leasing in the above asymmetric information environment. In particular, we analyze the following question: Under what conditions are different kinds of leasing (as well as sales) contracts offered in equilibrium? We show that, depending upon the nature of the capital equipment and the characteristics of the lessor and the lessee, the following leasing contract provisions emerge in equilibrium: short-term and long-term operating leases (with non-cancellation provisions); leases which grant the lessee an option to buy the

asset at a pre-specified price at the termination date; service leases, where the manufacturer agrees to maintain the equipment leased; and leases involving “metering,” where the lease payment is a function of an observed measure of the intensity of usage of the asset.

We develop our model in a setting of asymmetric information where the manufacturer of capital equipment (lessor) has private information about the intrinsic value (type) of the asset he leases to the entrepreneur (lessee). The entrepreneur, however, can learn more about the value of the equipment over time as she uses the asset. We assume that entrepreneurs (lessees) are also heterogeneous. This heterogeneity can be in their cost of maintaining the leased equipment (as in our basic model) or in their intensity of usage of the leased equipment (as in Section 5.2).¹ We assume that entrepreneurs have superior information compared to manufacturers about their cost of maintenance (or usage intensity, in Section 5.2). While all entrepreneurs have some incentive to maintain the equipment (since the condition of the equipment affects the future profits it can generate for entrepreneurs), this incentive is weaker for higher maintenance cost entrepreneurs than for lower maintenance cost entrepreneurs. We demonstrate that, in this setting, the decision by a manufacturer regarding whether to offer his capital equipment under a leasing or a sales contract, as well as the contractual provisions in the leases he offers, allows him not only to reveal the true quality of his equipment, but also to segment the market for capital equipment among different kinds of entrepreneurs, thus maximizing his profit.

In equilibrium, high type manufacturers choose to lease their capital equipment to entrepreneurs, while lower type manufacturers choose to sell the equipment outright. Manufacturers are aware that entrepreneurs will learn the true type of the leased equipment after using it for some time, and will renew the lease if the value of the equipment to them is high, while returning lower value equipment to the manufacturers (who receive the residual value of the equipment). Consequently, while manufacturers of high value equipment are better off leasing their equipment, those of low value equipment are better off selling them outright at the price reflecting their true value. At the same time, manufacturers of high value equipment are able to segment the capital equipment market between the two kinds of entrepreneurs by offering leases with different contractual provisions. In one situation (analyzed in Section 4.1), this is achieved by offering a combination of a short-term and a long-term (non-cancellable) operating lease: in equilibrium, lower maintenance cost entrepreneurs will choose the short-term leasing contract and purchase the equipment at the end of the initial leasing period, while higher maintenance cost entrepreneurs will choose the long-term leasing contract but will return the equipment

¹ In other words, our setting is one of contracting under double-sided asymmetric information, where both the manufacturer (lessor) and the entrepreneur (lessee) have some (private) information not available to the other party.

to the manufacturers at the end of the initial leasing period (i.e., they will not purchase the equipment at the end of the lease). In other situations (Section 5.1), manufacturers may make use of leases with service provisions to segment the leasing market: they may offer leases with and without service provisions. In this case, higher maintenance cost entrepreneurs will accept leases with service provisions in equilibrium, while lower maintenance cost entrepreneurs will accept leases without such provisions. Similarly, in Section 5.2, we demonstrate that manufacturers may use metering provisions in leases to distinguish between entrepreneurs with a high-intensity of usage and those with a low-intensity of usage of the capital equipment: in equilibrium, low-intensity entrepreneurs accept leases with metering while high-intensity entrepreneurs accept leases without metering.

The rationale for leasing developed here is particularly relevant to the leasing of capital equipment making use of newer technologies, which is more likely to be characterized by asymmetric information. In a recent survey of entrepreneurs by the Small Business Administration (SBA), regarding the motivations that led them to lease instead of purchasing capital equipment, 13% cited the ability to access the latest technology in the least risky way as the main motivation; another 13% mentioned maintenance options and costs. In contrast, only 9% mentioned tax-advantages as the main motivation behind leasing.² Further, one of the important motivations for leasing often given by practitioners is that leasing equipment allows technological risk (i.e., the risk that equipment using new technologies may not be appropriate for the use at hand, or the risk of technological obsolescence) to be transferred from the lessee (entrepreneur) to the lessor (manufacturer).³ However, it is not obvious how such a transfer of technology risk can create value if both lessors and lessees are corporations (and therefore essentially risk neutral). In this paper, we demonstrate that such a transfer of technological risk through leasing can indeed create value in an environment of asymmetric information: i.e., in a setting where lessors have more information, compared to lessees, about the quality of their capital equipment (and its underlying technology). Our model generates several implications for the prevalence of leasing contracts relative to sales contracts, the contractual provisions in leasing contracts, as well as for the relative magnitudes of leasing costs and sales price to users of the capital equipment.

Our research is related to several strands in the finance and economics literature. As mentioned before, there

² A significant percentage of entrepreneurs also gave cash flow constraints as the reason for leasing. In another recent survey conducted by Dun and Bradstreet of the top five reasons for choosing to lease, 18% chose rapid technological change as the main reason for leasing (see, Gerety (1995)).

³ This particular quote was taken from the web site of the Equipment Leasing Association. Similar quotes occur over and over again in the practitioner literature and practitioner surveys.

is a large finance literature on leasing focused on tax-related incentives to lease or buy. However, tax issues alone cannot explain the existence of leasing in many markets: while the tax benefits of leasing were lowered in the tax reform act of 1986, the importance of leasing has increased. Neither can tax arguments explain the existence of the variety of leasing contracts observed in practice. Smith and Wakeman (1985) provide an informal but insightful analysis of the determinants of corporate leasing policy. They argue that leases can reduce the transaction costs that arise when the physical life of the asset exceeds the economic life of the firm, and informally discuss several possible rationales for some of the common provisions in leasing contracts. Sharpe and Nguyen (1995) hypothesize that firms facing high financial contracting costs can alleviate these costs by leasing, and present evidence indicating that such firms have a high propensity to lease.⁴

Hendel and Lizzeri (2002) and Johnson and Waldman (2003) develop a theoretical analyses of leasing contracts focusing on the relationship between the new car market and the used car market. Hendel and Lizzeri (2002) study a setting where there are two types (levels of quality) of cars, with consumers having heterogeneous valuations for quality. To begin with, neither the manufacturer nor consumers know the true quality of a new car, so that there is no adverse selection in the new car market. However, consumers can observe the quality of a car through using it over time, so that the used car market is characterized by adverse selection. A leasing contract in their setting specifies not only the rental payment for the car, but also the “option” price at which a consumer can purchase the car at lease maturity. In the above setting, they demonstrate two important results. First, leasing and selling can co-exist in the new car market: consumers with a high valuation for quality prefer to lease a car while those with a low valuation prefer to buy. Leasing thus allows the manufacturer to increase profits by segmenting the new car market between the two kinds of consumers. Second, consumers leasing cars who observe that their cars are of a low quality return them to the manufacturers, while those observing a high quality purchase their cars at the buyback (or option) price. The latter result implies that the manufacturer can set the option price specified in the lease for a new car above the market clearing price in the used car market (to reflect the higher quality of off-lease cars). The analysis of Johnson and Waldman (2003) also generates results broadly similar to that of Hendel and Lizzeri (2002). While, like our paper, the above two papers also demonstrate that the manufacturer’s expected profit can be increased through leasing, the motivation for leasing in these papers is quite different from that in our paper (recall that, in these papers, the manufacturer of a new car does not have any private information about its quality). In particular, the signaling role of leasing, the

⁴ Other papers which lend support to the argument that leasing reduces contracting costs in various settings are Krishnan and Moyer (1994) and Barclay and Smith (1995).

primary focus of our paper, has not been explored before in the literature. Further, the above two papers do not incorporate differences in maintenance costs across lessees and therefore do not study the role of leases in separating high maintenance cost lessees from those with low maintenance costs.⁵ Finally, neither of the above papers analyzes the rich menu of contractual provisions present in real-world leasing contracts.⁶

Our paper is also related to the contemporaneous paper by Eisfeldt and Rampini (2005), who argue that, in the event of financial distress, Chapter 11 of the U.S. bankruptcy code makes it easier for a financier to repossess equipment that is leased compared to obtaining control of the same piece of equipment if it were used to secure a loan. Therefore, the debt capacity of leasing exceeds the debt capacity of secured lending, since leasing allows a financier to extend more credit to a financially constrained firm relative to the case where he makes a loan to the firm.⁷ Finally, from a technical perspective, our paper is also related to the literature on warranties (see, e.g., Grossman (1980)) which has analyzed how warranties can signal product quality in a setting where the manufacturer has private information about quality. It is also broadly related to the industrial organization literature on price discrimination under incomplete information (see Tirole (1999), Chapter 3 for a review), and contributes to this literature as well.

The rest of the paper is structured as follows. Section 2 describes the structure of our basic model. Section 3 discusses the benchmark outcomes. Section 4 characterizes the equilibrium in this model. Section 5 extends a simplified version of our basic model and analyzes service leases (Section 5.1) and leases with metering (Section 5.2). Section 6 discusses the implications of the model and section 7 concludes. The proofs of various propositions, as well as the definitions of various threshold values in these propositions, are confined to the appendix.

2 The Basic Model

The model has four dates (three periods). At time 0, a risk-neutral entrepreneur requires one unit of a capital good (equipment) to implement a positive net present value project. Capital equipment are produced by risk-

⁵ See, however, the contemporaneous paper by Johnson and Waldman (2004), who incorporate the moral hazard problem in maintenance in a setting otherwise similar to Johnson and Waldman (2003).

⁶ McConnel and Schallheim (1983) value various provisions in leasing contracts using the redundant-assets methodology of option pricing models. However, since they use the arbitrage-free option pricing methodology, they, by definition, do not study issues of the optimality of these provisions. Two other papers which take a valuation approach to leasing contracts are those by Grenadier (1995, 1996).

⁷ Two other arguments for leasing from the economics literature are provided by Bulow (1986), who argues that leasing can be used by a monopolist to overcome the Coasian time-inconsistency problem, and by Waldman (1997), where leasing is used by a durable goods manufacturer with significant market power to eliminate the second-hand goods market. See also Gavazza (2005), who argues that the rationale for leasing arises from lessors having a transaction cost advantage in redeploying capital.

neutral manufacturers who have private information regarding their type. Type G capital equipment generate greater cash flows for entrepreneurs than type B capital equipment (details of these cash flows will be discussed later). We can think of the “type” of a piece of capital equipment as any variable (or combination of variables) affecting the cash flows it can generate for users, and about which the manufacturer has private information. One such variable is the true quality of the equipment, which can affect its probability of breakdown, and thereby the cash flows it can generate for users. Another variable is the manufacturer’s own future rate of introduction of new products, which, in turn, will affect the rate of technological obsolescence of the capital equipment and thereby its value to users. At time 0, the entrepreneur is unable to distinguish between type G and type B capital equipment. She only knows the prior probability distribution of equipment type: she believes the equipment (manufacturer) to be of type G with a probability θ and of type B with the complementary probability $1 - \theta$.

The entrepreneur may buy or lease the capital equipment from the manufacturer. And the manufacturer may offer more than one kind of leasing contract to the entrepreneur (e.g., a short-term or a long-term lease). We will discuss the contract structure in more detail below.

The entrepreneur has private information about her own type. In the basic model, we assume that the entrepreneur’s private information is about her cost of maintaining the capital equipment per period.⁸ The type L (low-cost) entrepreneur has a lower cost c_L of maintaining the equipment in each period than the type H (high-cost) entrepreneur whose maintenance cost per period is c_H , $c_H > c_L$. We denote c by the difference in the maintenance cost between the type H and type L entrepreneurs; $c \equiv c_H - c_L$. At time 0, before observing the contracts accepted by entrepreneur, the manufacturer is unable to distinguish between the two types of entrepreneurs, so that he only has a prior probability distribution over entrepreneur types: he believes that an entrepreneur is to be of type H with a probability ϕ and of type L with the complementary probability $1 - \phi$.

Between time 0 and time 1, i.e., in the first period, as the entrepreneur uses the capital equipment, she receives additional information about the type of the capital equipment. For simplicity, we assume that this information is not noisy, i.e., the entrepreneur comes to know the true type of the capital equipment at this time. After the arrival of this information, the entrepreneur decides whether to perform maintenance for the first period. The entrepreneur makes a similar maintenance decision in the second period as well. In addition, the entrepreneur has other choices to make depending on the terms of the type of leasing contract she accepts. If the entrepreneur chooses a short-term lease, she chooses whether or not to buy the equipment at time 1. On

⁸ We will modify this assumption regarding the variable about which the entrepreneur has private information in section 5.2.

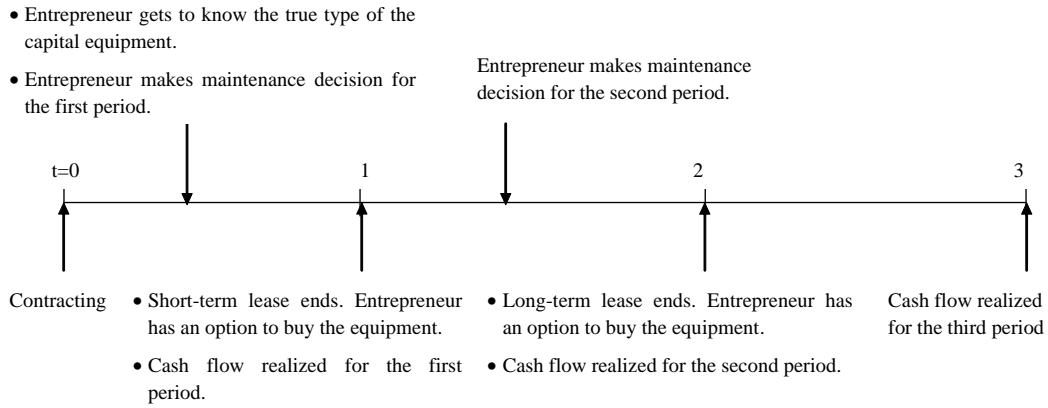


Figure 1: Sequence of Events

the other hand, if the entrepreneur chooses a long-term lease at time 0, she has the option to buy the equipment at time 2. At time 3, the project ends, and the final cash flows from the project are realized. The sequence of events is summarized in figure 1. We normalize the risk-free rate of return to be zero.

2.1 Cash Flow Structure

If the equipment is well-maintained (i.e., in good condition), the type G equipment will yield a cash flow of x in each of the three periods for which it is utilized for the entrepreneur’s project. For the type B equipment, the corresponding cash flow per period will only be fx , $f < 1$. (We will often refer to f as the “quality factor” capturing the difference in value between the two types of equipment, for a given level of maintenance.) If the equipment is not well-maintained, the cash flow generated by the equipment will decline by a fraction of $1 - \delta$ in the next period. We assume throughout the paper that $\delta < 1$. We consider δ as a “damage factor” gauging the damage sustained by the equipment due to a lack of maintenance. For example, if the equipment is not well-maintained in the first period, the cash flow in the second period will be δx instead of x for the type G equipment; this cash flow will be $f\delta x$ for the type B equipment. We assume that the useful life of either type of equipment is three periods, so that the equipment cannot generate any cash flows to the entrepreneur (or the manufacturer, if the equipment is returned to him) after time 3.

For tractability, we assume that f is sufficiently small such that $(1 - \delta)fx < c_L$. This assumption implies that the cash flow from the type B capital equipment is such that it is not optimal to maintain the type B equipment even for the type L entrepreneur (as well as the type H entrepreneur). We also assume that $c_L < (1 - \delta)x$, so that it is optimal for the type L entrepreneur to maintain the type G capital equipment. Note that whether or not the type H entrepreneur finds it optimal to maintain the type G equipment depends on c , the difference in

maintenance cost between the type H and the type L entrepreneurs. If c is sufficiently large so that $c_H > (1-\delta)x$, then it is not optimal for the type H entrepreneur to maintain the type G equipment at all.

The entrepreneur has an option to return the equipment to the manufacturer at the end of the lease (if she does not choose to renew the lease). We assume that, if the entrepreneur returns the equipment, she receives zero cash flow for each period and the manufacturer owns the residual value of the returned equipment. We assume the following about the residual value of capital equipment.⁹ First, we assume that it is the entrepreneur who can put any piece of new or well-maintained equipment to its most productive use, so that the residual value of any piece of well-maintained type G equipment will be less than its value to either a type H or a type L entrepreneur.¹⁰ On the other hand, for type G equipment that is not well maintained (i.e., for older equipment for which maintenance has not been performed in the previous period), our assumption is that its residual value is β times the present value of future cash flows that would be generated by the equipment by a type H entrepreneur, $\beta > 1$. In other words, for type G equipment that is not well maintained, its residual value to the manufacturer will be greater than its value to a type H entrepreneur.¹¹ Finally, for simplicity, we assume that the residual value of type B equipment to its manufacturer is zero at any date.¹²

2.2 Contract Structure

In the basic model, we allow the following menu of contracts between the manufacturer and the entrepreneur: a sales contract, where the entrepreneur pays the sales price S up-front (at time 0) and possesses the ownership

⁹ The residual value can arise in many ways. One possibility is that the manufacturer is able to put the capital equipment to some alternative use for himself. Another possibility is that there exists a second hand market for the capital goods which can be used by the manufacturer to dispose of any units of the capital goods which are returned to him by entrepreneurs.

¹⁰ This assumption implies that all manufacturers have an incentive to lease out their equipment for at least one period, regardless of the maintenance cost of the entrepreneur leasing the equipment (rather than retaining the equipment themselves starting from time 0). Recall that the only difference between type H and type L entrepreneurs in our setting is their cost of maintaining equipment, so that the two are equal in their productive capacity on a well-maintained equipment. Thus, the residual value of a piece of well-maintained equipment cannot exceed its value to a type H or a type L entrepreneur.

¹¹ For example, if a type H entrepreneur returns the equipment to the type G manufacturer at time 1 without performing maintenance in the previous period, the residual value of this returned equipment to the manufacturer would be $\beta(\delta x + \delta^2 x)$, where δx and $\delta^2 x$ are the cash flows of the type G equipment at time 2 and time 3 respectively.

¹² We assume that the residual value of type B equipment is zero only to minimize mathematical complexity. Our results go through as long as the residual value of type B equipment to its manufacturer is significantly low, so that this residual value is lower than the value of the equipment to a type H entrepreneur. It seems reasonable to assume that the latter condition holds, since, as long as $c_L > (1-\delta)fx$ (as we assume throughout the paper), neither a type L nor a type H entrepreneur has an incentive to maintain type B equipment, so that its second hand market value cannot exceed its value to a type H entrepreneur at any time. Further, even if a type B manufacturer can himself make use of type B equipment returned by an entrepreneur, it seems reasonable to assume that the cash flows he can generate from this alternative use do not exceed those that can be generated by a type H entrepreneur, provided that the manufacturer's maintenance cost is not lower than that of a type L entrepreneur, c_L (since, in this case, the manufacturer himself will not have an incentive to maintain type B equipment returned by an entrepreneur). In contrast, it is reasonable to assume that the residual value to the manufacturer of a piece of type G equipment will be greater than its value to the type H entrepreneur if the type H entrepreneur does not maintain the equipment. This is because the manufacturer can either sell it in the second hand market to a type L entrepreneur (who has an incentive to maintain even equipment returned by a type H entrepreneur as long as $c_L < (1-\delta)\delta x$), or put it to an alternative use generating higher cash flow than can be generated by a type H entrepreneur (as long as the manufacturer's maintenance cost is sufficiently smaller than that of a type H entrepreneur).

of the equipment for the entire useful life of the equipment, i.e., for all three periods; a short-term leasing contract with an option to buy $\{M, R\}$, where the entrepreneur pays the initial leasing price M up-front and has an option to buy the equipment at time 1 by paying a purchase price R ; and a long-term leasing contract with an option to buy $\{N, P\}$, where the entrepreneur leases the capital good for two periods (i.e., till time 2) by paying the initial leasing price N up-front, with an option to buy the equipment by paying a purchase price P at time 2.¹³ We will introduce two additional types of leasing contracts, namely, service leases and leases with metering in Sections 5.1 and 5.2, respectively.

Of the above menu of contracts, the set of contracts actually offered will be determined in equilibrium: i.e., not all contracts will be offered in all situations.¹⁴ We assume that the manufacturer first chooses the set of contracts to be offered to the entrepreneur from the above menu (at time 0). Then, after observing the contracts offered, the entrepreneur chooses the contract to accept and makes further decisions about the capital equipment over time according to the options specified in the contract accepted.

2.3 The Manufacturer's Objective

The objective of the manufacturer in choosing the menu of contracts (including contract provisions, as well as prices) to be offered to entrepreneurs is to maximize the expected value of his future cash flows.

Consider the objective of the type G manufacturer. If the type G offers a short-term leasing contract with an option to buy $\{M, R\}$, his expected payoff is:

$$\Pi_G(ST) = M + I_{ST}^H \phi R + (1 - I_{ST}^H) \phi \beta (\delta x + \delta^2 x) + I_{ST}^L (1 - \phi) R + (1 - I_{ST}^L) (1 - \phi) \beta (\delta x + \delta^2 x). \quad (1)$$

Here, I_{ST}^L is an indicator variable which captures the type L entrepreneur's choice regarding the purchase of the equipment at time 1. If the type L entrepreneur purchases the equipment, $I_{ST}^L = 1$, in which case the type G manufacturer is expected to receive the purchase price R . If the type L entrepreneur does not purchase the equipment at time 1, i.e., $I_{ST}^L = 0$, she will return the equipment to the type G manufacturer without any maintenance in the first period. In this case, the type G manufacturer receives the residual value of the equipment, equal to $\beta(\delta x + \delta^2 x)$. Similarly, I_{ST}^H is an indicator variable which captures the type H entrepreneur's

¹³ It should be obvious that the sales contract is equivalent to a three-period non-cancelable lease (since the capital equipment is worthless after three periods of use). Note that the equivalences between various leasing and sales contracts that we note above are not confined to our model, but arise in practice as well. In other words, these are features of the real world captured by our model. For example, even in the real world, a non-cancelable lease for the entire useful life of an asset is clearly equivalent to a sales contract. While it is possible to study other possible specifications of leases (in terms of lease lengths or intermediate options, for example), we choose to confine the menu of contracts to the above, since this menu incorporates all the leases commonly observed in practice.

¹⁴ We assume that the contracts that are not accepted in equilibrium by either type of entrepreneur are never offered by any manufacturer.

choice regarding the purchase of the equipment at time 1. We will discuss I_{ST}^L and I_{ST}^H in more detail when we discuss the entrepreneur's objective in the next section.

If the type G manufacturer offers a long-term leasing contract with an option to buy $\{N, P\}$, his expected payoff is:

$$\Pi_G(LT) = N + I_{LT}^H \phi P + (1 - I_{LT}^H) \phi \beta \delta x + I_{LT}^L (1 - \phi) P + (1 - I_{LT}^L) (1 - \phi) \beta \delta x, \quad (2)$$

where I_{LT}^H and I_{LT}^L are indicator variables capturing the entrepreneur's decision regarding whether or not to exercise the option to buy the equipment at time 2, for the type H and type L entrepreneur, respectively. The objective function (2) considers only the case where the maintenance cost of the type H entrepreneur is sufficiently low. In this case, both the type H and the type L entrepreneur will perform maintenance in the first period during the initial lease. However, both types of entrepreneur will not perform any maintenance in the second period covered by the long-term lease if they decide not to exercise the purchase option at the end of the second period (i.e., at time 2). Thus, the residual value of the equipment returned by the type H or the type L entrepreneur is $\beta \delta x$.

If the type G manufacturer offers a combination of a short-term leasing contract $\{M, R\}$ and a long-term leasing contract $\{N, P\}$, his expected payoff in the case where the type L entrepreneur accepts the short-term lease and the type H entrepreneur accepts the long-term lease is:¹⁵

$$\Pi_G(CB) = \phi N + (1 - \phi) M + I_{LT}^H \phi P + (1 - I_{LT}^H) \phi \beta \delta x + I_{ST}^L (1 - \phi) R + (1 - I_{ST}^L) (1 - \phi) \beta (\delta x + \delta^2 x). \quad (3)$$

The type G manufacturer compares the payoffs from the above contracts and chooses the type of contract(s) that maximizes his objective Π_G .

Similarly, the type B manufacturer chooses the type of contract that maximizes his objective Π_B . If the type B manufacturer offers a sales contract $\{S\}$, his expected payoff $\Pi_B(S) = S$. If the type B manufacturer offers a short-term lease with an option to buy $\{M, R\}$, his expected payoff $\Pi_B(ST) = M$ if the entrepreneur chooses not to exercise the purchase option at time 1. Note here that we assume the residual value of type B equipment to be zero. Further, if the type B manufacturer offers a long-term lease with an option to buy $\{N, P\}$, his expected payoff $\Pi_B(LT) = N$ if the entrepreneur chooses not to exercise the purchase option at time 2. Finally, if the type B manufacturer offers a combination of a long-term lease and a short-term lease, his

¹⁵ In the case where the type H entrepreneur accepts the short-term lease and the type L entrepreneur accepts the long-term lease, $\Pi_G(CB) = \phi M + (1 - \phi) N + I_{ST}^H \phi R + (1 - I_{ST}^H) \phi \beta (\delta x + \delta^2 x) + I_{LT}^L (1 - \phi) P + (1 - I_{LT}^L) (1 - \phi) \beta \delta x$. The type G manufacturer also has an option to offer a sales contract $\{S\}$ or a combination of a leasing contract and a sales contract. It will be clear later that these cases never occur in equilibrium.

expected payoff $\Pi_B(CB) = \phi N + (1 - \phi)M$ if the entrepreneur chooses not to exercise the purchase option for both leases.

2.4 The Entrepreneur's Objective

The objective of the entrepreneur at each date is to maximize the expected value of her future cash flow from using the equipment, net of any maintenance costs. Thus, at time 0, the entrepreneur, facing the menu of contracts offered by the manufacturer, chooses the contract which maximizes the expected value of her cash flows over the following periods. The entrepreneur also makes choices on subsequent dates (e.g., whether or not to perform maintenance or whether or not to buy the equipment from the manufacturer at the end of the lease period) in order to maximize her expected cash flows from the remainder of the game.

For instance, consider the case where the type L or the type H entrepreneur is offered a short-term lease $\{M, R\}$ and she infers that the short-term lease is offered by the type G manufacturer. In this case, the type L entrepreneur accepts the short-term lease at time 0 only if it is profitable for her to do so: i.e.,

$$x - M + I_{ST}^L(2x - 2c_L - R) \geq 0. \quad (4)$$

At time 1, the type L entrepreneur purchases the equipment (i.e., $I_{ST}^L = 1$) only if it is profitable for her to do so, i.e., $2x - 2c_L - R \geq 0$. Similarly, the type H entrepreneur accepts the short-term lease at time 0 only if:

$$x - M + I_{ST}^H[\max(2x - 2c_H, \delta x + \delta^2 x) - R] \geq 0. \quad (5)$$

At time 1, the type H entrepreneur purchases the equipment (i.e., $I_{ST}^H = 1$) only if $\max(2x - 2c_H, \delta x + \delta^2 x) - R \geq 0$. Note that the latter condition on $I_{ST}^H = 1$ implies that the type H entrepreneur will maintain the equipment if her maintenance cost c_H is low (in which case her expected payoff from operating the equipment is $2x - 2c_H$), and will not maintain the equipment if her maintenance cost c_H is large (in which case her expected payoff is $\delta x + \delta^2 x$).

Now consider the case where the type L or the type H entrepreneur is offered a long-term lease $\{N, P\}$ and she infers that the long-term lease is offered by the type G manufacturer. In this case, the type L entrepreneur accepts the above contract at time 0 only if it is profitable for her to do so: i.e.,

$$2x - c_L - N + I_{LT}^L(x - c_L - P) \geq 0. \quad (6)$$

At time 2, the type L entrepreneur purchases the leased equipment (i.e., $I_{LT}^L = 1$) only if $x - c_L - P \geq 0$.

Similarly, the type H entrepreneur accepts the contract at time 0 only if:

$$x + \max(x - c_H, \delta x) - N + I_{LT}^H [I_{MT}^H(x - c_H) + (1 - I_{MT}^H)\delta^2 x - P] \geq 0, \quad (7)$$

where I_{MT}^H is an indicator variable which captures the type H entrepreneur's maintenance decision at time 1. $I_{ST}^L = 1$ if $x - c_H > \delta x$ so that the type H entrepreneur chooses to maintain the equipment at time 1. $I_{ST}^L = 1$ if $I_{ST}^L = 0$ if $x - c_H < \delta x$. The type H entrepreneur purchases the leased equipment (i.e., $I_{LT}^H = 1$) only if $I_{MT}^H(x - c_H) + (1 - I_{MT}^H)\delta^2 x - P \geq 0$.

Further, consider the case where the type L or the type H entrepreneur is offered both a short-term and a long-term lease and she infers that these leases are offered by the type G manufacturer. In this case, both the type H and type L entrepreneur have a choice regarding the contract to accept at time 0. The type L entrepreneur will choose the short-term lease rather than the long-term lease at time 0 if both her break-even (individual rationality (IR)) constraint (4) and the following constraint (8) are satisfied:

$$x - M + I_{ST}^L(2x - 2c_L - R) \geq 2x - c_L - N + I_{LT}^L(x - c_L - P). \quad (8)$$

The constraint (8) ensures that accepting the short-term lease is more profitable for the type L entrepreneur than accepting the long-term lease. On the other hand, the type L entrepreneur will choose the long-term lease at time 0 if both her break-even constraint (6) and the opposite of constraint (8) are satisfied. Similarly, the type H entrepreneur will choose the long-term lease rather than the short-term lease at time 0 if both her break-even constraint (7) and the following constraint (9) are satisfied:

$$x + \max(x - c_H, \delta x) - N + I_{LT}^H [I_{MT}^H(x - c_H) + (1 - I_{MT}^H)\delta^2 x - P] \geq x - M + I_{ST}^H [\max(2x - 2c_H, \delta x + \delta^2 x) - R]. \quad (9)$$

On the other hand, the type H entrepreneur will choose the short-term lease if both her break-even constraint (5) and the opposite of constraint (9) are satisfied. The type H or the type L entrepreneur's subsequent purchase decisions I_{ST}^H , I_{ST}^L , I_{LT}^H , and I_{LT}^L are similar to those discussed in the case where only a short-term or only a long-term lease is offered.

Finally, consider the case where the type L or the type H entrepreneur is offered a sales contract and she infers that the sales contract is offered by the type B manufacturer. In this case, both the type L and type H entrepreneur will accept the sales contract only if it is profitable for them to do so: i.e.,

$$-S + fx + f\delta x + f\delta^2 x \geq 0. \quad (10)$$

3 Benchmark Outcomes

In this section, we establish two benchmark outcomes to evaluate the efficiency of various equilibria that we characterize in the following section. We will refer to these as the “first best” and “second best” outcomes. We define first best as the situation where there is symmetric information and each type of manufacturer has available to him both a type H and a type L entrepreneur as customers. In this case, each type of equipment is put to its best use: i.e., to the use which produces the largest value net of maintenance costs. Thus, first best in our setting involves the type G equipment being used by low cost (type L) entrepreneurs, since they have a lower maintenance cost than the type H and their using it for all three periods (rather than, for example, using it for only two periods, and returning it to the manufacturer) creates the largest total value. On the other hand, first best involves the type B equipment being used by either type of entrepreneur for all three periods (since, given the lower value created by using such equipment, it is not worth maintaining such equipment for either type of entrepreneur).¹⁶

We now establish a second benchmark in the symmetric information case, which we will refer to as the second best outcome. In contrast to the first best case, second best characterizes the best use of the equipment in a situation where a type L entrepreneur is not available (in other words, only a type H entrepreneur is available) as a customer to the equipment manufacturer. Unlike the first best outcome, which remains unchanged regardless of the maintenance cost differential c , the second best outcome will vary depending on the maintenance cost differential c (i.e., depending on the magnitude of the type H entrepreneur’s maintenance cost c_H , for a given value of the type L entrepreneur’s maintenance cost c_L). We characterize the second best outcome for various values of c in the following proposition.

Proposition 1 (Second best outcome)

- (i) *The second best use of a piece of type G equipment involves the following, depending on the value of c :*
 - (a) *If $c < x - \beta\delta x - c_L$, it involves the type H entrepreneur using the equipment for three periods, with the entrepreneur performing maintenance for the first two periods.*
 - (b) *If $x - \beta\delta x - c_L \leq c < x - \beta\delta^2 x - c_L$, it involves the type H entrepreneur using the equipment for two periods (performing maintenance only in the first period), with the manufacturer owning it in the third period.*
 - (c) *If $c \geq x - \beta\delta^2 x - c_L$, it involves the type H entrepreneur using the equipment for only one period (not performing any maintenance), with the manufacturer owning it for the remaining two periods.*
- (ii) *The second best use of a piece of type B equipment involves the type H entrepreneur using it for all three periods without performing any maintenance.*

Note that, even in a symmetric information setting, whether a social planner is able to allocate a type G

¹⁶ Since a formal characterization of the first best outcome is very straightforward, we omit it here; it is available to interested readers upon request.

equipment to a type L entrepreneur (and thus achieve the first best outcome) depends on the proportion of type G among manufacturers, and of type H among entrepreneurs. Thus, while the first best is the appropriate benchmark with which to compare the efficiency of a particular equilibrium if a type L entrepreneur is available to accept a piece of equipment, the proper benchmark of comparison is the second best if only a type H entrepreneur is available to accept the equipment.

4 Equilibrium in the Basic Model

Definition of equilibrium. The equilibrium concept we use is that of a Pareto dominant or efficient Perfect Bayesian Equilibrium which survives the Cho-Kreps Intuitive Criterion.¹⁷

4.1 Equilibrium with a Short-term Lease, a Long-term Lease, and a Sales Contract Offered

In this section, we analyze the situation where all three contracts including a short-term lease, a long-term lease, and a sales contract are offered in equilibrium. Before we characterize the equilibrium, we first analyze the problem faced by the type G and the type B manufacturer in arriving at the equilibrium choice of contract(s) to offer in this situation.

4.1.1 The Manufacturer's Problem

When there exists asymmetric information about the manufacturer's equipment, the type G equipment may be underpriced, since entrepreneurs may be unable to distinguish type G from type B equipment and therefore price it at the pooling price. In this case, in order to avoid mispricing of his equipment, the type G manufacturer has an incentive to distinguish himself from the type B manufacturer. Further, given the asymmetric information he faces about the entrepreneur, the type G manufacturer also has an incentive to separate the type H entrepreneur from the type L entrepreneur in order to maximize his profit.

The type G manufacturer can accomplish these two different objectives by offering leasing contracts, i.e., either a short-term lease, a long-term lease, or a combination of a short-term and a long-term leases. Leasing can help the type G manufacturer to distinguish himself from the type B in future periods since the entrepreneur can recognize the quality of the leased equipment during the initial leasing period. The type B manufacturer will not mimic the type G by offering the same leasing contracts, since, if he offered leasing contracts, the entrepreneur

¹⁷ In other words, equilibrium strategies and beliefs in our model are defined as those constituting a Perfect Bayesian Equilibrium (PBE) satisfying the Cho-Kreps Intuitive Criterion, and which minimizes dissipative costs incurred by the type G manufacturer. See Fudenberg and Tirole (1991) for a formal definition of a PBE and Cho and Kreps (1987) for a definition of the Cho-Kreps Intuitive Criterion. See Milgrom and Roberts (1986) for an application of a Pareto dominant or efficient PBE to signaling games.

would not renew these contracts after the initial leasing period, and will instead return the equipment without performing maintenance (i.e., in bad condition). At the same time, the various types of leasing contracts offered and the specific features of these contracts can also help the type G manufacturer segment the user market by separating the two types of entrepreneurs.

If the type G manufacturer offers a short-term lease with an option to buy $\{M, R\}$, it maximizes $\Pi_G(ST)$. In this case, to ensure that the type B manufacturer does not mimic the type G by offering the same short-term lease, the following incentive compatibility (IC) condition has to be satisfied:

$$\Pi_B \geq \Pi_B(ST) = M. \quad (11)$$

Here, Π_B is the type B manufacturer's expected payoff if he offers a contract (e.g., a sales contract) that reveals the true quality of his capital equipment. As we will discuss later, the type B manufacturer can achieve this expected payoff by offering a sales contract $\{S\}$ so that $\Pi_B = S$. $\Pi_B(ST)$ is the type B manufacturer's expected payoff if he offers a short-term lease (thus mimicking the type G). Note that no entrepreneur will purchase the type B manufacturer's equipment at the end of the lease after recognizing the quality of the leased equipment during the initial leasing period. Thus, $\Pi_B(ST) = M$. Further, the type G manufacturer also has to design the short-term lease so that either the IR constraint (4), or (5), or both are satisfied. The IR constraints (4) and (5) ensure that the type L and the type H entrepreneur, respectively, are willing to accept the short-term lease. Whether the type G manufacturer prefers that both types of entrepreneur or only one type of entrepreneur accept the short-term lease depends on whether the type G manufacturer prefers to distinguish between these two types of entrepreneur or pool them in equilibrium.

If the type G manufacturer offers a long-term leasing contract with an option to buy $\{N, P\}$, it maximizes $\Pi_G(LT)$. Similar to the case of a short-term lease, the type B manufacturer's IC constraint has to be satisfied in this situation as well:

$$\Pi_B \geq \Pi_B(LT) = N. \quad (12)$$

Depending on the nature of the equilibrium, the IR constraint (6), (7), or both also have to be satisfied to ensure that either the type L or the type H entrepreneur or both will accept the long-term lease.

Finally, if the type G manufacturer offers a combination of a short-term leasing contract $\{M, R\}$ and a long-term leasing contract $\{N, P\}$, it maximizes $\Pi_G(CB)$. Similarly, the following IC constraint on the type B manufacturer has to be satisfied:

$$\Pi_B \geq \Pi_B(CB) = \phi N + (1 - \phi)M. \quad (13)$$

The IC constraint (13) takes into consideration that the type L entrepreneur is expected to accept the short-term lease and the type H entrepreneur is expected to accept the long-term lease. To meet this expectation, the type G manufacturer also has to design the leases so that the IR constraints (4), (7), (8), and (9) are satisfied.¹⁸

Unlike the type G manufacturer, the type B manufacturer does not benefit from separating the two types of entrepreneurs, since neither the type H nor the type L entrepreneur has the incentive to maintain the type B equipment. In other words, the type B manufacturer's objective is maximized by pooling the two types of entrepreneurs. Further, as discussed under the type G manufacturer's problem, if the type G manufacturer chooses the terms of the leasing contracts he offers in such a way as to distinguish himself from the type B, then the type B is worse off if he attempts to mimic the type G, compared to the case where he reveals his type by offering a sales contract. As a result, the type B manufacturer is better off (in terms of maximizing his expected cash flows) offering only a sales contract and charging the entrepreneur a sales price corresponding to the true quality of the capital equipment sold.¹⁹ In sum, the type B manufacturer maximizes his objective $\Pi_B = S$, subject to the entrepreneur's IR constraint (10) and the following IC constraint (14):

$$\Pi_G \geq S. \tag{14}$$

The IC constraint (14) ensures that the type G manufacturer has no incentive to mimic the type B manufacturer (this constraint is satisfied trivially).

4.1.2 The Equilibrium

When the difference in equipment quality between the two types of manufacturer is large (i.e., the quality factor is large) and the difference in the maintenance cost between the type H and type L entrepreneur is sufficiently small, the type G manufacturer's equilibrium choice consists of a combination of a long-term lease and a short-term lease while the type B manufacturer offers only a sales contract in equilibrium. We characterize the conditions for the existence of this equilibrium in the following proposition.

Proposition 2 (Separating equilibrium on both sides: a short-term lease, a long-term lease, and a sales contract offered) *When the quality factor is large enough so that $f \geq \underline{f}$ and the difference in the*

¹⁸ The type G manufacturer also has an option to offer a sales contract $\{S\}$ or a combination of a leasing contract and a sales contract. However, unlike short-term or long-term leasing contracts, a sales contract cannot help the type G manufacturer to distinguish himself from the type B manufacturer, since the type B would not incur any cost of mimicking the type G by offering the same sales contract. Thus, it can be shown that the type G manufacturer is at least weakly better off offering leasing contracts alone rather than any combination of leasing contract(s) and a sales contract.

¹⁹ The assumption here is that if a manufacturer obtains the same expected cash flows from offering a leasing or a sales contract, he would choose to offer a sales contract. It seems reasonable to make such an assumption, since, in practice, the total transaction costs to the manufacturer involved in offering (and following up) a lease will be at least marginally higher than that associated with offering a sales contract.

maintenance cost between the type H and L entrepreneur is such that $\underline{c} \leq c < \bar{c}$, then there exists an equilibrium in the capital goods market involving the following:

- (i) The type G manufacturer offers both a short-term leasing contract and a long-term leasing contract, and the type B manufacturer offers only a sales contract.
- (ii) If the manufacturer offers the above leasing contracts, both types of entrepreneur believe that the manufacturer is of type G with probability one. The type L entrepreneur accepts the short-term contract, purchase the equipment at time 1, and performs maintenance in the first and the second period; the type H entrepreneur accepts the long-term contract, uses the equipment for two periods, performs maintenance only in the first period, and does not purchase the equipment at time 2.
- (iii) If the manufacturer offers only a sales contract, both the type H and type L entrepreneurs believe that the manufacturer is of type B with probability one, accept the sales contract, use it for three periods, and do not perform maintenance.^{20 21}

As we discussed in the previous section, when there exists asymmetric information about the manufacturer's equipment, the type G manufacturer has an incentive to distinguish himself from the type B manufacturer by offering leasing contracts. However, by doing so, the type G manufacturer incurs a signaling cost. This cost arises from the fact that the type G may have to sacrifice some of his profits in the initial leasing period by strategically setting a low price for that period in order to prevent mimicking by the type B. When the quality difference between the type G and the type B equipment is sufficiently large so that $f \geq \underline{f}$, the cost arising from setting such a low initial leasing price is small and outweighed by the benefit arising from setting a fair price in future periods.

The type G manufacturer also has an incentive to separate the type H entrepreneur from the type L entrepreneur so that his equipment can be used by each entrepreneur for an optimal period. The type G manufacturer always prefers the type L entrepreneur to use the equipment for three periods. This is because the type L entrepreneur will properly maintain the type G equipment and generate high cash flows for all three periods. The type G manufacturer also prefers the type H entrepreneur to use the equipment for the first period since the type H entrepreneur is able to generate more profit from new equipment compared to the manufacturer himself. Further, when $c < \bar{c}$ so that the type H entrepreneur has an incentive to maintain the equipment, the type G manufacturer has an incentive to let the type H entrepreneur utilize the equipment beyond the first period. However, to implement it, the type G manufacturer has to strategically charge a price which allows the type H entrepreneur to break even. This price is lower than the maximum price that the type G manufacturer can charge the type L entrepreneur, thereby causing the type G manufacturer to sacrifice part of his profit from

²⁰ The out-of-equilibrium beliefs for these and the following propositions are specified in the appendix. These beliefs are such that they satisfy the Cho-Kreps Intuitive Criterion.

²¹ The definitions of various threshold values in this proposition as well as the following propositions are confined to the appendix.

leasing the equipment to the type L entrepreneur. When $c \geq \underline{c}$, the potential cost from the type H entrepreneur using the equipment in the third period exceeds the expected benefit. In this case, the type G manufacturer finds it optimal to let the type H entrepreneur use the equipment for only two periods rather than for all three periods.

To achieve the optimal use of the equipment, the type G manufacturer offers a combination of a short-term lease and a long-term lease in equilibrium. He sets the leasing prices in such a way that a type H entrepreneur will accept the long-term lease and use the equipment for two periods (returning the equipment to the manufacturer after the second period), while a type L entrepreneur will accept the short-term lease and use the equipment for all three periods, purchasing the equipment at the end of the first period.²²

In the above equilibrium, if the entrepreneur facing a type G manufacturer turns out to be a type L entrepreneur, the first best outcome would be achieved, since a type L entrepreneur will accept the short-term lease and purchase the equipment at the end of the first period (performing maintenance in the first two periods). If, however, the entrepreneur facing the type G manufacturer turns out to be of type H, then clearly the first best outcome is not achievable so that the appropriate benchmark of efficiency is the second best outcome. However, in this case, the second best outcome (as characterized in proposition 1(i.a)) is not achievable as well, since the type H entrepreneur uses the equipment for only two periods, performing maintenance for only one period. This is because, given the asymmetric information facing the type G manufacturer about the maintenance cost of the entrepreneur, inducing a type H entrepreneur to use the type G equipment for all three periods by charging a lower purchase price at the end of a long-term lease is not a profit maximizing strategy (since it will induce the type L to accept such a leasing contract as well, reducing the potential profit that the manufacturer can earn from a type L entrepreneur). Finally, the first best outcome is achieved for type B equipment in this equilibrium, since the first best outcome requires type B equipment to be used by either type of entrepreneur for all three periods without performing maintenance.

²² Note that, in this case, a short-term lease alone or a long-term lease alone can also help the type G manufacturer achieve the separation from the type B manufacturer. However, a short-term lease alone is an inferior choice for the type G, since the short-term lease cannot allow the type H entrepreneur to use the equipment beyond the first period. Similarly, a long-term lease alone is also an inferior choice. This is because the type G manufacturer has to sacrifice some of his profit in the initial leasing period in order to attain separation from the type B manufacturer, and offering a long-term lease would require him to sacrifice a larger fraction of his profit in the initial leasing period compared to the case where he offers a combination of a short-term and a long-term lease. Thus, the asymmetric information on the manufacturer's side interacts with the asymmetric information on the entrepreneur's side, forcing the type G manufacturer to use a combination of leasing contracts to separate the two types of entrepreneurs.

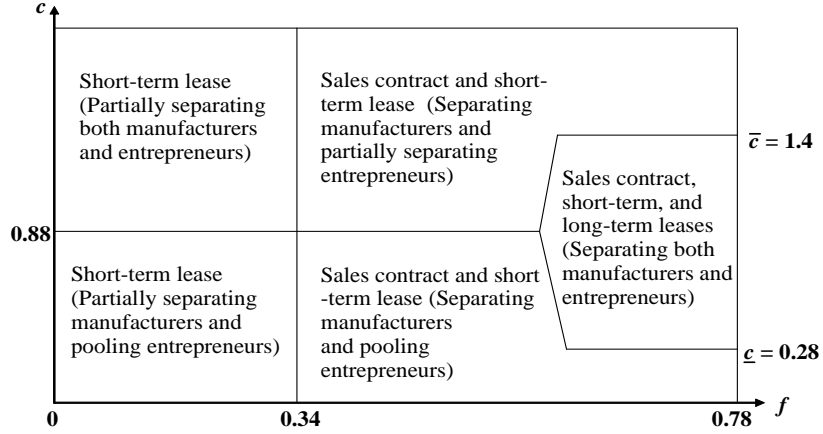


Figure 2: Characterization of the entire range of equilibria with respect to the maintenance cost differential c and the quality factor f

4.1.3 A Numerical Example

Assume the following values for the parameters employed in the basic model: $\delta = 0.6$, $x = 16$, $c_L = 5$, $\beta = 1.05$, $\theta = 0.5$, and $\phi = 0.3$. Based on these numbers, we depict in figure 2 the equilibrium characterized in proposition 2, as well as the equilibria characterized in the following sections. We depict these equilibria in $c - f$ space: On the c -Axis, we start from the situation where the difference in maintenance cost between the type H and type L entrepreneurs c is small and end at the situation where c is large; on the f -Axis, we start from the situation where the quality factor f is small (i.e., difference in equipment quality between the two types of manufacturer is large) and end at the situation where f is large and close to $\frac{c_L}{(1-\delta)x} = 0.78$, the maximum value of f under our assumption. Thus, we characterize the equilibria for the entire range of values of $c \in (0, \infty)$ and $f \in (0, \frac{c_L}{(1-\delta)x})$. It is worth noting that c can be viewed as measuring the extent of asymmetric information faced by the manufacturer regarding the entrepreneur. When c is larger, the extent of asymmetric information facing the manufacturer about the entrepreneur is larger. Similarly, f can be viewed as measuring the extent of asymmetric information faced by the entrepreneur regarding the manufacturer. When f is smaller, the extent of asymmetric information facing the entrepreneur about the manufacturer is larger. Thus, we characterize the equilibria for the entire range of situations where the manufacturer and the entrepreneur face various degrees of asymmetric information. It can be shown that the equilibrium that we characterize in each range of parameter values is unique. We now move on to briefly discuss the conditions under which these equilibria will differ from the one in proposition 2, i.e., we will characterize all the other equilibria presented in figure 2.

4.2 Equilibria with Only a Short-term Lease and a Sales Contract Offered

When the difference in the maintenance costs between the type H and the L entrepreneur is larger than that characterized in proposition 2 so that the maintenance cost of the type H is sufficiently large, the profit generated by the equipment if used by a type H entrepreneur during the second and the third periods will be smaller than the residual value of the equipment to the type G manufacturer. This will be the case when $c_H > (1 - \delta)x$, so that the type H entrepreneur does not find it optimal to maintain the type G equipment. It could also happen when the type H has an incentive to maintain the type G equipment (i.e., $c_H \leq (1 - \delta)x$) but the cash flow generated by the type H entrepreneur net of the maintenance cost is still sufficiently small. In both cases, the type G manufacturer has an incentive to repossess the equipment from the type H entrepreneur after the first period.²³ The following proposition characterizes this situation.

Proposition 3 (Manufacturers separate and entrepreneurs partially separate: a short-term lease and a sales contract offered) *When the quality factor is large enough ($f \geq \underline{f}$) and the difference in the maintenance cost between the type H and L entrepreneur is large enough ($c \geq \bar{c}$), then the equilibrium in the capital goods market involves the following:*

- (i) *The type G manufacturer offers only a short-term leasing contract and the type B manufacturer offers only a sales contract.*
- (ii) *If the manufacturer offers the short-term leasing contract, the type L entrepreneur accepts the contract, purchases the equipment at time 1, and performs maintenance in the first and the second period; the type H entrepreneur accepts the contract as well, uses the equipment for one period without performing maintenance, and does not purchase the equipment at time 1. Both types of entrepreneur believe the manufacturer to be of type G with probability one in this case.*
- (iii) *If the manufacturer offers only a sales contract, both the type H and type L entrepreneurs accept the sales contract and do not perform maintenance, believing the manufacturer to be of type B with probability one.*

When the quality difference between the type G and type B equipment is the same as that in proposition 2 while the difference in the maintenance cost is larger than that in proposition 2, the type G manufacturer offers only a short-term lease and the type B manufacturer offers a sales contract in equilibrium. Following the same intuition as in proposition 2, the short-term lease in this equilibrium can help the type G manufacturer to achieve the separation from the type B manufacturer. Further, the short-term lease also enables the type G manufacturer to separate the type H entrepreneur from the type L entrepreneur and maximize his expected payoff. When $c \geq \bar{c}$, the type G manufacturer prefers to repossess his equipment from the type H entrepreneur after the first period while enabling the type L entrepreneur to utilize the equipment for as long a period as possible. To achieve this, the type G manufacturer sets the purchase price of his short-term lease high enough

²³ Note that the type G manufacturer still prefers the type H entrepreneur to use the equipment for the first period, since the entrepreneur is able to generate more cash flows from new equipment compared to the manufacturer himself.

that the type H entrepreneur does not find it optimal to exercise the purchase option after the initial leasing period, while the type L entrepreneur will exercise it.²⁴

In the above equilibrium, if the entrepreneur facing a type G manufacturer turns out to be of type L, the first best outcome would be achieved, since a type L entrepreneur will accept the short-term lease and purchase the equipment at the end of the first period (performing maintenance in the first two periods). If, however, the entrepreneur facing the type G manufacturer turns out to be of type H, then clearly the first best outcome is not achievable for the type G equipment, and the appropriate benchmark is the second best outcome. In this case, the second best outcome may or may not be achievable, depending on the maintenance cost of the type H entrepreneur.²⁵ The first best outcome is achieved for the type B equipment here, since the first best outcome requires type B equipment to be used by either type of entrepreneur for all three periods without performing maintenance.

We now consider the case where the quality difference between the type G and type B equipment is the similar to that in proposition 2, but the difference in the maintenance costs between the type H and the L entrepreneur is smaller than that in proposition 2. The following proposition characterizes this situation.

Proposition 4 (Manufacturers separate and entrepreneurs pool: a short-term lease and a sales contract offered) *When the quality factor is large enough that $f \geq \underline{f}$ while the difference in the maintenance cost between the type H and L entrepreneur is small enough that $c < \underline{c}$, then the equilibrium in the capital goods market involves the following:*

- (i) *The type G manufacturer offers a short-term leasing contract, and the type B manufacturer offers only a sales contract.*
- (ii) *If the manufacturer offers the above leasing contract, both the type L and the type H entrepreneur accept the short-term contract, purchase the equipment at time 1, and perform maintenance in the first and the second period. Both types of entrepreneur believe the manufacturer to be of type G with probability one in this case.*
- (iii) *If the manufacturer offers only a sales contract, both the type H and type L entrepreneurs accept the sales contract and do not perform maintenance, believing the manufacturer to be of type B with probability one.*

²⁴ In this case, a long-term leasing contract (or a combination of a long-term and a short-term contract) is an inferior choice for the type G manufacturer compared to a short-term lease even if the long-term lease could also help the type G manufacturer separate himself from the type B manufacturer. First, given the high maintenance cost of the type H entrepreneur and the potential lack of maintenance, the type G manufacturer prefers to repossess his equipment from the type H entrepreneur after the first period. Second, the initial leasing price that can be charged by the type G manufacturer is constrained by the need to prevent mimicking from the type B manufacturer. This implies that the type G manufacturer would sacrifice more of his expected cash flow when he offers a leasing contract with a longer initial leasing period. As a result, a long-term lease will not be offered in equilibrium. In summary, the interaction between the asymmetric information existing on the manufacturer's side and the asymmetric information existing on the entrepreneur's side drives the equilibrium choice of contracts offered by the manufacturer in this setting.

²⁵ If her maintenance cost is large enough that proposition 1(i.c) holds, i.e. $c \geq x - \beta\delta^2x - c_L$, then the second best is achievable, since in this case, the second best outcome calls for the type G equipment to be used by the type H entrepreneur for only one period, which is the case in this proposition. If, however, her maintenance cost is smaller, so that it is in the range where either proposition 1(i.a) or proposition 1(i.b) holds, i.e., $c < x - \beta\delta^2x - c_L$, then the second best is not achievable, since the second best outcome requires the type G equipment to be used for more than one period.

As discussed under proposition 2, whether it is optimal for the type G manufacturer to have a type H entrepreneur use his equipment for two or three periods depends on the maintenance cost of the type H entrepreneur, the potential damage to the equipment due to lack of maintenance, and the reduction in the type G manufacturer's profit from having to charge a lower price which would allow a type H entrepreneur to break even. Under the conditions characterized in this proposition, the type H entrepreneur's maintenance cost is small enough that the type G manufacturer's profit from the type H entrepreneur's use of the equipment for an additional two periods exceeds his sacrifice in the profit that he would earn from charging a fair price to the type L entrepreneur. Consequently, the optimal choice for the type G manufacturer is to enable both the type L and type H entrepreneurs to use the equipment for all three periods. The type G manufacturer can achieve this by offering a short-term leasing contract, and charging a purchase price that is low enough that both the type H and the type L entrepreneur will exercise the purchase option at time 1. The short-term lease offered can also help the type G manufacturer to signal his firm type to the entrepreneur for the reasons discussed in the previous propositions.²⁶

4.3 Equilibria with Only a Short-term Lease Offered

In the equilibria characterized in the previous sections, the type G manufacturer uses different types of leasing contracts to separate himself from the type B manufacturer. However, when the quality of the type B capital equipment is significantly lower than that of the type G, achieving separation in the initial period from the type B manufacturer will not be the equilibrium choice of the type G manufacturer. We characterize such situations below.

Proposition 5 (Manufacturers and entrepreneurs partially separate: only a short-term lease offered) *When the quality factor is small enough that $f < \underline{f}$ and the difference in the maintenance cost between the type H and L entrepreneur is large enough that $c \geq \bar{c}$, then the equilibrium in the capital goods market involves the following:*

- (i) *Both the type G manufacturer and the type B manufacturer offer a short-term leasing contract.*
- (ii) *Both types of entrepreneur accept the above leasing contract. If the equipment is of type G, the type L entrepreneur purchases the equipment at time 1 and maintains the equipment during the first and the second periods; if the equipment is of type B, she does not perform maintenance and she does not purchase the equipment. Regardless of the true type of the equipment, the type H entrepreneur uses the equipment*

²⁶ In the above equilibrium, if the entrepreneur facing a type G manufacturer turns out to be of type L, the first best outcome would be achieved, since a type L entrepreneur will accept the short-term lease and purchase the equipment at the end of the first period for another two periods (performing maintenance in the first two periods). If, however, the entrepreneur facing the type G manufacturer turns out to be of type H, then clearly the first best outcome is not achievable for the type G equipment, and the second best is the appropriate benchmark. In this case, the second best outcome will be achieved, since the second best outcome in this range of parameter values calls for the type G equipment to be used by the type H entrepreneur for all three periods with maintenance performed for the first two periods (see proposition 1(i.a)). The first best outcome is achieved for the type B equipment here, since the first best outcome requires type B equipment to be used by either type of entrepreneur for all three periods without performing maintenance.

for only one period without performing any maintenance and she does not purchase the equipment at time 1.²⁷

If the quality factor f is sufficiently small (i.e., the quality of the type B capital equipment is sufficiently lower than that of the type G), then the sales price that the type B can charge corresponding to the true value of his own equipment is substantially smaller than the true value of the type G equipment. This creates a strong incentive for the type B manufacturer to mimic the type G. The type G manufacturer, therefore, has to set a significantly lower initial leasing price to prevent mimicking by the type B, thereby incurring a large cost of separation. Given this, the type G manufacturer finds it optimal to pool with the type B in the initial leasing period by offering the same short-term lease as the type B manufacturer does. However, the type G manufacturer can still achieve separation in subsequent periods. At time 1, after recognizing the true type of the leased equipment, neither type of entrepreneur will purchase the type B equipment, while the type L entrepreneur will purchase the type G equipment.

Further, given the high maintenance cost of the type H entrepreneur, i.e., $c \geq \bar{c}$, it is optimal for the type G manufacturer to induce the type H entrepreneur not to purchase the equipment and instead return the equipment to the manufacturer (since the residual value of the equipment is greater than the profit that can be generated by the type H entrepreneur in the second and third periods). The type G manufacturer can do so by setting a sufficiently large purchase price, so that the type L entrepreneur exercises the purchase option at time 1 while the type H does not exercise. As a result, while the type L entrepreneur pools with the type H in the initial leasing period, she will separate from the type H in the subsequent periods, if the capital equipment is of type G.²⁸

Proposition 6 (Manufacturers partially separate and entrepreneurs pool: only a short-term lease offered) *When the quality factor is small enough that $f < \underline{f}$ and the difference in the maintenance cost between*

²⁷ Since, at time 0, both types of manufacturers offer the same leasing contract, and both types of entrepreneur accept this contract, the beliefs of manufacturers about entrepreneurs and of entrepreneurs about manufacturers remain the same as their prior beliefs at time 0. At time 1, entrepreneurs are able to distinguish between the type G and type B equipment with probability one (through their use of the equipment). At time 1, the type G manufacturer is also able to distinguish between the type H and type L entrepreneurs with probability one, since only the type L entrepreneur purchases the equipment (while the type H does not); the type B manufacturer is unable to distinguish between the two types of entrepreneurs even at time 1 since neither type purchases the type B equipment.

²⁸ In this situation, the first best outcome will be achieved for the type G equipment, for the reasons discussed under proposition 3. The second best outcome may or may not be achieved for the type G equipment, depending on the maintenance cost of the type H entrepreneur, for the reasons discussed under proposition 3 (please see that discussion for the parameter ranges of this maintenance cost where second best is achieved or otherwise). Unlike in the situation characterized in previous propositions, neither first best nor second best is achievable for the type B equipment regardless of whether or not a type L entrepreneur is available to lease the equipment. This is because neither type of entrepreneur uses the type B equipment for all three periods, which the first best outcome calls for: while the type B manufacturer finds it profit maximizing to take advantage of the asymmetric information facing entrepreneurs by offering a short-term lease on the same terms as the type G, neither type of entrepreneur will purchase the equipment once the true quality of the equipment is revealed in the initial leasing period, since the equipment is overpriced relative to its true quality.

the type H and L entrepreneur is small enough that $c < \bar{c}$, then the equilibrium in the capital goods market involves the following:

- (i) Both the type G manufacturer and the type B manufacturer offer a short-term leasing contract.
- (ii) Both types of entrepreneur accept the above leasing contract. If the equipment is of type G, they purchase the equipment at time 1 and maintain the equipment during the first and second periods; if the equipment is of type B, they do not maintain the equipment at all and do not purchase the equipment at time 1.

Similar to the case in the previous proposition, the type G manufacturer chooses to pool with the type B manufacturer in the first period by offering a short-term lease, since the difference in quality between the two types of equipment is very large. However, in this case, the type H entrepreneur’s maintenance cost is small enough that the value of the type G equipment if it is used by the type H entrepreneur is larger than the residual value of the off-lease equipment to the type G manufacturer. Thus, it is optimal for the type G to induce the type H entrepreneur to use the equipment during the second and third periods. The type G manufacturer accomplishes this by setting the purchase price low enough that the type H entrepreneur (as well as the type L) will choose to exercise the purchase option at time 1. In summary, while the equilibrium is partially separating on the manufacturer’s side (since, while both type G and type B offer a short-term lease, only the type G’s equipment is purchased by entrepreneurs), it is fully pooling on the entrepreneur’s side.²⁹

5 Service Leases and Metering in a Simplified Model

In this section, we will analyze the rationale for service leases and leases with metering, and investigate the conditions under which they are offered. Since our focus in this section is on the service and metering provisions in leasing contracts rather than on the duration of leases, we will simplify our basic model from a three-period model to a two-period model. Thus, in this simplified model, equipment cannot generate any cash flows to the entrepreneur after two periods and the residual value of returned equipment is zero after time 2. All other features of the basic model will remain unchanged in this simplified model. In the following, we first analyze service leases and then study leases with metering.

5.1 Service Leases

A “service” lease refers to a lease where a contractual provision in the leasing contract requires the manufacturer (lessor) to provide maintenance to the entrepreneur (lessee).³⁰ In other words, in a service lease, a

²⁹ In this situation, the first best and second best outcomes will be achieved for type G equipment for the reasons discussed under proposition 4. However, neither first best nor second best outcomes will be achieved for type B equipment, for the reasons discussed under proposition 5.

³⁰ In contrast, a lease where the entrepreneur (lessee) has the responsibility to maintain the asset is referred to as a “net” lease in the leasing terminology.

service contract is bundled with the leasing contract.

We modify two assumptions in the basic model here. First, we simplify the model to two periods rather than three periods, as we discussed above. Second, we modify the menu of contracts that can be offered, by allowing for the possibility of a service lease. Thus, the menu of contracts now consists of three possible contracts: a short-term renewable lease with a service contract bundled with it (i.e., a service lease); a short-term renewable lease without any service provision (as in our basic model); or a sales contract.³¹ If a service lease is renewed, the entrepreneur obtains the use of the equipment for another period, with the manufacturer obligated to maintain the equipment for the second period as well.

Following the notation in the basic model, we will use M_1 and R_1 to denote the initial leasing price and the renewal price, respectively, in the short-term lease without a service provision; M_2 and R_2 will denote the corresponding prices in a short-term service lease. We denote the manufacturer's maintenance cost by c_P . All other notations will remain the same as in the basic model. We now characterize the situation in which a service lease is offered in equilibrium.

Proposition 7 (Equilibrium with a service lease) *When the quality factor is large enough that $f \geq \underline{f}$ and the maintenance cost of the manufacturer $c_P \in [c_L, \widehat{c}]$, there exists a separating equilibrium in the capital goods market involving the following:*

- (i) *The type G manufacturer offers two different leasing contracts: a short-term renewable service lease and a short-term lease without a service provision. The renewal price on the service lease is higher than that on the short-term lease without a service provision. The type B manufacturer offers a sales contract.*
- (ii) *If the manufacturer offers the above leasing contracts, entrepreneurs believe that he is of type G with probability one. The type L entrepreneur accepts the short-term leasing contract without the service provision, and at time 1, she renews her lease. She performs maintenance for the first period. The type H entrepreneur accepts the service lease, and at time 1, she renews her lease. She performs no maintenance, relying on the maintenance performed by the manufacturer in the first period as specified by the service lease.*
- (iii) *If the manufacturer offers only a sales contract, both the type H and type L entrepreneur accept the sales contract, and perform no maintenance in any period, believing the manufacturer to be of type B with probability one.*

The intuition behind the above proposition is as follows. The difference between the cost to the entrepreneur for the net lease (i.e., the lease without a service provision) and that for the service lease is such that the type L entrepreneur benefits from taking the net lease, while the type H entrepreneur is better off accepting the service lease. In contrast to the case where no service lease is offered, the type H entrepreneur also chooses to renew the (short-term) service lease, since the properly maintained capital equipment yields her a positive expected cash flow. Recall that, when the service lease is not offered, the type H entrepreneur would have to incur a high

³¹ Recall that, since there are only two periods in this simplified model, a long-term (two-period) lease would be identical to a sales contract.

cost to perform the maintenance, so that she is better off returning the equipment after one period (without performing any maintenance in the first period).

As before, the type G manufacturer chooses to offer leases in equilibrium to signal his type and to prevent the type B manufacturer from mimicking. However, when his own maintenance cost is not too large, the type G manufacturer chooses to offer a service lease rather than offering the leasing contract without service described in the basic model. This is because, as discussed above, offering a service lease induces the type H entrepreneur (as well as the type L) to renew her short-term lease and use the equipment for two periods, thus generating greater cash flows compared to the situation in which the type H entrepreneur uses the equipment for only one period and returns it to the manufacturer. Given that the manufacturer can extract much of this additional cash flow generated by the type H entrepreneur by charging a higher renewal price on the service lease, he is better off offering a service lease. In equilibrium, the type G manufacturer also offers a short-term lease without service which is accepted by the type L entrepreneur. Since the maintenance cost of the type L is lower than that of the type H, she is better off taking the lease without a service provision and enjoying the lower renewal price associated with that lease.

In the above equilibrium, the manufacturer's maintenance cost, c_P , may be lower or greater than that of the type H entrepreneur, c_H : in other words, the threshold value of c_P for which the equilibrium exists, \hat{c} , may be greater than c_H . Further, \hat{c} is decreasing in the residual value of the returned equipment to the manufacturer, β . Thus, when β is large, an equilibrium with a service lease exists only if the manufacturer's maintenance cost is lower than that of the type H entrepreneur. However, when this residual value is lower, the type G manufacturer may offer a service lease even when his maintenance cost is greater than that of the type H entrepreneur, as we show below.

Corollary 1 *When the residual value factor $\beta < \frac{x-c_H}{\delta x}$, there exists an equilibrium where the type G manufacturer offers the combination of a short-term service lease and a short-term lease without service (as in proposition 7) even when $c_P > c_H$.*

The above corollary characterizes the conditions under which the type G manufacturer is better off (in terms of maximizing his expected cash flow) offering a service lease even when his maintenance cost is greater than that of the type H entrepreneur. In other words, under the above conditions, the manufacturer is better-off "eating" the maintenance cost differential between himself and the type H entrepreneur and offering maintenance through the service lease. If, instead, the type G manufacturer offers a short-term lease without service, the type H entrepreneur would not renew the lease at time 1, and she will return the equipment without performing

maintenance. As discussed before, offering a service lease is a better strategy for the type G manufacturer in the above situation, since, in the case of a service lease, the type H entrepreneur will renew the lease and generate greater cash flows from the well-maintained equipment, which can be extracted by the manufacturer through a higher renewal price. When the equipment is sufficiently sensitive to lack of maintenance ($\delta < \frac{x-c_H}{\beta x}$) or the residual value of the equipment is low ($\beta < \frac{x-c_H}{\delta x}$), the difference in revenue to the type G manufacturer between offering a service lease and a short-term lease without service is large enough that it is optimal for him to offer a service lease even when his cost of providing maintenance is greater than that of the type H entrepreneur.

5.2 Leases with Metering

“Metering” refers to a contractual provision in leasing contracts which links the lease payments to some measure of the intensity of the asset’s usage by the lessor (e.g., computer lease payments may be linked to CPU cycles; automobile lease payments to odometer mileage, etc.). In many situations, leases with metering may be the most efficient way for the type G manufacturer to segment entrepreneurs (lessees), while simultaneously achieving separation from the type B manufacturer. We will characterize the conditions under which this is the case below.

Similar to the model in the previous section on service leases, we consider a simplified two-period model here, where the value of any equipment is zero after time 2, both to the entrepreneur and to the manufacturer. Also, unlike in the basic model, we now assume that entrepreneurs differ in usage intensity. There are two kinds of entrepreneurs: the high-intensity entrepreneur uses the capital equipment more intensely (for instance, for more hours per period) than the low intensity entrepreneur. We assume that high intensity use yields the entrepreneur a greater expected cash flow than low intensity use (denote the cash flow ratio between low and high intensity use by l , $l \leq 1$). Therefore, for the type G equipment, the low-intensity entrepreneur receives cash flows of lx at each period, and the high-intensity entrepreneur receives cash flows of x for the same two periods. For simplicity, we assume that, for the type B equipment, both types of entrepreneurs receive the same expected cash flows of fx in each period. The manufacturer has the ability to meter the intensity of usage of the equipment using a metering technology at a cost m . To minimize complexity in this section, we set the maintenance costs of both type H and type L entrepreneurs to be equal to zero ($c_H = c_L = 0$). Similar to the basic model, we assume that the residual value of the equipment to the manufacturer is β times the present

value of the cash flows from the equipment to the low-intensity entrepreneur.

In this section, we modify the menu of contracts that can be offered by allowing for the possibility of a short-term renewable lease with metering. Thus, the menu of contracts consists of three possible contracts: a short-term renewable lease with metering; a short-term renewable lease without metering (as in our basic model); or a sales contract. Following the notation in our basic model, we will use M_1 and R_1 to denote the initial leasing price and the renewal price, respectively, in the short-term lease without a metering provision; M_2 and R_2 denote the corresponding prices in a short-term lease with metering. If the entrepreneur accepts a leasing contract with metering, she uses the equipment for one period by paying an initial leasing payment M_2 upfront at time 0, with an additional charge V at time 1 if she uses the equipment above a threshold usage u , as measured by metering. At time 1, the entrepreneur has an option to renew the contract for another period by paying R_2 . On the other hand, if the entrepreneur accepts the leasing contract with no metering, she can use the equipment for one period without any constraint on usage by paying M_1 upfront at time 0, with an option to renew for one more period by paying R_1 at time 1.

Proposition 8 (Equilibrium with metering) *When the quality factor is large enough that $f \geq f_2$ and the metering cost is small enough that $m \leq \bar{m}$, the equilibrium in the capital goods market involves the following:*

- (i) *The type G manufacturer offers two different leasing contracts: a leasing contract with metering; and a leasing contract with no metering. The type B manufacturer offers a sales contract.*
- (ii) *If the manufacturer offers the above leasing contracts, entrepreneurs believe that the manufacturer is of type G with probability one. The low intensity entrepreneur accepts the leasing contract with limited usage and metering, uses the equipment within the threshold level u , and renews her lease at time 1. The high-intensity entrepreneur accepts the leasing contract with no metering, and renews her lease at time 1.*
- (iii) *If the manufacturer offers only a sales contract, both the high-intensity and low-intensity entrepreneurs accept the sales contract, believing the manufacturer to be of type B with probability one.³²*

As in the basic model, the type G manufacturer uses leasing contracts to prevent the type B from mimicking. Further, metering allows the type G manufacturer to increase his expected profits by segmenting the user market between high-intensity and low-intensity usage entrepreneurs. Under the contract with metering, the manufacturer sets a high charge for usage above the threshold level u , so that the high intensity entrepreneur does not accept this contract. At the same time, he sets a comparatively high initial leasing price in the leasing contract without metering (and unlimited usage), which ensures that the low-intensity entrepreneur is better off choosing the metering contract rather than the contract without metering. The only additional cost incurred

³² The proof of this proposition is lengthy and is omitted due to space limitations. It is available in the working paper version of this article.

in the equilibrium with metering is the metering cost (since the additional charge for usage above the threshold level is never incurred in equilibrium). When this metering cost is low enough, metering contracts will be offered, since this enables the type G manufacturer to segment the market for capital equipment between high-intensity and low-intensity usage entrepreneurs in the least-cost way.

6 Implications of the Model

We now discuss some of the testable implications of our model.

(i) *Implication for the prevalence of leasing contracts:* The first implication of our model relates to the kinds of equipment that are more likely to be leased rather than sold outright. Our model predicts that leasing will be more prevalent in industries where there is a greater extent of asymmetric information between manufacturers of capital equipment and entrepreneurs (users). In this context, the manufacturer's private information need not necessarily be about the quality of the capital equipment, as we discussed earlier: it may relate to any other aspect of the capital equipment which affects its value to users: e.g., the manufacturer's own future rate of introduction of a new product, which, in turn, affects the rate of technological obsolescence of the capital equipment and thereby its value to users. Thus, we predict that industries making use of newer technologies or those characterized by more rapid technological change will have a greater proportion of capital equipment being leased compared to those employing more conventional technologies and those having a slower rate of technological change. Consistent with this prediction, Richter (1998) documents that the proportion of leased capital equipment in the semiconductor manufacturing industry is considerably greater than in other industries characterized by a slower rate of technological change.³³

(ii) *Implications for contractual provisions in leases:* Our model has several implications for the contractual provisions in leasing contracts, and the relationship of these provisions to various characteristics of the lessor and the lessee. The first implication is that lessees with a comparative advantage in providing maintenance will use leased equipment for a longer period and renew their initial lease more often, while lessees with a high opportunity cost of providing maintenance will use leased equipment only for shorter periods, and renew their initial leases less often.

³³ This implication is also consistent with evidence from many other industries. For example, when GM introduced its new electric car (the EV1), it was available only on a lease-only basis. (See BusinessWeek, 03/03/97.) Also, IBM made its mainframe computers available initially on a lease-only basis. Also, many kinds of medical equipment using the latest technologies are initially made available primarily through leasing.

The second implication deals with the situations under which both short-term and long-term leases will be offered, and for the situations under which leasing and sales contracts will co-exist (see figure 2). Our model predicts that, when the extent of asymmetric information facing entrepreneurs regarding the value of capital equipment is less severe, while the extent of asymmetric information facing manufacturers regarding entrepreneurs' maintenance costs is only moderately severe, both short-term and long-term leases, as well as sales contracts, will be offered (proposition 2). Second, if the extent of asymmetric information facing entrepreneurs regarding the value of capital equipment is extremely severe, only the short-term lease will be offered regardless of the extent of asymmetric information faced by manufacturers about entrepreneurs' maintenance costs (propositions 5 and 6). Finally, when both the extent of asymmetric information facing entrepreneurs about the value of capital equipment and the extent of asymmetric information facing manufacturers about the entrepreneurs' maintenance costs are less severe, only a short-term lease and a sales contract will be offered (proposition 4).

The third implication deals with the existence of service leases (leases bundled with service contracts). Our model predicts that service leases will be offered in situations where the manufacturer either has a lower cost of providing maintenance compared to certain users, or the equipment is particularly sensitive to the provision of appropriate maintenance (so that the value of the equipment deteriorates dramatically due to lack of maintenance, and the value to the manufacturer of any equipment returned to him is low if the equipment has not been maintained properly) or both (proposition 7). Thus, complex, specialized assets like mainframe computers and medical equipment are provided under a service lease, since typically the manufacturer has a significant comparative advantage in the provision of maintenance in these cases, and the equipment value is very sensitive to the provision of maintenance.

The fourth implication relates to the presence of metering provisions. If it is relatively inexpensive to ascertain the intensity of usage, leases will contain metering provisions allowing the lessor to distinguish between lessees of different usage intensities, and to charge higher intensity lessees a greater amount (e.g., rental rates for farm equipment are often based on the number of hours of usage per day; also truck and automobile leases containing mileage provisions). Thus, leases with such metering provisions also allow the lessor to maximize profit by segmenting the market between these two types of lessees (proposition 8).

(iii) Implications for leasing costs and sales prices: The first implication in this regard is that the initial leasing price per period will be greater on average for short-term leases rather than for long-term leases. The second implication is for sales prices versus leasing costs: our model predicts that the equilibrium sales price

will be lower on average than the total leasing cost for an *a priori* indistinguishable piece of equipment (since the average quality of leased equipment will be better than that of equipment sold outright).³⁴

7 Conclusion

Leasing is an important source of external financing for U.S. corporations: it has been estimated that about a third of the capital equipment used by corporations is leased. However, the motivations for leasing, and for the various contractual provisions in leasing contracts, are not yet fully understood. In this paper, we developed a novel non-tax rationale for leasing in a double-sided asymmetric information setting, and analyzed how various contractual provisions in leasing contracts arise in equilibrium. We assumed a capital goods market where the manufacturer of capital goods has private information about the quality of goods he produces; entrepreneurs (users of these capital goods) come to learn this quality only over a period of time. Each unit of the capital good requires a certain level of maintenance in each period. Entrepreneurs differ in their cost of providing this maintenance; this maintenance cost is information private to each entrepreneur. Leasing emerged as an equilibrium solution to this double-sided asymmetric information problem. Various contractual provisions in leasing contracts (e.g., short-term versus long-term leases with non-cancellation provisions, option to buy at lease termination, and service leases) also emerged as equilibrium solutions under various alternative settings. Finally, leases with metering provisions emerged in equilibrium when entrepreneurs differ in dimensions other than their maintenance cost, such as their intensity of using the capital good. An interesting aspect of our model is that, in equilibrium, leasing co-existed with a sales contract in some cases, while it was the sole financing contract in other cases. We developed the testable implications of our model for the lease-versus-sell decision, the situations under which various leasing contract provisions are appropriate, and for the relative magnitudes of sales prices and leasing costs for leases with different contractual provisions.

The rationale for leasing we developed here is consistent with an argument often given by practitioners for leasing, namely, that leasing allows the transfer of technological risk (e.g., the risk that the technology underlying the capital equipment may not be appropriate for the use at hand, or may become obsolete soon) from lessors to lessees. Our model suggests that, in a setting where lessors have information superior to lessees about the technology underlying their capital equipment, such transfer of technological risk indeed creates value even when both the lessor and lessee are risk-neutral. Thus, our results can explain the high prevalence of leasing in

³⁴ There is some empirical evidence indicating that the quality of off-lease cars is greater than sold cars of a similar age: e.g., Desai and Purohit (1998), using auction data for a popular car model, provide evidence that the value decline for off-lease cars is lower than those cars sold outright.

industries using newer technologies (since the extent of asymmetric information between lessors and lessees is likely to be more significant in these industries).

It is not our view, however, that the double side asymmetric information rationale for leasing that we developed above applies to all possible leasing situations: there are many interesting issues related to leasing that cannot be fully explained by our model. For example, one interesting puzzle in the leasing literature relates to why new cars are leased much more often than used cars despite the greater extent of asymmetric information characterizing the latter market. Our model does not shed light on the greater prevalence of leasing in the new car market, though it does predict that the variety of leasing contracts observed in the new car market would not be observed in the used car market, given the shorter remaining useful life of used cars compared to that of new cars (and the consequent lower benefit to sellers from separating users in the used car market). Our model also does not shed light on leasing by firms other than the manufacturer of the equipment leased (i.e., leasing companies, which are less likely to have private information about the intrinsic value of the leased equipment). Clearly, factors other than asymmetric information, such as taxes or the relaxation of a firm's financial constraint through leasing (as argued by Eisfeldt and Rampini (2005)) may be at work in the above situations. As is the case with other important corporate decisions, leasing also may have multiple driving factors, so that alternative rationales may apply, depending on the specifics of a given leasing situation.

References

- Barclay M. J. and Smith C. W., 1995a, "The Priority Structure of Corporate Liabilities," *Journal of Finance* 899-916.
- Barclay M. J. and Smith C. W., 1995b, "The Determinants of Corporate Leverage and Dividend Policies," *Journal of Applied Corporate Finance* 7, 4-19.
- Bulow, Jeremy., 1986, "An Economic Theory of Planned Obsolescence," *Quarterly Journal of Economics* 101, 729-749.
- Desai, P and Purohit D., 1999, "Leasing and Selling: Optimal Marketing Strategies for a Durable Good Firm," *Management Science* 18, 42-58.
- Eisfeldt, A. and A. Rampini, "Leasing, Ability to Repossess, and Debt Capacity," working paper, Northwestern University.
- Fudenberg, D. and Tirole, J., 1991, "Perfect Bayesian Equilibrium and Sequential Equilibrium," *Journal of Economic Theory* 53, 236-60.
- Gavazza, A., 2005, "Leasing and Secondary Markets: Theory and Evidence from Commercial Aircraft," working paper, Yale University.
- Gerety, V. E., 1995, "Understanding the Equipment Leasing Marketplace," *Journal of Equipment Lease Financing* 13, 3-12.

- Grenadier, S., 1995, "Valuing Lease Contracts A Real-Options Approach," *Journal of Financial Economics* 38, 297-331.
- Grenadier, S., 1996, "Leasing and Credit Risk," *Journal of Financial Economics* 42, 333-54.
- Grossman, S., 1980, "The Role of Warranties and Private Disclosure about Product Quality," *Journal of Law and Economics* 24, 461-483.
- Hendel, I. and Lizzeri, A., 2002, "The Role of Leasing Under Adverse Selection," *Journal of Political Economics* 110, 113-143.
- Johnson, J.P., and Waldman, M., 2003, "Leasing, Lemons, and Buybacks," *Rand Journal of Economics* 34, 247-265.
- Johnson, J.P., and Waldman, M., 2004, "Leasing, Lemons, and Moral Hazard," Working Paper, Cornell University.
- Krishnan, S. V. and Moyer, C. R., 1994, "Bankruptcy Costs and the Financial Leasing Decision," *Financial Management* 23, 31-42.
- Lewellen, W. G., Long, M. S. and McConnell, J. J., 1976, "Asset Leasing in Competitive Capital Markets," *Journal of Finance* 31, 737-98.
- McConnell, J. and Schallheim, J. S., 1983, "Valuation of Asset Leasing Contracts," *Journal of Financial Economics* 12, 237-61.
- Milgrom, P., and Roberts, J., 1986, "Price and Advertising Signals of Product Quality." *Journal of Political Economy* 94, 796-821.
- Miller, M. and Upton, C., 1976, "Leasing, Buying, and the Cost of Capital Services," *Journal of Finance* 31, 761-86.
- Richter A., 1998, "Leasing Will Play a Bigger Role in Lab-equipment Acquisition," *Semiconductor Business*, News, May 1.
- Schallheim, J. C., Johnson, R. E., Lease, R. C. and McConnell, J., 1987, "The Determinants of yields on Financial Leasing Contracts," *Journal of Financial Economics* 19, 45-67.
- Sharpe, S. A. and Nguyen, H. H., 1995, "Capital Market Imperfection and the Incentive to Lease," *Journal of Financial Economics* 39, 271-294.
- Smith, C. W. and Wakeman, L. M., 1985, "Determinants of Corporate Leasing Policy," *Journal of Finance* 40, 895-908.
- Tirole, J., 1999, *The Theory of Industrial Organization*, the MIT Press, Cambridge, MA.
- Waldman, M., 1997, "Eliminating the Market for Secondhand Goods: An Alternative Explanation for Leasing," *Journal of Law and Economics* 40, 61-92.

Appendix

Proof of Proposition 1. First, consider the case where the type H entrepreneur does not maintain the type G equipment at all. In this case, if the type H entrepreneur uses the type G equipment for all three periods, the value of the equipment from a social planner's perspective is $x + \delta x + \delta^2 x$; if she uses it for the first two periods and the manufacturer repossesses the equipment in the third period, the value of the type G equipment is $x + \delta x + \beta \delta^2 x$; if she uses it only for the first period, the value of the type G equipment is $V_1 = x + \beta \delta x + \beta \delta^2 x$. Clearly, given $\beta > 1$, the latter alternative is more valuable from a social planner's perspective than the first two alternatives.

Now consider the case where the type H entrepreneur maintains the type G equipment. Note that it is not optimal for the equipment to be maintained in the third period, given that the life of the equipment ends at time 3. In this case, if the type H entrepreneur uses the type G equipment for all three periods and maintains the equipment for the first two periods, the net value of the equipment is $V_2 = 3x - 2c_H$. Further, if the type H entrepreneur uses the type G equipment for two periods and maintains it for only one period, the net value of the equipment is $V_3 = 2x - c_H + \beta \delta x$. Finally, given our assumption that the residual value of the well-maintained type G equipment is smaller than its value to the type H (and the type L) entrepreneur, it is never optimal for the type H entrepreneur to maintain the equipment for two periods and use it for two periods or to maintain the equipment for one period and use it for one period.

It can be shown that when $c < x - \beta \delta x - c_L$ (so that $x - c_H > \beta \delta x$), V_2 is the largest. When $c \in [x - \beta \delta x - c_L, x - \beta \delta^2 x - c_L)$, V_3 is the largest. Finally, when $c \geq x - \beta \delta^2 x - c_L$, V_1 is the largest. ■

Proof of Proposition 2. The type B manufacturer's problem is trivial. In equilibrium, the type B offers a sales contract with $S^* = fx + f\delta x + f\delta^2 x$. The type G manufacturer maximizes $\Pi_G(CB)$, by offering both a short-term lease and a long-term lease at the prices such that the type L entrepreneur will accept the short-term lease and the type H entrepreneur will accept the long-term lease. The type G manufacturer prefers the type L entrepreneur to purchase the equipment at time 1, given our assumption that the type L entrepreneur's maintenance cost is low, i.e., $c_L < (1 - \delta)x$. Thus, $I_{ST}^L = 1$, which yields $R \leq 2x - 2c_L$. Further, if the type G manufacturer designs the long-term lease so that the type H entrepreneur will exercise the purchase option at time 2, then the combination of such a long-term and a short-term lease (satisfying all IR constraints and the IC constraint as discussed in Section 4.1.1) would yield a smaller or at best an equal payoff to the type G compared to the short-term lease characterized in proposition 3. As a result, in equilibrium, the purchase

price of the long-term lease $P > \max(x - c_H, \delta x)$, at which price the type H entrepreneur will not exercise the purchase option at time 2, i.e., $I_{ST}^H = 0$. Now IR constraints (9) and (8) have only two indicator variables I_{ST}^H and I_{LT}^L :

$$\begin{aligned} x + \max(x - c_H, \delta x) - N &\geq x - M + I_{ST}^H[\max(2x - 2c_H, \delta x + \delta^2 x) - R], \text{ and} \\ x - M + 2x - 2c_L - R &\geq 2x - c_L - N + I_{LT}^L(x - c_L - P). \end{aligned} \tag{A1}$$

Consider the case where $x - c_H > \delta x$. In this case, it can be shown that if $I_{ST}^H = 1$ and $I_{LT}^L = 1$, IR constraint (A1) cannot be satisfied. If $I_{ST}^H = 1$ and $I_{LT}^L = 0$, the type G's expected payoff is $\min[x + \phi(x - c_H), fx + f\delta x + f\delta^2 x] + (1 - \phi)(2x - 2c_H) + \phi\beta\delta x$, which is smaller than Π_G^1 (we will derive Π_G^1 below). Thus, in equilibrium, $I_{ST}^H = 0$, and either $I_{LT}^L = 1$ or $I_{LT}^L = 0$. The equilibrium solutions to the type G's problem $\{M^*, N^*\} = \{M, N \mid \phi N + (1 - \phi)M = \min[x + \phi(x - c_H), S^*], M, N \leq x, \text{ and } N - M = x - c_H\}$, $P^* \geq x - c_L$, and $R^* = 2x - c_H - c_L$. In this case, the type G's expected payoff $\Pi_G^* = \Pi_G^1 \equiv \min[x + \phi(x - c_H), fx + f\delta x + f\delta^2 x] + (1 - \phi)(2x - c_L - c_H) + \phi\beta\delta x$. On the other hand, in the case where $x - c_H < \delta x$, the type G manufacturer's expected payoff is $\min[x + \phi\delta x, fx + f\delta x + f\delta^2 x] + (1 - \phi)(x - c_L + \delta x) + \phi\beta\delta^2 x$ and it is smaller than the expected payoff when the type G offers a short-term lease as characterized in proposition 3. Thus, the equilibrium characterized in proposition 2 exists only if $x - c_H > \delta x$.

This PBE described above satisfies the Cho-Kreps Intuitive Criterion. If a manufacturer offers any sales contract with sales price $S > fx + f\delta x + f\delta^2 x$, or a long-term lease with initial leasing price $N > fx + f\delta x + f\delta^2 x$, or a short-term lease with $M > fx + f\delta x + f\delta^2 x$, or a combination of a long-term lease and a short-term lease with $\phi N + (1 - \phi)M > fx + f\delta x + f\delta^2 x$ (off-equilibrium moves), the entrepreneur would infer the manufacturer being of the type B with probability 1. Thus, the type G manufacturer has no incentive to deviate by offering the above sales contract and leasing contracts, since the type B manufacturer would have a definite incentive to deviate whenever the type G has a (weak) incentive to offer these contracts. Given the above off-equilibrium beliefs, the type B will not offer the above contracts as well since no entrepreneur would accept these contracts offered by the type B. Further, if a manufacturer offers a long-term lease with $N \leq fx + f\delta x + f\delta^2 x$ (another off-equilibrium move), the entrepreneur would infer the manufacturer being of the type G with probability 1, since the type B manufacturer has no incentive to offer such contracts. However, the type G manufacturer has no incentive to offer such long-term contracts since his maximum expected payoffs by doing so are smaller than the expected payoff by offering the leases as characterized in proposition 2.

Now we compare the expected payoff in the above PBE with the payoffs in other equilibria, and derive the conditions for the above PBE to be satisfied as an efficient PBE. As we will prove later, the type G manufacturer

can also offer a short-term lease with a purchase price such that only the type L entrepreneur, but not the type H, finds it optimal to purchase the equipment at time 1 (as characterized in proposition 3). In this case, the expected payoff is Π_G^2 (defined later). On the other hand, the type G manufacturer can also offer a short-term lease with a purchase price such that both the type L and the type H entrepreneur find it optimal to purchase the equipment at time 1 (as characterized in proposition 4). In this case, the expected payoff to the type G manufacturer is Π_G^3 (defined later). The type G manufacturer can also offer short-term leases to pool with the type B manufacturer (as characterized in propositions 5 and 6), with expected payoffs Π_G^4 and Π_G^5 (defined later), respectively.

Define $c_1 \equiv \min[\phi(x - c_L) - \phi\beta(\delta x + \delta^2 x)/2, (1 - \delta)x - c_L]$; $c_2 \equiv \frac{1}{1-\phi}[(fx + f\delta x + f\delta^2 x) - x - \phi\beta\delta^2 x]$; $c_3 \equiv \min[\phi(x - c_L) - \phi\beta\delta^2 x, (1 - \delta)x - c_L]$; $c_4 \equiv \frac{1}{1+\phi}[(1 + 2\phi)x - (fx + f\delta x + f\delta^2 x) - 2\phi c_L - \phi\beta\delta x]$; $c_5 \equiv \min[\phi(x - c_L) - \phi\beta\delta x, (1 - \delta)x - c_L]$; $f_1 = \{f \mid c_1 = c_4\} \equiv \frac{\phi(1-\phi)(2x-2c_L-\beta\delta x-\beta\delta^2 x)+2x+2\phi\beta\delta^2 x}{x+\delta x+\delta^2 x}$; $f_2 = \{f \mid c_2 = c_3\} \equiv \frac{x+\phi(1-\phi)(x-c_L)+\phi^2\beta\delta^2 x}{x+\delta x+\delta^2 x}$; and $f_3 = \{f \mid c_4 = c_5\} \equiv \frac{x+\phi(1-\phi)(x-c_L)+\phi^2\beta\delta x}{x+\delta x+\delta^2 x}$. Note that $f_1 < f_2$ and $f_1 < f_3$. Further define $\underline{f} \equiv \frac{(1-\theta)x}{(1-\theta)x+\delta x+\delta^2 x}$ (where $\underline{f} < f_1$). \bar{c} equals c_1 if $f < f_1$; c_2 if $f_1 \leq f < f_2$; and c_3 if $f \geq f_2$. \underline{c} equals c_1 if $f < f_1$; c_4 if $f_1 \leq f < f_3$; and c_5 if $f \geq f_3$. When $f \geq \underline{f}$ and $\underline{c} \leq c < \bar{c}$, the PBE characterized in proposition 2 satisfies as an efficient PBE, i.e., Π_G^1 is greater than Π_G^2 , Π_G^3 , Π_G^4 , and Π_G^5 . ■

Proof of Proposition 3. The type B manufacturer offers a sales contract with $S^* = fx + f\delta x + f\delta^2 x$. The type G manufacturer maximizes $\Pi_G(ST)$ by offering a short-term lease. In order for the type L entrepreneur to purchase the equipment at time 1, i.e., $I_{ST}^L = 1$, the purchase price $R \leq 2x - 2c_L$. On the other hand, in order for the type H entrepreneur not to exercise the purchase option (i.e., $I_{ST}^H = 0$), $\max(\delta x + \delta^2 x, 2x - 2c_H) - R < 0$. Thus, the equilibrium purchase price $R^* = 2x - 2c_L$. Now the type G manufacturer maximizes $\Pi_G(ST) = M + \phi\beta(\delta x + \delta^2 x) + (1 - \phi)R^*$. In equilibrium, $M^* = \min(x, S^*)$, and $\Pi_G^* = \Pi_G^2 \equiv \min(x, fx + f\delta x + f\delta^2 x) + (1 - \phi)(2x - 2c_L) + \phi\beta(\delta x + \delta^2 x)$.

Similar to what we discussed in the proof of proposition 2, it can be shown that the above PBE satisfies the Cho-Kreps Intuitive Criterion. It can also be shown that when $f \geq \underline{f}$ and $c \geq \bar{c}$, the PBE described in proposition 3 satisfies as an efficient PBE, i.e., Π_G^2 is greater than Π_G^1 , Π_G^3 , Π_G^4 , and Π_G^5 . ■

Proof of Proposition 4. In this equilibrium, the type B manufacturer offers a sales contract with $S^* = fx + f\delta x + f\delta^2 x$. The type G manufacturer designs its short-term lease so that both the type L and the type H entrepreneur will purchase the equipment at time 1, i.e., $I_{ST}^L = 1$ and $I_{ST}^H = 1$. This implies that $R \geq 2x - 2c_L$ and $\max(\delta x + \delta^2 x, 2x - 2c_H) - R \geq 0$. When $x - c_H > \delta x$, the type G manufacturer sets the

purchase price $R^* = 2x - 2c_H$. Following the previous proofs, we can also show that $M^* = \min(x, S^*)$, and $\Pi_G^* = \Pi_G^3 \equiv \min(x, fx + f\delta x + f\delta^2 x) + 2x - 2c_H$. Similar to the proofs of propositions 2 and 3, the PBE here satisfies the Cho-Kreps Intuitive Criterion. Also, the above PBE satisfies as an efficient PBE, i.e., $\Pi_G^3 > \Pi_G^1$, $\Pi_G^3 > \Pi_G^2$, $\Pi_G^3 > \Pi_G^4$, and $\Pi_G^3 > \Pi_G^5$, when $f \geq \underline{f}$ and $c < \underline{c}$. ■

Proof of Proposition 5. In this case, the type G manufacturer maximizes $\Pi_G(ST)$, subject to the IR constraint that the type L entrepreneur will accept the contract and purchase the equipment at time 1 and the IR constraint that the type H entrepreneur will accept the contract but will not purchase the equipment at time 1:

$$(1 - \theta)x + \theta fx - M + 2x - 2c_L - R \geq 0 \text{ and } I_{ST}^L = 1, \quad (\text{A2})$$

$$(1 - \theta)x + \theta fx - M \geq 0, \text{ and } I_{ST}^H = 0. \quad (\text{A3})$$

It can be shown that the prices of the short-term lease to pool the type G and type B manufacturers $M^* = (1 - \theta)x + \theta fx$ and $R^* = 2x - 2c_L$. In this case, the expected payoff to the type G manufacturer is $\Pi_G^* = \Pi_G^4 \equiv (1 - \theta)x + \theta fx + \phi\beta(\delta x + \delta^2 x) + (1 - \phi)(2x - 2c_L)$. Following the same steps as in the previous proofs, we can show that the PBE here satisfies the Cho-Kreps Intuitive Criterion and satisfies as an efficient PBE when Π_G^4 is greater than Π_G^1 , Π_G^2 , Π_G^3 , and Π_G^5 , which holds when $f < \underline{f}$ and $c \geq \bar{c}$. Note when $f < \underline{f}$, $\bar{c} = \underline{c}$. ■

Proof of Proposition 6. In this case, the type G manufacturer maximizes $\Pi_G(ST)$, subject to the IR constraint (A2) and the IR constraint that the type H entrepreneur will accept the contract and purchase the equipment at time 1:

$$(1 - \theta)x + \theta fx - M + \max(2x - 2c_H, \delta x + \delta^2 x) - R \geq 0, \text{ and } I_{ST}^H = 1. \quad (\text{A4})$$

The initial price of the short-term lease that pools the type G and type B manufacturers, M^* , is the same as that in proposition 4, and the purchase price $R^* = \min(\delta x + \delta^2 x, 2x - 2c_H)$. In this case, the expected payoff to the type G manufacturer $\Pi_G^* = \Pi_G^5 \equiv (1 - \theta)x + \theta fx + \min(\delta x + \delta^2 x, 2x - 2c_H)$. The equilibrium here is an efficient PBE when Π_G^5 is greater than Π_G^1 , Π_G^2 , Π_G^3 , and Π_G^4 , which holds when $f < \underline{f}$ and $c < \bar{c}$. ■

Proof of Proposition 7 and Corollary 1. The type G manufacturer maximizes $\Pi_G = \phi(M_2 + R_2) + (1 - \phi)(M_1 + R_1) - \phi(c_P)$, subject to the IC constraint that the type B manufacturer will not mimic:

$$\phi M_2 + (1 - \phi)M_1 \leq S, \quad (\text{A5})$$

the IR constraints that the type H entrepreneur will accept the short-term service lease and renew the lease at time 1:

$$\begin{aligned}
-M_2 - R_2 + 2x &\geq -M_1 + x, \\
-M_2 - R_2 + 2x &\geq \max(0, -M_2 + x), \\
-M_1 - R_1 + x + \delta x &\leq -M_1 + x,
\end{aligned} \tag{A6}$$

and the IR constraint that the type L entrepreneur will accept the short-term lease without service and renew the lease at time 1:

$$\begin{aligned}
-M_1 - R_1 + 2x - c_L &\geq -M_2 - R_2 + 2x, \\
-M_1 - R_1 + 2x - c_L &\geq \max(0, -M_1 + x), \\
-M_2 - R_2 + 2x &\geq -M_2 + x.
\end{aligned} \tag{A7}$$

The type B manufacturer maximizes his sales revenue S subject to:

$$\begin{aligned}
-S + fx + f\delta x &\geq 0, \\
\phi(M_2 + R_2) + (1 - \phi)(M_1 + R_1) - \phi(c_P) &\geq S.
\end{aligned} \tag{A8}$$

The equilibrium prices to the type G manufacturer $\{M_1^*, M_2^*\} = \{M_1, M_2 \mid \phi M_2 + (1 - \phi)M_1 = \min(x, S^*)$ and $M_1, M_2 \leq x\}$, $S^* = fx + f\delta x$, $R_2^* = x$, $R_1^* = x - c_L$. The equilibrium payoff to the type G $\Pi_G^* = \Pi_G^6 \equiv \min(fx + f\delta x, x) + x - \phi c_P - (1 - \phi)c_L$.

On the other hand, if the type G manufacturer offers only a lease with service to pool the two types of entrepreneur, his expected payoff is $\Pi_G^7 = \text{Min}(fx + f\delta x, x) + x - c_P$. If the type G offers only a lease without service, and sets the renewal price such that only the type L entrepreneur but not the type H entrepreneur will renew the lease at time 1, then his expected payoff is $\Pi_G^8 = \text{Min}(fx + f\delta x, x) + (1 - \phi)(x - c_L) + \phi\beta\delta x$. If the type G offers only a lease without service and set the renewal price such that both the type L and the type H entrepreneur will renew the lease at time 1, then his expected payoff is $\Pi_G^9 = \text{Min}(fx + f\delta x, x) + x - c_H$. Define $c_6 \equiv x - \beta\delta x$, $c_7 \equiv \frac{1}{\phi}[c_H - (1 - \phi)c_L]$, and $\hat{c} \equiv \text{Min}(c_6, c_7)$. Then, when $c_P \in [c_L, \hat{c}]$, $\Pi_G^6 > \Pi_G^7$, $\Pi_G^6 > \Pi_G^8$, and $\Pi_G^6 > \Pi_G^9$. Further, it can also be shown that when $f \geq \underline{f}$, Π_G^6 is larger than the type G manufacturer's expected payoff from any short-term lease that pools the type G with the type B manufacturer. Thus, the equilibrium characterized in proposition 7 is an efficient PBE when $f \geq \underline{f}$ and $c_P \in [c_L, \hat{c}]$.

It is straightforward to show that when $\beta < \frac{x - c_H}{\delta x}$, $\hat{c} > c_H$. In this case, the equilibrium characterized in proposition 7 exists even when $c_P > c_H$. ■