

Captive Finance and the Coase Conjecture*

Justin Murfin

Ryan Pratt

Yale University

Brigham Young University

First Draft: November 2013

This Draft: September 2014

Abstract

In this paper, we propose an explanation for the prominent role of manufacturers in the financing of their own product sales— so called “captive finance.” By lending against their own product as collateral, durable goods manufacturers with market power can commit to restrict production and maintain resale values in future periods, preserving rents today. Using data on captive financing support by the manufacturers of heavy equipment, we find evidence that captive financed models retain higher resale values, especially when the manufacturer has pricing power. The higher resale values enjoyed by captive financed models also convey higher pledgeability and thus allow lower downpayments, even when machines are financed by banks. We find that models with a history of captive support are preferred by buyers when financing constraints are binding. Although motivated as a rent-seeking device, captive financing may generate positive spillovers if credit constraints are important.

*Correspondence: Murfin: justin.murfin@yale.edu, (203)436-0666. Pratt: ryan.pratt@byu.edu, (801)422-1222.

1 Introduction

A substantive share of durable goods financed with credit in the US is not financed by banks or finance companies, but rather by the manufacturer of the good itself. Manufacturing firms such as Toyota, John Deere, and Caterpillar originate loan portfolios in a given year which would rank them among the top banks in terms of business and non-credit card installment lending (as of 2012, #9, 15, and 17, respectively).¹ On the liabilities side, captive finance arms of manufacturers are among the largest issuers of short-term, money-like liabilities.

As the line between traditional banking and manufacturing firms' bank-like activities—so-called “captive finance”—is blurred, a natural question arises. What are the economic motives behind captive finance? If banks are specialists in credit evaluation, monitoring, and fundraising and thus might be natural candidates to finance durable goods investment, what is the comparative advantage of captive finance?

Our paper provides a candidate answer to this question that focuses on the simple observation that when manufacturers are also lenders, they internalize the dynamic implications of their own production. Captive finance may thus serve as a solution to the famous Coase conjecture: that even a monopolist producer of a durable good faces competition from its own future production, as current period customers may opt to delay their purchases, just as the next period's customers may purchase used goods (Coase 1972).² Based on this idea, Coase proposed that, without commitment to restrict production in each period, the monopolist firm converges on a competitive equilibrium. We show that, by financing its own sales, manufacturers resolve this time inconsistency problem by making future profits dependent on the resale values. By offering high enough loan-to-values to current customers, captive finance producers use the threat of strategic borrower default to commit to low production/high resale prices in the future.

Aside from providing a new motivation for the ubiquity of captive financing for durable goods³,

¹This is based on bank holding company call report data, where bank loan portfolios excluded interbank, charge-card, or mortgage lending for comparability.

²The customer's used vs. new equipment purchases based on customer financial constraints.

³Brennan, Maksimovic, and Zechner (1988) develop a theory of vendor financing in which the financing is used as a means of price discrimination between rich and poor customers. Mian and Smith (1992) provide a unified analysis of a variety of alternative motivating factors behind captive finance, as well as early evidence on the subject. We

the model also suggests an important byproduct of the equilibrium. Because captive financed products depreciate more slowly, active lending by the producer ensures greater asset pledgeability and lower downpayment amounts. Even non-captive lenders are able to offer lower downpayments on machines that receive significant captive finance support, effectively free-riding off of the producer's commitment.

After sketching out a handful of key implications of our model of captive finance, we explore these implications using data on the financing and sales of new and used heavy machinery. Consistent with the model's predictions, we show that captive finance is predominantly used in oligopolistic markets where one or several firms control a large segment of the market, and therefore have a role in price setting. Moreover, large firms tend to be more active lenders in those products where they have more pricing power, suggesting more than just a big firm effect driving lending behavior.

Meanwhile, the model's central prediction that captive finance will predict higher resale values in secondary markets is readily apparent in the data. Using secondary market sales at used equipment auctions, we show that products which receive more captive support from their manufacturers depreciate more slowly. Although it appears part of this is related to product durability, conditioning out the effect of superior quality goods, we still find higher resale values among predominantly captive financed models. Consistent with our hypothesis the effect is limited to markets where producers have market power.

Thus, the theory and evidence appear to suggest a role for captive finance as a rent seeking device for oligopolistic producers which otherwise would lack commitment to maintain higher prices/lower production over time. While healthy banks might arguably provide a public good, the initial analysis would suggest welfare losses from a healthy captive sector.

In the second part of our empirical section we explore a possible positive externality associated with a healthy captive finance sector. Products receiving captive finance enjoy increased pledgeability due to their lower depreciation rates, even when financed by bank lenders. If credit constraints are a sufficient drag on profitable investment, captive finance may provide a social good by relaxing these constraints.

return to these ideas later in the text.

Again, using data on new and used equipment sales, we show that banks extend higher loan to values on equipment models receiving captive support from manufacturers. Over time, this becomes most valuable in periods of tight credit. In particular, there is a large shift towards models receiving captive support (and thus higher resale values) when lenders report tightening their conditions for collateral. This is evident even among purchasers using bank financing and therefore cannot be attributed to a pull back in bank credit. This result extends beyond the time-series variation and into the cross-section. We are able to show that at a given point in time, borrowers with less internal cash will tend towards the purchase of models receiving captive support. To generate variation in downpayment availability, we track recent sales of old equipment at used equipment auctions by firms in the market for a new machine. Buyers who have recently suffered an unexpectedly low sales price when selling old equipment due to a poor auction outcome will make a smaller downpayment and be more likely to choose a new model which benefits from greater captive finance support.

The paper will begin by formalizing the proposed role for captive finance and generating testable implications in Section 2. We describe the data on equipment sales and financing and present results in Sections 3 and 4 before concluding.

2 Hypothesis Development

In this section we consider the problem faced by a producer of durable goods with market power. As is well known in the industrial organization literature, durable goods monopolists face a time inconsistency problem because they compete with their own anticipated future production. Because customers will pay higher prices for goods that are expected to better retain their value, the monopolist today would like to commit to supporting resale prices by restricting quantities in the future. However, such a commitment would not be credible since once the sale is made, the monopolist will no longer have an incentive to support resale prices. Instead, the monopolist tomorrow will choose production to maximize tomorrow's profits and in doing so will drive down the resale value of used goods. Anticipating this, customers' willingness to pay today will reflect the lower values of their goods in the future. Another way to think about this problem is to note that customers today have

the option of delaying their purchase and may choose to do so if the monopolist cannot commit to keep prices high in the future. Thus, the durable goods monopolist's market power is undermined and his rents are eroded by inter-temporal competition with himself. Coase (1972) introduced this problem and argued that with perfectly durable goods, a monopolist would revert to the perfectly competitive production path as the time between periods shrinks.

Several solutions to this problem have been posed in the literature⁴, some of which have limited feasibility. For example, if the monopolist were able to destroy his production technology, he would make his commitment to limit quantities credible, and would thereby retain his market power. Perhaps the most common solution to this problem is that the monopolist lease rather than sell its output (Bulow 1982). By leasing rather than selling, the monopolist operates in a non-durable market (the market for rental services). Importantly, as the owner of the durable goods, the monopolist internalizes the effect of future production on resale value of equipment and can therefore commit to the optimal production path.

In a similar vein, we propose vendor financing as a mechanism by which the monopolist can retain his market power and commit to the optimal production path. To the best of our knowledge we are the first to focus on this particular mechanism. Intuitively, vendor financing gives the monopolist conditional exposure to resale prices. To see this, consider a monopolist who finances the sale of equipment to buyers today. The terms of financing offered by the monopolist will determine the future path of loan balances. Similarly, the production choices of the monopolist will determine the future path of market prices. If at any point the monopolist were to produce enough to push market prices below the outstanding loan balances, buyers would find it in their best interest to default on their loan and return the equipment to the manufacturer. With captive finance, the cost of depressing market prices would be borne by the monopolist. Thus captive finance can make credible the monopolist's commitment to keep prices high by restricting production.

More formally, consider a simple model of a durable goods monopolist. We assume two periods in the model, and the discount rate is normalized to 0. In each period the firm faces a demand

⁴Bulow (1986) explores the possibility of the monopolist deliberately making his output less durable; Butz (1990) studies contractual provisions such as the use of most-favored-customer clauses; and Karp and Perloff (1996) and Kutsoati and Zabochnik (2001) focus on the deliberate adoption of an inferior production technology

schedule for rental services of its output given by

$$p_r = a - bQ, \quad (1)$$

where Q denotes the stock of machines in the economy. The firm produces q_t machines in each period $t = 1, 2$ using a production technology with constant marginal cost which we normalize to 0. We assume that machines do not depreciate. We then have $Q_1 = q_1$ and $Q_2 = q_1 + q_2$.

There is a frictionless resale market for used equipment. Since the model consists of only two periods, the market price in period 2 is equal to the rental price, $p_2 = a - bQ_2$. In contrast, a first-period buyer receives the equipment's services in both periods, the present value of which is given by $p_1 = a - bQ_1 + a - bQ_2 = a - bQ_1 + p_2$. This equation reflects the fact that the sale price of equipment in the first period is affected by the anticipated resale value of equipment, which in turn is affected by second-period production. That is, buyers care about the resale value of their equipment so that the price they pay for equipment is the sum of the first-period rental price and the resale value.⁵

2.1 Full Commitment Equilibrium

As a baseline we first establish the optimal production path of a monopolist who is able to commit credibly to future production. The monopolist solves:

$$\max_{q_1, q_2} p_1(q_1, q_2) \cdot q_1 + p_2(q_1, q_2) \cdot q_2 \quad (2)$$

⁵Equivalently, we could think of the first-period sales demand as arising from the buyers' option to wait to purchase. Given an anticipated price path $\{p_1, p_2\}$, a buyer with reservation price x will purchase in the first period if $2x - p_1 \geq x - p_2 \iff x \geq p_1 - p_2$. From the demand for rental services, the quantity of machines with such a reservation price is $Q_1 = \frac{1}{b}(a - (p_1 - p_2))$. This is equivalent to the inverse sales demand above.

where p_1 and p_2 are given in the paragraph above. It is straightforward to show that the solution to this full-commitment problem with the corresponding prices and profit is given by:

$$\begin{aligned} q_1^* &= \frac{a}{2b}, & p_1^* &= a, & \pi^* &= \frac{a^2}{2b} \\ q_2^* &= 0, & p_2^* &= \frac{a}{2}. \end{aligned} \tag{3}$$

This is the first-best solution from the perspective of the monopolist. In each period the quantity of equipment in the market is equal to the amount that would be chosen by a monopolist producer of consumption goods. When we assume that the monopolist has the ability to commit to future production, we assume away his time-inconsistency problem.

2.2 Equilibrium with Bank Financing

We now consider the problem faced by a monopolist who lacks the ability to credibly commit to future production. We start by analyzing the problem when buyers finance their purchases through a bank. Importantly, since there are no meaningful economic ties between the monopolist and the banks who finance the purchase of their output, the financing is inconsequential to the monopolist. From his perspective these are cash sales, and he solves his optimization problem without any consideration of the financing. In our analysis, then, we first solve the monopolist's problem as if he were selling to cash buyers, and then we derive the implications of the monopolist's decisions for the financing contract between the buyers and the bank. In the next subsection we show how the solution changes when the monopolist offers vendor financing.

Absent the ability to commit, the firm will choose second period production to maximize second period profits, conditional on first period production. So at time 2 the firm solves:

$$\max_{q_2} (a - b(q_1 + q_2))q_2 \tag{4}$$

It follows immediately from the first-order condition that the optimal production and corresponding price and profit are $q_2^b = \frac{1}{2b}(a - bq_1)$, $p_2^b = \frac{1}{2}(a - bq_1)$, and $\pi_2^b = \frac{1}{4b}(a - bq_1)^2$.

Given this solution to the second period problem, the first period sales price is $p_1 = \frac{3}{2}(a - bq_1)$,

and the firm's first period problem can be written as:

$$\max_{q_1} \quad \frac{3}{2}(a - bq_1)q_1 + \frac{1}{4b}(a - bq_1)^2 \quad (5)$$

The first term in the objective function is the monopolist's profit from first period production, and the second is his profits from second period production. The solution to this problem yields the following quantities and prices

$$\begin{aligned} q_1^b &= \frac{2a}{5b}, & p_1^b &= \frac{9a}{10}, & \pi^b &= \frac{9a^2}{20b} \\ q_2^b &= \frac{3a}{10b}, & p_2^b &= \frac{3a}{10} \end{aligned} \quad (6)$$

Several things are immediately apparent when comparing this solution to the full-commitment solution. First, the firm's profits are lower, an illustration of the value that the firm can derive from any mechanism that enables it to commit to restrict future production. This is because the firm's production in the second period drives down the price that buyers are willing to pay in both the first and second period. The first period price is lower than in the full-commitment case despite the fact that the firm produces fewer machines in the first period than it would if it could commit. This lower price consists of a higher rental rate in the first period (because machines are relatively scarce in the first period) but a lower resale value (because machines are relatively abundant in the second period). Second, because of second period production, first period machines have a higher depreciation rate. This will have very important implications for the financing contract, which we now consider.

First period buyers finance their equipment through loans from a competitive banking sector. Competitive banking implies that $d_1^b + d_2^b = p_1^b$, where d_1^b denotes the down payment required by the bank and d_2^b denotes the size of the loan. We assume that buyers have limited commitment to repay and that a buyer who defaults cannot be excluded from the second period market for machines. Under these assumptions, a buyer will default any time that he owes more than his machine is worth. It follows immediately that $d_2^b \leq p_2^b = \frac{3a}{10}$.⁶ The down payment must then satisfy $d_1^b \geq p_1^b - d_2^b = \frac{3a}{5}$.

⁶Rampini and Viswanathan (2010) formalizes the equivalence between limited commitment of the type used here

Indeed, under the assumption that funds are scarce for the buyer, these constraints would bind, and the unique optimal debt contract would be given by $d_1^b = \frac{3a}{5}, d_2^b = \frac{3a}{10}$.

2.3 Equilibrium with Captive Financing

Now assume that the monopolist offers financing for its first period output. As with bank financing, the vendor financing contract consists of a required downpayment, d_1 , and a promise to pay, d_2 . Again we start by analyzing the firm's problem in period 2. In the second period the firm inherits the promised debt payment, d_2 , and the first period production, q_1 , as state variables. We let ϕ_d be an indicator variable for default, which occurs whenever first-period buyers find that they owe more than their machine is worth ($d_2 > p_2$). Notice that conditional on the state variables d_2 and q_1 , ϕ_d is a function of second period production. In particular, $d_2 > p_2 = a - b(q_1 + q_2) \iff q_2 > \frac{1}{b}(a - bq_1 - d_2)$. Thus, for any given level of the state variables the monopolist can produce at most $\bar{q}_2 \equiv \frac{1}{b}(a - bq_1 - d_2)$ before he causes his borrowers to default, so we can write $\phi_d = \mathbb{1}_{(q_2 > \bar{q}_2)}$. We will refer to \bar{q}_2 as the default boundary. Using this notation, we can write the firm's problem at time 2 as:

$$\max_{q_2} \quad p_2(q_2) \cdot q_2 + (1 - \phi_d)d_2q_1 + \phi_d \cdot p_2(q_2)q_1 \quad (7)$$

The first term in (7) represents the profit from selling new machines in the second period; the second term represents the cash flow from the remaining debt payment on first period machine sales; and the third term represents the firm's proceeds from repossessing machines conditional on default.

The solution with captive finance is more complicated than the solution with bank financing because the objective function is not differentiable at the default boundary. The optimal solution could occur where the first order condition holds, or it could occur at the default boundary. It turns out that without loss of generality we can focus attention on solutions to (7) that occur at the default boundary. For a more detailed discussion of the solution, see the appendix.

Knowing that the optimal solution to (7) must occur at the default boundary, we can write the

and collateral constraints.

first period problem as

$$\begin{aligned} \max_{q_1, d_1, d_2} \quad & (d_1 + d_2)q_1 + \frac{1}{b}(a - bq_1 - d_2)d_2 \\ \text{subject to} \quad & d_1 + d_2 \leq a - bq_1 + d_2 \end{aligned} \tag{8}$$

The first term in (8) is the proceeds from the sale of equipment produced in the first period, and the second term is proceeds from the sale of equipment produced in the second period, where we have substituted in $q_2 = \bar{q}_2$ and $d_2 = p_2$ since these are equal at the default boundary. The constraint says that the sum of the debt payments cannot exceed the price of machines produced in the first period. The right-hand side of the constraint is the purchase price of machines produced in the first period incorporating the anticipated second period production.

It is clear that the constraint must bind, since if it did not the firm could simply increase d_1 to make itself better off. Substituting the constraint into the objective function and taking first-order conditions gives $q_1^* = \frac{a}{2b}$, $d_2^* = \frac{a}{2}$. Combining this solution with the solution to (7) gives the firm's optimal production and financing policies under vendor financing:

$$\begin{aligned} q_1^c &= \frac{a}{2b}, \quad p_1^c = a, \quad d_1^c = \frac{a}{2}, \quad \pi^c = \frac{a^2}{2b} \\ q_2^c &= 0, \quad p_2^c = \frac{a}{2}, \quad d_2^c = \frac{a}{2} \end{aligned} \tag{9}$$

Notice that with vendor financing the firm is able to achieve the perfect commitment solution to its optimization problem.

There are several differences between the optimal solution under bank financing and under captive financing. First, as noted above, machines depreciate less when they are captive financed. This is because the firm can use financing as a commitment device to solve its time-inconsistency problem. By restricting production in the second period, the firm helps support secondary market prices. Second, the firm is able to offer a higher loan-to-value when it finances its own machines. This is tied to the depreciation rate. Because the machine will be worth more in the future, the firm can loan more without pressing the buyer into default. In fact, since the prospect of default is what provides commitment to the firm, it is more accurate to say the the firm *must* offer a higher loan-to-value. If the firm were to offer the same financing contract as we found under bank

financing, it would lack the commitment to keep secondary market prices high.

Lastly, while the stylized model above only considers the opportunity for all bank financing or all captive financing, it is easy to imagine a more general model where the two co-exist. We derive this in the appendix. One implication of such a model is that the resale value to which the manufacturer commits raises pledgeability even for machines financed by banks. Thus, a worthwhile byproduct of captive finance might be its ability to relax credit constraints for anyone purchasing the product receiving captive support.

3 Data

To test the implications of the model presented above, we focus our attention on the market for heavy equipment used in construction and agriculture. We focus on heavy equipment for a number of related reasons. First, to match the interesting features of the model, we need a less than perfectly competitive industry such that production and financing choices can have a meaningful interaction. While not monopolistic, the market for heavy machinery is controlled by a handful of large firms. By way of example, the most purchased piece of equipment in our sample is a skid steer loader- a small, four-wheeled machine with lift-arms capable of pushing or lifting heavy material. In 2012, 5 manufacturers produced 93% of debt-financed skid-steers in the US. Thus, it may not be unreasonable to presume that individual manufacturers may have some pricing power.

The durable quality of goods is also central to our argument. Returning again to skid-steers as an example, the median used skid-steer financed with secured credit in 2012 was 8 years old. Durability, meanwhile begets a healthy secondary market, which is both a feature of the model and allows us to track prices over time.

Finally, we focus on heavy equipment because of its nature as capital investment (as opposed to a consumption good). Although, in theory, the model applies to consumer durables equally well, we think that some of the more interesting implications of our theoretical findings pertain to the potential link between captive finance and pledgeability and how this may impact borrowers facing credit constraints. To the extent that the relaxation of credit constraints is an important outcome

of captive financing, any resulting impact on firm investment could have large spillover effects for the aggregate economy.

For our primary tests, we rely on two distinct sources of data. One, produced and sold by Equipment Data Associates, tracks financing statements filed by secured lenders for sales – new or used – of heavy equipment financed by secured debt (hereafter, the “UCC data”, because statements of financing are designated as the means of documenting liens under the uniform commercial code). We use these financing statements to infer the extent to which financing is done by manufacturers or by competing banks, the central predictions of our model having to do with how much financing support a manufacturer lends to a given model.⁷ We’ll also use a limited sample of the data which allow us to observe the actual loan amount extended by the lender, and an EDA formulated estimate of the equipment value, thereby allowing us to infer loan to value, or percent downpayment.

The data on financing statements are self-reported by lenders motivated by the need to “stake a claim” to specific pieces of collateral. In the event of a default on a secured loan in which multiple lenders report liens against the same piece of equipment, the first lender to have filed a UCC financing statement on that specific piece of equipment is given priority. Thus lenders have strong incentives to promptly report the collateral they have lent against. Financing statements are publicly available, but EDA sells cleaned and formatted versions going back to 1990. An introduction to financing statements and the claim-staking process is available in Edgerton (2012), which is the first and only other work we are aware of to use these data.

The second dataset we exploit is produced by EquipmentWatch, a data provider which reports results from heavy equipment auctions going back to 1993. While not comprehensive, we have data on the sales/purchases of over one million pieces of equipment from the largest auctioneers of heavy equipment. The sales level observations include sales price, as well as both auction and equipment information such as age, condition, and make/model. Serial numbers are also reported in both datasets, allowing us to identify the probable auction buyers and sellers based on past financing

⁷Although it is debatable as to whether or not financing statements are required for leases, the data and conversations with the data provider suggest that it is a common practice to file financing statements for both loans and financing leases. As a result, we include both leases and loans in our analysis. The focus of our analysis will be who finances the equipment, not the contract, although leases admittedly provide potentially a more powerful device for aligning manufacturers incentives to support resale prices since they are the residual owner in a lease even without default. See Eisefeldt and Rampini (2009) for a theory of leasing based on borrower financial constraints.

statements.

The machines in our data represent substantial purchases for the average buyer. The average estimate of equipment value from EDA and actual sales prices at auction are \$89,455 and \$30,750, respectively. The difference partially reflects the fact that whereas auction sales include both cash and debt financed sales, the EDA estimates only reflect sales financed by secured debt, as well as the fact that auctions are comprised almost exclusively of used sales, while financing statements include new and used sales. For reference, the appendix lists the most common machine types and manufacturers in the UCC data by observation count.

4 Results

4.1 Captive Finance and Resale Support

The central result of the model, and thus the first testable implication we investigate, is that firms which can provide their own financing to buyers are able to commit to higher future resale values.⁸ For now, we take the variation in the availability of captive finance support as given, although we'll show that in practice, the incentives to extend captive financing are closely linked to market power.

Table 1 explores this link by first estimating depreciation rates in the used equipment market on a model-by-model basis and comparing these with the degree of financing support offered for that model. Specifically, the variable *MODEL CAPTIVE SUPPORT* is the percentage of new machines of a given model financed by a captive finance lender over the entire sample (note, we only observe purchases financed with secured debt, so our measure of captive support is conditional on debt financed purchases). Our focus on captive support only over new machines allows us to isolate the effect of captive financing availability, rather than variation in new vs. used sales, which is closely related to lender type. As a point of reference, for the average make and model, 28% of new machine

⁸The mechanism by which prices are supported in the model is restricted production. Therefore, we might consider testing the impact of captive finance on production, if we had data on this. Unfortunately, information on production levels is closely guarded by firms, which go so far as to stagger and skip serial numbers just to hide information about how many machines are produced each year. Moreover, although the model predictions regarding quantities are straightforward in a world where a manufacturer makes only one type of machine, when manufacturers make multiple substitute models and change those models over time, it becomes harder to know how the captive backing of a specific model should impact production choices of related models. Thus, we focus on the predicted end goal of captive finance (price support) as opposed to the lever through which that is achieved (quantities).

sales were financed by the manufacturer.

Meanwhile, we estimate depreciation rates using the auction sample, by regressing the log sales price on log machine age. Regressions are estimated on a model-by-model level. Before running model level regressions, year fixed effects, estimated over the entire sample, are removed from both equipment age and price. Thus, time fixed effects are treated as constant across model-specific regressions. Formally, our measure of depreciation comes from the regression

$$\ln(AuctionPrice_{i,t}) = \alpha_{model} + \delta_{model} \ln(1 + EquipmentAge_{i,t}) + \alpha_{year} + \epsilon_{i,t} \quad (10)$$

where δ_{model} is estimated separately for each model based on the sales of individual machines, i , at auctions in year t . The variable *Equipment Age* is the number of years between the original manufacture date and the date of resale for each machine being sold. δ_{model} captures the model-specific depreciation rate. It should be interpreted as the percentage loss in value for a proportional increase in age.

With a measure of depreciation in hand, we can now project it on the level of captive financing support available for a given model, *MODEL CAPTIVE SUPPORT*, again, estimated as the percentage of new model sales reported in the UCC data which were financed by a captive. To limit noise, we limit ourselves to models for which we have 30 or more transactions in both the auction sales and the UCC data. After dropping equipment models which have too few observations, we are left with 1,727 models with which to estimate the conditional mean depreciation rate based on captive support. To isolate the effect of financing, we control for fine level equipment type fixed effects, as well as a set of 26 size dummy variables, where size is characterized by EDA based on important machine characteristics, often horsepower or weight.

Column 1 of Table 1 reports the estimates from the model

$$-\delta_{model} = \alpha + \beta_1 ModelCaptiveSupport + \beta_{2...k} Controls_{model} + \epsilon \quad (11)$$

We estimate a coefficient on *MODEL CAPTIVE SUPPORT* of -0.14, suggesting that moving from a fully bank financed model to one which is completely financed by the manufacturer would predict

a reduction in the machine’s depreciation rate by 14 percentage points. Meanwhile, the mean depreciation rate is 60% (that is, doubling the median equipment age of 8 years to 16 years is expected to wipe 60% off of machine value). Figure 1 shows this graphically, plotting mean depreciation rates across levels of captive finance. While the relationship is flat for small amounts of captive financing, we can see that above some threshold amount (roughly 50% of machines), depreciation rates appear strongly inversely related to captive support.

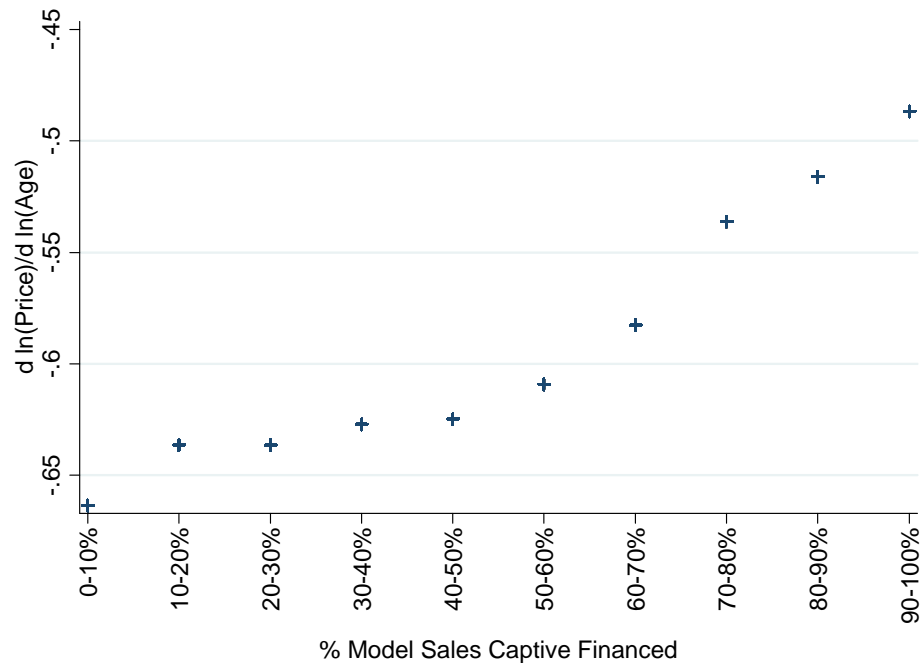


Figure 1: Resale Depreciation and Captive Finance. The figure plots mean depreciation rates across different levels of captive finance. On the horizontal axis is the percentage of new sales of a given model that are financed by the manufacturer. On the vertical axis is the proportional decrease in resale price for a proportional increase in age.

A sensible response to the observed correlation between captive financing and machine characteristics is to look for alternative machine characteristics which might drive both who finances machines and how the machine holds its value. Note, the inclusion of machine-type and size fixed effects appear to rule out omitted variables related to physical features of machines or intended uses, say of back-hoes vs. excavators. Instead, it seems more likely that plausible confounding variables are in fact driven by manufacturer characteristics. One such folk argument might be that bigger,

better companies make better machines and are capable of financing their own products. To answer this, column 2 of Table 1 includes manufacturer fixed effects, testing for differentials in rates of product depreciation across models within a manufacturer. The coefficient on *MODEL CAPTIVE SUPPORT* is largely unchanged and not statistically distinct from the results in column 1 without manufacturer fixed effects. That is, unobserved manufacturer characteristics which are related to the level of captive financing do not explain the observed correlation.

The use of fixed effects and the persistence of the observed relationship between captive financing and resale values within-manufacturer raises an interesting question. Why would a manufacturer provide financing to some makes and models but not others? The mechanism underlying our model suggests one potential answer. Manufacturers do not need captive finance and the commitment it provides in markets where they have limited ability to set prices. That is, if a manufacturer’s production level has no impact on price, then commitment to restrict production over time is not valuable. Simply put, our hypotheses can only explain the use of captive finance by firms with market power.

It turns out this is consistent with the data. Figure 2 plots the use of captive finance across different models against the market concentration for the equipment type. The y-axis presents the average *MODEL CAPTIVE SUPPORT*, while the x-axis represents deciles based on the average of annually calculated Herfindahl index values for a given model’s type of machine (e.g. skid-steer loader, mini-excavator, etc). An active role for captive finance appears to manifest more prevalently in concentrated industries where individual firms possess market power.

Table 2 brings us to a similar, but more pronounced conclusion. Column 1 regresses *MODEL CAPTIVE SUPPORT* on the natural log of a model’s market share, along with controls for equipment type, size, and manufacturer fixed effects. Market share is estimated for new equipment sales within a given equipment type. It is calculated annually and averaged over the life of the model. Importantly, market share estimates are based only on bank financed sales. This helps us avoid capturing market share which is driven by aggressive captive financing terms.

We find that, even within a given manufacturer, models receiving captive support are more likely to be models with substantial market share. Although earlier work has suggested a relationship

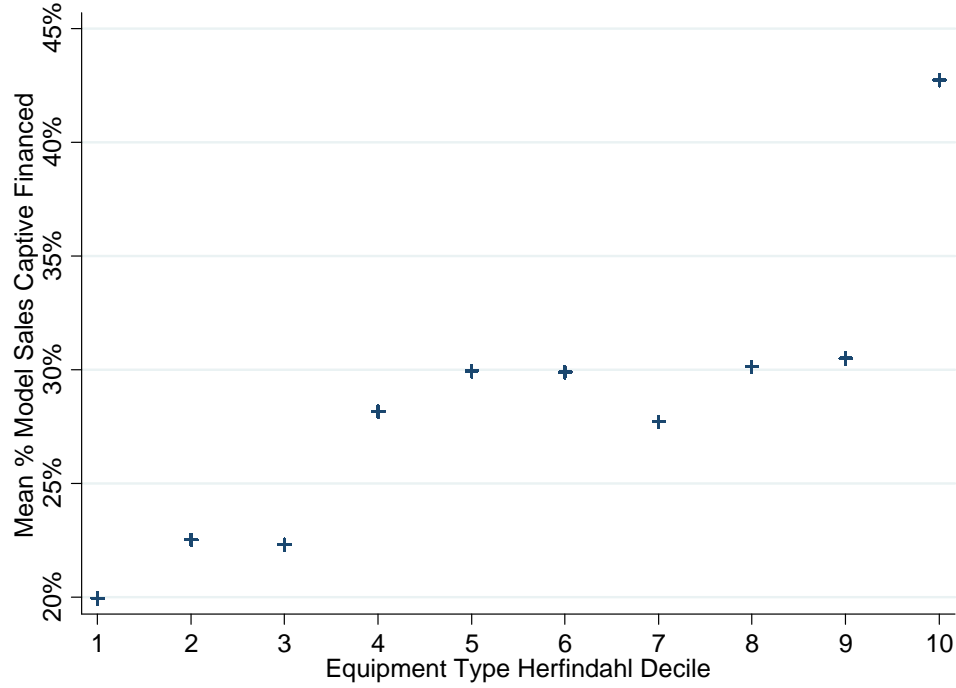


Figure 2: Captive Finance Intensity and Market Power. The figure plots the level of captive finance support received by a equipment model as a function of the concentration of the model’s market. The vertical axis is the average percentage of new model sales financed by the manufacturer. The horizontal axis is the decile of the Herfindahl index for the model’s machine type.

between firm size or market share and the use of captive finance (see Mian and Smith (1992) and Bodnaruk, Simonov, and O’Brien (2012)), we are able to exploit machine level data to show that this relationship holds within manufacturer. This allows us to rule out explanations that would link market share and captive support indirectly through observed or unobserved manufacturer characteristics. Moreover, estimating market share within the universe of bank-financed machines eliminates the natural hypothesis that captive finance is causing market share.

Finally, column 2 puts these two results together to show that captive finance can only predict resale values when the manufacturer has market power. We replicate the regression of depreciation rates on *MODEL CAPTIVE SUPPORT* and controls for equipment type, size, and manufacturer, but add an interaction with a dummy variable for models with above median market share. The interaction is negative and significant. For manufacturers with above-median market share for a

given machine type, going from 0 to 100% captive finance of new sales reduces depreciation rates by 13 percentage points, versus a statistically insignificant reduction of 4 percentage points for manufacturers with below-median market share.

Of course, we can think about other mechanisms of price support which would be consistent with the findings from Tables 1 and 2, but outside of the model. Perhaps manufacturers are better monitors of their collateral than bank lenders (Mian and Smith 1992). Affirmative covenants requiring routine maintenance, for example, may be cheaper or easier to enforce for manufacturers than for bank lenders. Alternatively, it might be the case that manufacturers signal high machine durability by providing financing (Stroebe1 2013), which in turn generates the correlation with higher resale values we observe in our data.

While we can't rule out either hypothesis, the fact that captive finance can only explain resale depreciation for models where the manufacturer has market power is a unique prediction of our model. In contrast, if captive finance signals high machine quality or simply leads to better maintained machines, we would expect that correlation to hold more broadly. We can also, however, attempt to measure and control for ex-post machine quality using information on machine condition and age at the time of sale. If we can effectively control for how well machines survive over time in our regressions, that will help inform the extent to which this is an important aspect of captive financing and the lower depreciation rates associated with captive-backed machines.

In table 3, we first estimate the relationship between physical durability and captive financing support, and then isolate the purely financial depreciation effect related to captive financing from a "better machines" or "better maintenance" hypothesis.⁹ Following the same framework as above, we estimate the relationship between durability and captive support in two stages. The first provides an estimate of durability from the auction dataset, and the second projects this estimate on captive support. The first stage is accomplished by regressing a dummy variable for machine condition on

⁹Although the model currently includes no such mechanism, we think it is plausible that producers with captive finance capabilities may find this a more attractive means of avoiding inter-temporal competition with itself than the alternative proposed in the industrial organization literature: planned obsolescence. If producers can avoid planned obsolescence by offering financing, it might also be the case that captive financing should predict durability. Thus, we can think of these tests as either tests of a secondary (informal) prediction, or at a minimum, as a manner of ruling out alternative hypotheses which may drive the relationship observed in Table 1.

the logarithm of machine age,

$$MachineCondition_{i,t} = \alpha_{model} + \theta_{model} \ln(1 + EquipmentAge_{i,t}) + \epsilon_{i,t} \quad (12)$$

where subscript i indexes an individual machine sold at an auction in year t . Machine condition is an indicator variable set to one if the machine is reported in good or better condition or zero otherwise. Machine condition is reported as excellent, very good, good, fair, or poor in the auction data. Making “good” the condition cutoff roughly cuts the sample in half, allowing for maximal variation on the first stage regression. Our measure of model-specific durability is therefore captured by θ_{model} and represents the likelihood a machine will remain in good condition as time progresses. Because we only use estimates of durability for models with 30 or more observations in the auction sample, we are left with just 879 models.

Columns 1 and 2 of Table 3 first estimate the relationship between durability and captive finance support, again, with and without manufacturer fixed effects. That is, we estimate β_1 from

$$\theta_{model} = \alpha + \beta_1 ModelCaptiveSupport + \beta_{2...k} Controls_{model} + \epsilon \quad (13)$$

and find a positive and significant relationship. Going from fully bank financed model to a fully captive financed model increases durability by 0.15, relative to a mean of -0.42 (where $\theta_{model} = -0.42$ suggests that doubling the machine’s age should imply a 42% reduction in the likelihood that machine will remain in good condition). Again, we can interpret this as support for the prediction (outside of the model) that captive financing may induce the production of more durable machines as firms substitute away from a strategy of planned obsolescence as a solution to the Coase conjecture problem.

However, we’re also sympathetic to the competing explanation— that identically produced machines may be better, or at least better maintained, when financing is done through the captive. Recall, the central prediction of the model is that the manufacturer will maintain prices in secondary markets through its production choices, independent of chosen durability. In columns 3-6 we re-estimate the relationship between machine depreciation and captive financing support, this

time controlling for durability. Columns 3 and 5 replicate specifications from columns 1 and 2 in Table 1 on the reduced sample size, while columns 4 and 6 add controls for durability. We find that the inclusion of durability measures mildly attenuates the effect of captive financing on the purely financial depreciation rate, but not significantly so. Holding machine durability fixed, column 4 reports that by fully-financing its production, the manufacturer can commit to reducing the drop in resale price implied by a doubling of machine age by 12 percentage points. In Columns 4 and 6 we add manufacturer fixed effects and again find that, holding manufacturer and machine durability constant, captive financed models depreciate more slowly. Note that controlling for durability has little impact on the coefficient on model captive support. While our measure of durability is of course noisy, the fact that its inclusion as a control doesn't at all attenuate the main effect of captive backing on depreciation makes it seem unlikely that a perfect measure would qualitatively change the results.

Whereas in the model, the mechanism for maintaining higher resale values is solely production, we can imagine that in practice, firms may impact resale prices through a variety of channels. Advertising, the introduction of new models, the quality and pricing of repair and maintenance services, and even decisions which impact perceived firm longevity and thus, the expected availability of parts and service in the future, will all determine the prices faced by past customers trading in their old models. To the extent that firms may not fully internalize the effects of these choices on their past customers, captive finance may thus be useful.

4.2 Captive Finance and Pledgeability

While we find support for the notion that captive finance can be motivated by the desire to commit to restricted production over time for a durable goods producer with market power, perhaps the more interesting implication of this hypothesis is that captive financing allows for, or to be more precise, requires lower downpayments from the buyer, relaxing credit constraints for borrowers with limited internal cash. High loan-to-values provide commitment to the producer not to lower prices in the future, but if the captive's financing activities are observable to bank lenders, they may free-ride and extend the same loan-to-value without incurring risk of default. Thus, sufficient

captive finance backing will generate lower downpayments, even when machines are financed by banks. Whereas simply observing more aggressive lending standards by captives would perhaps not be surprising (suppose, for example, that captives are able to cross subsidize loan losses with additional profits generated by aggressive lending), the prediction that banks will lend more on machines which receive large amounts of captive finance is a prediction unique to our model. We test it in Table 4 by using a relatively small subset of loans for which the lender reports an exact loan amount on their loan filing. Combining loan value with an EDA provided estimate of purchase price based on machine value at that point in time, we create a variable, *DOWNPAYMENT* as the difference between the log of purchase price and the log loan amount. Of interest is the effect of captive financing on predicted downpayment amount, controlling for machine characteristics as well as borrower characteristics. While borrower characteristics are limited, we observe the borrower’s state and industry and include dummy variables for each (industry dummies are at the level of a 2-digit SIC code). For the machine, we can control for the equipment type, size, and the age of the machine, all of which may plausibly impact both the required downpayment and the lender of choice.

Column 1 reports that, over the entire sample, individual purchases which are financed by captives do appear to require lower downpayments on machines. Note, however, this is not the central prediction of the model, which instead suggests that how an individual machine is financed is irrelevant. Rather, it is the aggregate level of financing support a model receives which will drive the loan-to-value a lender can support.

Column 2 provides a test of the more interesting prediction of the model by focusing on machine sales which were financed by a bank, but for which the purchased model had received varying degrees of captive support. The effect is large and significant. A model without captive support requires a downpayment (as a fraction of value) which is 14% larger than a machine which is otherwise always financed by the captive. With 20% as a typical rule of thumb required downpayment and average machine values of \$89,455, this implies an additional \$2,504 downpayment amount required of machines receiving no captive support (relative to \$17,891 for a fully captive financed model).

This result is suggestive of a possibly positive spillover effect of captive finance. While the

reduced depreciation and higher resale values are clearly serving as rent seeking devices in the model, the resulting low required downpayments/higher pledgeability of physical machines which have received captive financing support may be of value if and when credit constraints bind. While not formally considered in the model, we now ask, can the outcomes from rent-seeking generate positive spillover effects in periods when financing frictions, and the thus the shadow value of pledgeable equipment, are high.¹⁰

To test this possibility, and to provide additional support for our prior arguments that captive finance may help commit companies to build machines with greater pledgeability, we look to the revealed preference for makes and models receiving strong captive support during periods of extreme credit tightening by banks. Our prediction is that borrowers facing rising shadow costs of internal capital, will choose machines with greater pledgeability— machines which have received captive financing support from their makers. Because we’d like to avoid documenting substitution effects of bank financing being replaced by captive financing during periods of tight credit, we again limit our attention to the machine choice of borrowers who are financing their purchases with banks.

Figure 3 gives a taste of our findings. Using two measures of bank tightness, we observe a strong variable demand for machines with captive finance support during periods of tight credit. The top panel plots the probability a given new machine purchase, when financed by a bank, will be of a make and model that received strong captive finance support over the entire sample period (specifically, the fraction of total machines financed by the manufacturer is more than 50%), controlling for equipment type and size.¹¹ This series (the solid line) is plotted against a dashed line representing a survey-based measure of bank’s demand for pledgeable assets taken from the senior loan officer survey performed quarterly by the Federal Reserve Board of Governors. The survey asks surveyed loan officers about whether or not they have tightened collateral requirements for small businesses. The Fed then reports the net percentage reporting tightening (percentage tightening minus percentage loosening). There is an apparent correlation between the two time series driven by large changes during boom and busts periods, but also in the quarterly changes

¹⁰Benmelech and Bergman (2009) show that pledgeability in the airline industry is most valuable during industry downturns when rationing is likely to be greatest.

¹¹Specifically, we plot the time fixed-effect from a regression of machine choice (captive supported machine or not) on quarter, equipment size, and type.

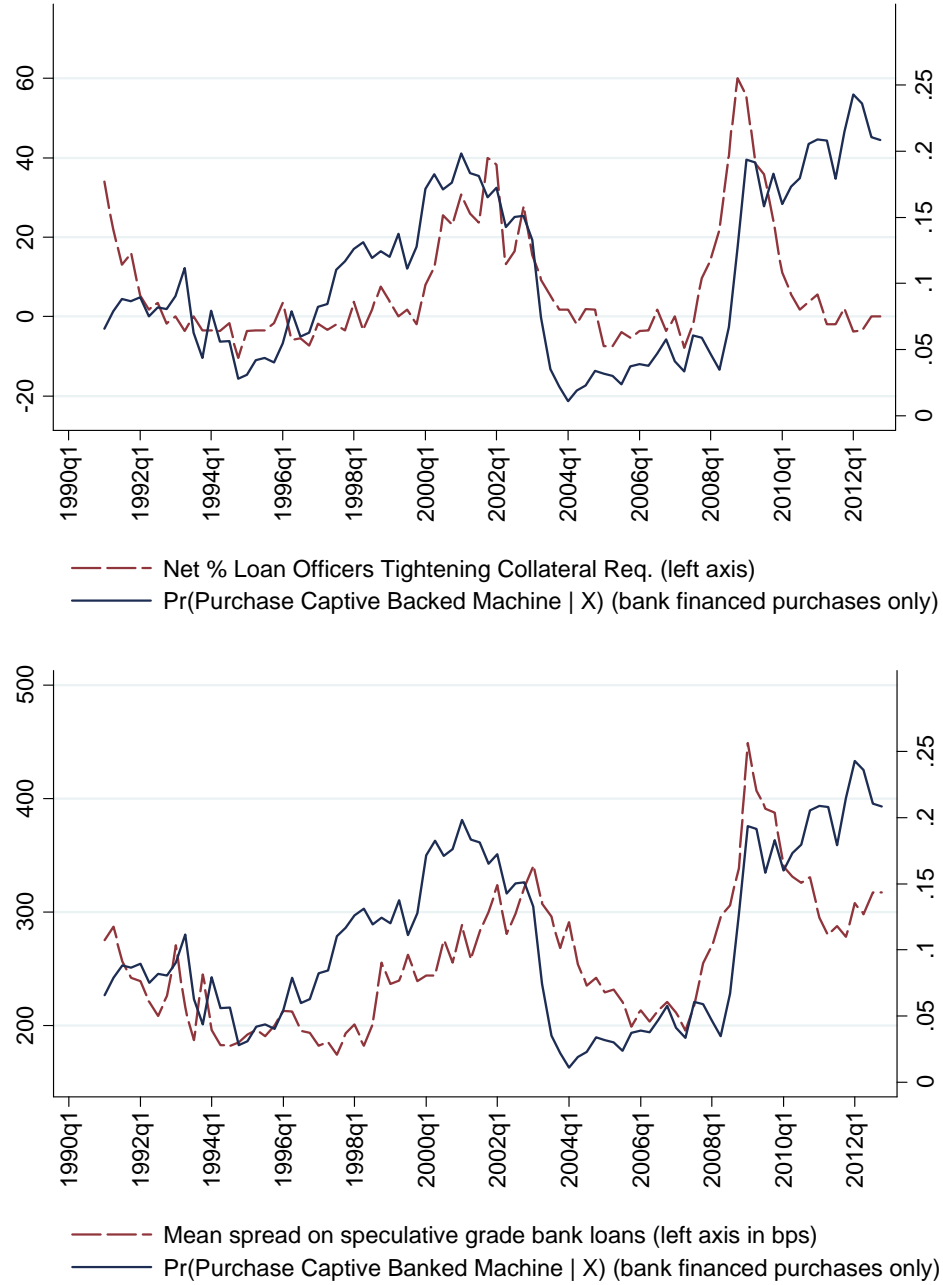


Figure 3: Machine Choice and Credit Tightness. The figure plots the time series of the proportion of new, bank-financed purchases of models with high captive support (more than 50% of machines captive financed) on the right-hand axis of both panels. In the first panel, we compare this to the net percentage of loan officers that reported tightening collateral requirements on the left-hand axis. In the second panel, we plot the mean spread on speculative grade bank loans on the left-hand axis.

(the correlation between the two series is 0.38, and the correlation between the first-differenced series is 0.23). The bottom panel, meanwhile shows a similar relationship between machine choice and tightening as seen via increases in loan spread. The dashed line represents the mean spread over libor of new issue speculative grade loans in the DealScan database. Again, in periods of tight credit/high spreads, the demand for machines with captive finance support increases, even among bank financed purchases. Note, we'll show below this is not driven by time series variation in the availability of captive finance relative to bank lending, which actually decreases in periods of tight bank credit.

Table 5 reduces the picture in Figure 3 into a regression of an individual purchaser's machine choice on financing conditions, this time allowing for the sale of new and used goods as well as controls for machine age, type, and size. We are also concerned that the recent credit crunches may have disproportionately affected industries which use machines receiving more captive support. As a result, we include both 2 digit SIC industry and state fixed effects for machine buyers. Meanwhile, the left hand side variable is again the familiar measure of a make and model's captive finance support estimated over the entire sample for models with more than 30 observations.

Column 1 reports the basic finding from Figure 3 that buyer preference for machines receiving captive support increases during periods of credit tightness, even among bank-financed purchases. Because we estimate the captive finance support the buyer's chosen model has received over the entire sample (and because it is stubbornly persistent within models), this is unlikely to be an artifact of relatively more captive financing being available in periods of tight bank credit. However, to rule this out formally, we add the quarterly mean percentage of purchases financed by captives to the right hand side. The results from column 1 remain significant and do not attenuate. This is due to the fact that captive financing does not appear to be crowded-out during periods of loose bank credit, nor was it a major substitute during the crisis. If anything, captives have been generally more sensitive to changes in lending standards reported by banks than the banks themselves.

Of course periods of credit tightness covary closely with other business cycle measures. As a result, it may be reasonable to interpret this pattern loosely as a preference for captive financed machines in downturns generally and not necessarily as evidence of a direct link to credit frictions.

Moreover, we are sensitive to the fact that, while the time-series results appear statistically significant under our best conservative standard error estimates, we only have data over a few credit cycles.

In Table 6, we therefore attempt to test for the relationship between machine choice and credit constraints using a small cross sectional sample of borrowers for whom we can exploit variation in internal cash for downpayments using prior asset sales. To accomplish this, we focus on borrowers (purchasers of new and used machines) that have recently sold financed equipment at auction and then use the unexpected value they receive on their assets sales at auction as an instrument for their available downpayment on purchases made within the next year. We are able to track buyers' recent auction sales by looking at past purchases identified by serial number and finding identical serial numbers at auction. Then for each auction, we estimate the mean unexpected sales price, where expectations take into account for the auction location, month and year, as well as machine characteristics such as make and model, age, and condition. Formally, we estimate μ_{auction} from the regression

$$\ln(\text{AuctionPrice}_{\text{machine}}) = \mu_{\text{auction}} + \gamma_{\text{year}} + \gamma_{\text{month}} + \gamma_{\text{state}} + \gamma_{\text{auctioneer}} + \beta_{1\dots k} \text{MachineControls} + \epsilon \quad (14)$$

where μ_{auction} is recoverable as the mean of auction level residuals. This recovers an auction fixed effect which is independent by definition of auction and machine controls. Without pinning our estimation to one specific mechanism driving auction effects, auction values may be affected by the performance of the auctioneer (Lacetera, Larsen, Pope, and Sydnor 2014), the number of bidders which attend, even the weather.¹² Meanwhile, our sampling of the largest auctioneers suggests that no reserve auctions are the norm. Thus, buyers who sell at ex-post bad auctions are not necessarily signaling financial weakness, other than that induced by the poor sale.

Between the limitations of focusing on UCC filings for which the loan amount is reported, and buyers who have sold at auction within the past year, we limit ourselves to 1,591 transactions.

¹²In a small subsample of outdoor auctions for which we have temperature data, the effects of cold weather on valuation, even after conditioning out location and season, appear convincingly related to auction prices. Sample size, however, is too small to exploit this as a plausible instrument.

Among those transactions, finally, we limit ourselves to both sales and purchases greater than \$10,000. For the remaining observations, the mean auctions sales-to-new purchase value is 41% (median 13.3%), sufficient to credibly impact new purchase decisions.

In order to derive a second test of the relationship between financing frictions, machine choice, and captive support, we use the estimated auction results as a source of arguably exogenous variation in the downpayment amount a given buyer has to offer. In practice, this means using the estimated auction effects as the instrument for downpayment in a regression predicting the buyer’s choice of machine— in particular, the degree to which their preferred machine benefits from captive financing support:

$$ModelCaptiveSupport = \alpha_{year} + \beta_1 DownPayment + \beta_{2...k} Borrower/MachineControls + \epsilon \quad (15)$$

Again, we will control for borrower location (state) and industry (2-digit SIC), as well as the machine type, size, and age, along with year fixed-effects. Because the left hand side variable varies at the level of make and model, we cluster by manufacturer and year.

The first stage regression of *DOWNPAYMENT* ($\ln(\text{value}) - \ln(\text{loan})$) as in Table 4) on auction results gives the predicted effect, with the coefficient on $\mu_{auction}$ both economically sensible and statistically significant at 0.17. To interpret this number, assume that buyers own 100% equity in the machines at the time of sale, such that a 10% decrease in sales price reduces their cash on hand by 10%. If buyers have no other source of downpayment— that is, financing constraints are hard and binding for all parties in the sample— we would expect to see a 10% impact on downpayments. Instead, we observe that a 10% unexpected shock to sales price is followed by a considerably smaller 1.7% reduction in the downpayment amount, consistent with detectable financing constraints for some, but not all of the buyers. Meanwhile, for a 1 standard deviation move in auction prices of 20%, a given buyer will provide a 3.4% lower downpayment amount. While the effect is not overwhelming in size, it is consistent with our expectations and statistically powerful enough with a F-stat of 11.04 to continue to the second stage.¹³

¹³Stock-Yogo critical values (Stock and Yogo 2005) put the instrument between 10% and 15% maximal IV size, although, as in most applied cases, our analysis assumes non-independent errors in the estimation (clustering is by

The second-stage, reported in column 2, extends the time-series findings. A coefficient on *DOWNPAYMENT* of -0.17 tells us that a doubling of a given buyer’s available downpayment will push her into a make and model which was 17.5% points less likely to be financed by the manufacturer over the entire sample. Column 2 confirms the result holds when we limit the sample to bank financed sales. This is consistent with the finding in Table 4: even banks are willing to extend higher loan-to-values on machines receiving captive support based on the manufacturers’ resale price commitment.

In interpreting Tables 4-6, we have to be somewhat careful. Note that, on one hand, Table 6 suggests that constrained borrowers may have preference for models benefiting from captive support, whereas our initial interpretation of Table 4 was that lenders were willing to relax downpayment requirements when buyers chose captive machines. In revisiting the interpretation of that table, we may wish to be more careful in acknowledging that the larger loan amounts reflect both lenders’ willingness as well as borrowers’ need for smaller downpayments. Given that borrowers buying captive-backed machines because they have less internal cash to put down are also likely to be riskier and thus merit smaller loans generally, we think the estimated effect of captive support on pledgeability in Table 4 will tend to be biased towards zero.

5 Discussion

A simple model of a durable goods manufacturer operating with pricing power suggests that the act of financing one’s own sales may provide a commitment to supporting higher resale values in the future, and as a result, lower downpayments today. We’ve found support for both those predictions in the data, as well as the corollary predictions which emerge outside of the model, that captive financed products will become favored by borrowers who find themselves with limited access to internal funds.

The welfare implications of captive finance, therefore, are blurred. On one hand, the evidence points to captive finance as a rent seeking device. Manufacturers that offer it would appear to do so, at least in part, to raise prices today and restrict production tomorrow. This has a clearly

year and manufacturer), so critical values based on independent errors should be taken with a grain of salt.

negative impact on consumer surplus. On the other hand, in a world with credit constraints where pledgeability is valuable, welfare implications become less clear. As we saw in the crisis (Figure 3), the demand for machines offering greater pledgeability appears to jump exactly when the need for lending was greatest. This suggests a value to captive finance which is perhaps largest in the worst states. Thus, it may be reasonable from a welfare context to think of captive finance as a costly hedge, where the cost of restricted supply and the associated manufacturer rents afford the benefit of relaxed credit constraints on capital investment during periods of tight credit.

Appendix

Appendix A Solution with Captive Finance

Figure A1 illustrates the objective function (7) for several values of q_1 and d_2 . In each panel we see that the objective function has a kink at the default boundary. At the default boundary the firm switches from receiving the previously contracted debt payment, d_2 , to receiving the resale value of the equipment, p_2 . At second-period production levels below the default boundary, producing a marginal machine costs the firm in the form of a lower price on all second period sales. Once the firm crosses the default boundary, however, producing a marginal machine costs the firm in the form of a lower sales price on second period sales as well as a lower resale price on the first period machines. Intuitively, the firm begins internalizing the impact of production on resale values at the default boundary. Thus the slope of the objective function is lower after the default boundary than it is before.

The first-order condition and corresponding price are given by:

$$q_2^c = \frac{1}{2b}(a - bq_1(1 + \phi_d)), \quad p_2^c = \frac{1}{2}(a - bq_1(1 - \phi_d)). \quad (16)$$

These conditions hold everywhere except at the default boundary, where the objective function is not differentiable. Thus, there are three possible solutions to this problem. We can have the first-order condition hold with $\phi_d = 0$, the first order condition hold with $\phi_d = 1$, or we can have the optimal solution occur at the default boundary. Which of these cases occurs depends on the state variables q_1 and d_2 , as illustrated in Figure A1.

Consider first the case in which the optimal second period production occurs at production levels below the default boundary. This case is illustrated in Panel A of Figure A1. The firm would choose the optimal production level strictly below the default boundary, meaning that it would not internalize the effect of production on resale values. The first-order condition would hold with $\phi_d = 0$, so that $q_2^c = \frac{1}{2b}(a - bq_1)$, which is exactly the second period production with bank financing. This case occurs whenever $d_2 < \frac{1}{2}(a - bq_1) = p_2^b$, where p_2^b is the second period price under bank

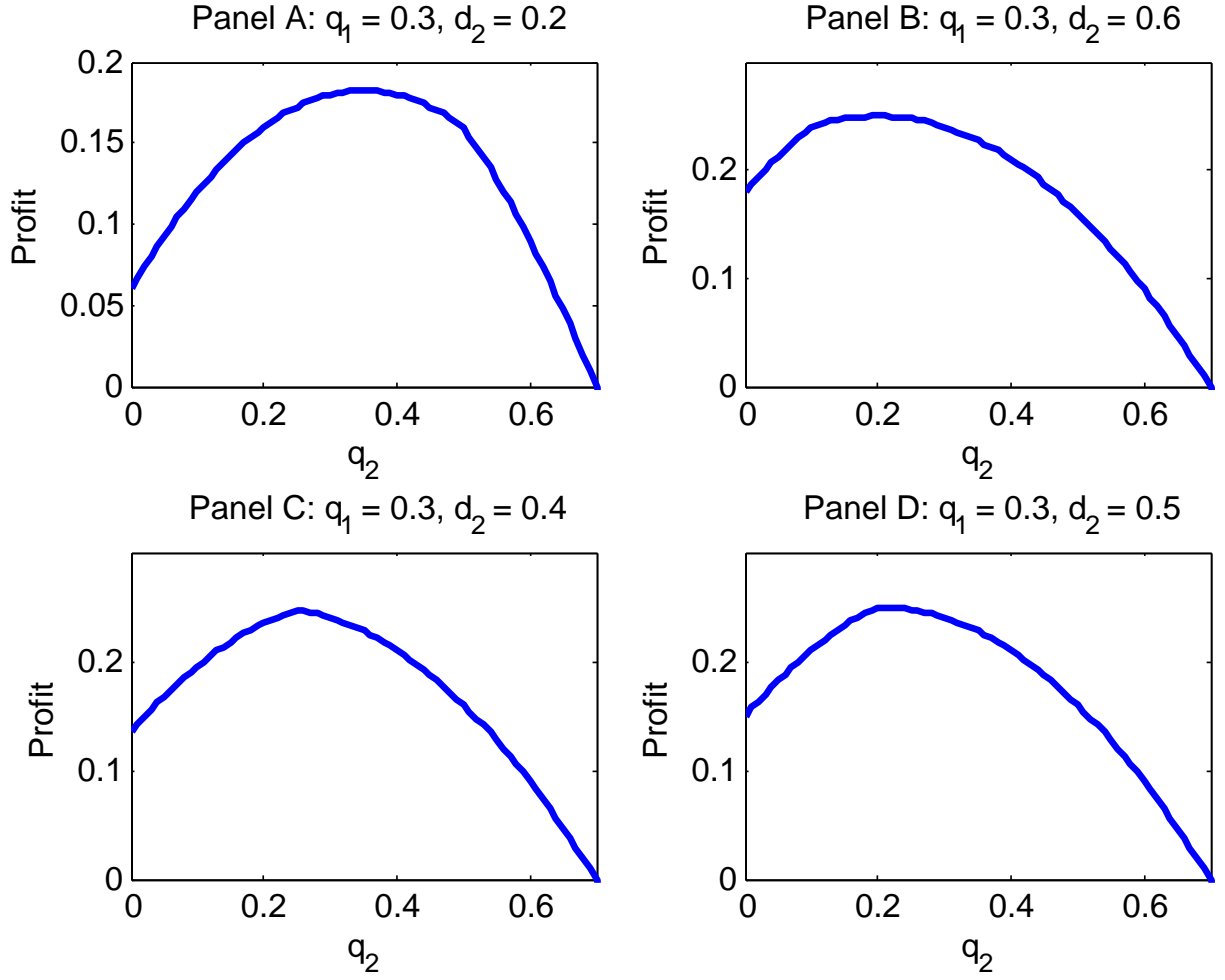


Figure A1: Regions of Interest for the Objective Function The figure plots the firm's second period objective function for various combinations of the state variables q_1 and d_2 . In Panel A, d_2 is inefficiently small so that the firm chooses to stop producing before reaching the default boundary. In Panel B, d_2 is inefficiently large, so that the firm chooses to produce well beyond the default boundary. In Panel C, d_2 is in the intermediate range so that the firm produces just up to the default boundary. In Panel D, d_2 is chosen as the optimal choice in the intermediate region.

financing. The debt payment here would be too small to provide an effective commitment device.

Next consider Panel B of Figure A1. In this case the optimal second period production would occur beyond the default boundary. As the lien holder, the firm would internalize the effect of production on the resale value of machines and would produce until the total quantity of machines in the market is equal to the perfect commitment quantity, $Q_2^c = \frac{a}{2b}$, as can be seen by the first-order condition with $\phi_d = 1$. This case occurs whenever $d_2 > \frac{a}{2}$. The debt payment here would be so high that the firm would prefer to take a loss on all first period loans rather than restrict production as drastically as would be needed to avoid default.

In Panel C of Figure A1 the optimal level of production is right at the default boundary. In this case the firm finds it optimal to continue producing machines when it is not the residual claimant on resale values, but finds it suboptimal to continue producing once it has become the residual claimant. The quantity of machines produced would fall between the perfect commitment quantity and the quantity generated by bank financing. This occurs for intermediate levels of debt given by $\frac{1}{2}(a - bq_1) \leq d_2 \leq \frac{a}{2}$. In this region, the first-order condition does not apply. Instead, the solution is given by setting the price of machines equal to the outstanding debt payment: $q_2^c = \frac{1}{b}(a - bq_1 - d_2)$, $p_2^c = d_2$, and $\pi_2^c = \frac{1}{b}(a - bq_1 - d_2)d_2$. Anywhere in this region the firm can use its financing policy to perfectly pin down its future production.

For example, Panel D shows the boundary case where $d_2 = \frac{a}{2}$. By choosing this amount the firm can commit to the perfect-commitment level of production (as in Panel B), but can do so without inducing default. Similarly, by setting $d_2 = \frac{1}{2}(a - bq_1)$, the firm could replicate the second period production $q_2^c = \frac{1}{2b}(a - bq_1)$ found in Panel A. Thus, for any state variables $\{q_1, d_2\}$ with associated optimal output $q_2^c(q_1, d_2)$, there exists $\hat{d}_2 \in [\frac{1}{2}(a - bq_1), \frac{a}{2}]$ such that $q_2^c(q_1, d_2) = q_2^c(q_1, \hat{d}_2) = \bar{q}_2(q_1, \hat{d}_2)$. Therefore, without loss of generality we can focus on solutions that occur at the default boundary.

Appendix B Equilibrium with Captive and Bank Financing

Empirically we observe that most machine types are neither purely captive nor purely bank-financed. In many of our empirical tests, we will divide machines types into high and low captive support. In order to support the empirical analysis, then, we now analyze the optimal financing contract when (for exogenous reasons) the firm finances a fraction α of the machines it produces and banks finance the remaining machines. Starting again at the firm's second period optimization problem, the firm solves

$$\max_{q_2} p_2(q_2)q_2 + (1 - \phi_d)d_2\alpha q_1 + \phi_d p_2(q_2)\alpha q_1 \quad (17)$$

The first term in (17) captures the firm's proceeds from second period production; the second term captures the debt payment made by first period buyers when they choose not to default; and the third term captures the firm's proceeds from repossession in default. The first-order condition and associated price are:

$$q_2^m = \frac{1}{2b}(a - bq_1(1 + \alpha\phi_d)), \quad p_2^m = \frac{1}{2}(a - bq_1(1 - \alpha\phi_d)) \quad (18)$$

This problem is identical to (7) except that in default the firm only has proportional exposure α to secondary market prices. The analysis is also nearly identical. In particular, there is a region where debt payments are too small to provide effective commitment so that resulting production would be equal to that under bank financing. Just as above, this region is defined by $d_2 < \frac{1}{2}(a - bq_1)$ as can be seen by setting $\phi_d = 0$ in (18). Additionally, there is a region where the debt payment is so high that the benefits to producing beyond the default region outweigh the losses on first period loans. By setting $\phi_d = 1$ in (18) we can see that this region is defined by $d_2 > \frac{a}{2} - \frac{1-\alpha}{2}bq_1$ and that in this region the firm will produce until $q_2^m = \frac{a}{2b} - \frac{1+\alpha}{2}q_1$. Here the firm would not be able to achieve the perfect commitment level of production because it is only exposed to resale prices for a fraction of the machines. Finally, for intermediate levels of debt given by $\frac{1}{2}(a - bq_1) \leq d_2 \leq \frac{a}{2} - \frac{1-\alpha}{2}bq_1$, the optimal level of production occurs at the default boundary $\bar{q}_2(q_1, d_2)$.

Just as in the case of all captive financing, we can assume without loss of generality that

the optimal production occurs at the default boundary so that $q_2^m = \bar{q}_2, p_2^m = d_2$, and $\pi_2^m = \frac{1}{b}(a - bq_1 - d_2)d_2$. Using this, the firm's first-period problem is:

$$\begin{aligned} \max_{q_1, d_1, d_2} \quad & (1 - \alpha)(d_1 + d_2)q_1 + \alpha(a - bq_1 + d_2) + \frac{1}{b}(a - bq_1 - d_2)d_2 \\ \text{subject to} \quad & d_1 + d_2 \leq a - bq_1 + d_2 \end{aligned} \quad (19)$$

The first term in the objective function captures the firm's proceeds from financing machines sold in the first period; the second term captures the firm's proceeds from selling machines to bank-financed buyers and uses the fact that $d_2 = p_2$; and the third term captures the firm's profits from second period production. The constraint says that the present value of debt payments cannot exceed the price of first-period machines, which we know must bind at the optimum. Thus we can substitute the constraint into the objective function. The optimal solution for d_2 occurs at the upper bound of the intermediate region of debt, $\frac{a}{2} - \frac{1-\alpha}{2}bq_1$. We then get the solution

$$\begin{aligned} q_1^* &= \frac{2a}{b(5 - 2\alpha + \alpha^2)}, & p_1^* &= \frac{a}{2} \left(\frac{9 - 4\alpha + 3\alpha^2}{5 - 2\alpha + \alpha^2} \right), & d_1^* &= a \left(\frac{3 - 2\alpha + \alpha^2}{5 - 2\alpha + \alpha^2} \right) \\ q_2^* &= \frac{a}{2b} \left(\frac{3 - 4\alpha + \alpha^2}{5 - 2\alpha + \alpha^2} \right), & p_2^* &= \frac{a}{2} \left(\frac{3 + \alpha^2}{5 - 2\alpha + \alpha^2} \right), & d_2^* &= p_2^* \\ \pi^* &= \frac{a^2}{4b} \left(\frac{9 - 2\alpha + \alpha^2}{5 - 2\alpha + \alpha^2} \right) \end{aligned} \quad (20)$$

It is easy to show that the firm's profit is strictly increasing in the proportion of machines it finances internally. Similarly, the depreciation rate and the down payment required are strictly decreasing in the proportion of machines financed internally.

Appendix C Machine Types and Manufacturers

Table A1: Machine Types and Manufacturers. We report the top 10 equipment types and manufacturers from the UCC filing data. Included are both new and used sales from 1990-2012. Ranking is based on number of observations.

	(1) Top 10 Machine Types	(2) Top 10 Manufacturers
1	SKID STEER LOADERS	CATERPILLAR
2	EXCAVATORS	DEERE
3	CRAWLERS	CASE
4	INDUSTRIAL TRACTORS	BOBCAT
5	WHEEL LOADERS	KOMATSU
6	ROUGH TERRAIN FORKLIFTS	NEW-HOLLAND
7	COMPACTORS	INGERSOLL-RAND
8	TRENCHERS	VOLVO
9	AERIAL LIFTS	DITCH-WITCH
10	DRILLS	FORD

References

- Benmelech, Efraim, and Nittai K. Bergman, 2009, Collateral Pricing, *Journal of Financial Economics* 91, 339–360.
- Bodnaruk, Andriy, Andrei Simonov, and William O’Brien, 2012, Captive finance and firms competitiveness, *Working Paper*.
- Brennan, Michael J., Vojislav Maksimovic, and Josef Zechner, 1988, Vendor Financing, *Journal of Finance* 43, 1127–1141.
- Bulow, Jeremy, 1982, Durable Goods Monopolists, *Journal of Political Economy* 90, 314–332.
- , 1986, An Economic Theory of Planned Obsolescence, *Quarterly Journal of Economics* 101, 729–749.
- Butz, David, 1990, Durable-Good Monopoly and Best-Price Provisions, *American Economic Review* 80, 1062–1076.
- Chevalier, Judith, and Austan Goolsbee, 2009, Are Durable Goods Consumers Forward-Looking? Evidence from College Textbooks, *Quarterly Journal of Economics* 124, 1853–1884.
- Coase, Ronald H., 1972, Durability and Monopoly, *Journal of Law and Economics* 15, 143–149.
- Edgerton, Jesse, 2012, Credit Supply and Business Investment During the Great Recession: Evidence from Public Records of Equipment Financing, Working paper, Federal Reserve Board.
- Eisfeldt, Andrea L., and Adriano A. Rampini, 2007, New or Used? Investment with Credit Constraints, *Journal of Monetary Economics* 54, 2656–2681.
- , 2009, Leasing, Ability to Repossess, and Debt Capacity, *Review of Financial Studies* 22, 1621–1657.
- Hortacsu, Ali, Gregor Matvos, Chad Syverson, and Sriram Venkataraman, 2013, Indirect Costs of Financial Distress in Durable Goods Industries: The Case of Auto Manufacturers, *Review of Financial Studies* 26, 1248–1290.

- Karp, Larry, and Jeffrey Perloff, 1996, The Optimal Suppression of a Low-Cost Technology by a Durable-Good Monopoly, *Rand Journal of Economics* 27, 346–364.
- Kutsoati, Edward, and Jan Zabochnik, 2001, Durable goods monopoly, learning-by-doing, and 'sleeping patents', Working paper, University of Southern California.
- Lacetera, Nicola, Bradley J. Larsen, Devin G. Pope, and Justin R. Sydnor, 2014, Bid Takers or Market Makers? The Effect of Auctioneers on Auction Outcomes, Working paper.
- Levine, David, 1985, A Simple Durable Goods Model, *Quarterly Journal of Economics* 100, 775–788.
- Mian, Shehzad, and Clifford Smith, 1992, Accounts receivable management policy: Theory and evidence, *The Journal of Finance* 47, 169–200.
- Rampini, Adriano A., and S. Viswanathan, 2010, Collateral, Risk Management, and the Distribution of Debt Capacity, *Journal of Finance* 65, 2293–2322.
- Stock, James H., and Motohiro Yogo, 2005, Testing for Weak Instruments in Linear IV Regression, *Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg* pp. 80–108 Cambridge University Press.
- Stroebel, Johannes, 2013, Asymmetric information about collateral values, *Working Paper*.
- Waldman, Michael, 2003, Durable Goods Theory for Real World Markets, *Journal of Economic Perspectives* 17, 131–154.

Table 1: Captive finance and resale prices. The table documents the relationship between resale value of heavy machinery and the extent of captive financing in the primary market. Depreciation rates are estimated for each make and model (conditional on having 30 or more resale observations) based on the following model-level regressions:

$$\ln(AuctionPrice_{i,t}) = \alpha_{model} + \delta_{model} \ln(1 + EquipmentAge_{i,t}) + \alpha_{year} + \epsilon_{i,t}$$

where subscript i indexes individual machine and t is the year of the auction. Equipment age is the number of years between the original manufacture date and the date of resale. $-\delta_{model}$, the model-specific depreciation rate, captures the percentage loss in value for proportional increases in age. Columns 1 and 2 report regressions of depreciation rate on the fraction of new machines which are financed by captive finance units for each model, along with controls for equipment subtype and size as described in the appendix,

$$-\delta_{model} = \alpha + \beta_1 ModelCaptiveSupport + \beta_{2...k} Controls_{model} + \epsilon.$$

Fraction captive financed is reported by model from the UCC filing data and is only included for models which had 30 or more machines financed from 1990-2012. Standard errors are clustered at the manufacturer level, are robust to heteroskedasticity, and are reported in parentheses. ***, **, and * signify results significant at the 1, 5, and 10% levels, respectively.

	(1) Depreciation Rate	(2) Depreciation Rate
Model Captive Support	-0.14*** (0.05)	-0.18*** (0.07)
Manufacturer Fixed Effects	NO	YES
Equipment Type Fixed Effects	YES	YES
Equipment Size Fixed Effects	YES	YES
Observations	1727	1727
R-squared	0.45	0.55

Table 2: Captive finance and resale prices (continued). Column 1 estimates the link between market share for a particular model and the extent to which that model receives captive support. Market share is estimated for new equipment sales within a given equipment type. It is calculated annually and averaged over the life of the model. Importantly, market share estimates are based on bank financed sales. This helps us avoid capturing market share which is driven by aggressive captive financing terms. Column 2 extends the regressions of Table 1 to include an interaction term with a measure of model specific market share. *High Market Share* is a dummy variable equal to one if a model is above the median market share in the sample. Sample size is slightly larger than in Table 1, where only models with more than 30 recorded sales were included in the analysis. Below, we include these models so as not to exclude models with low market share (the variable of interest). All regressions include manufacturer fixed effects. Standard errors are clustered at the manufacturer level, are robust to heteroskedasticity, and are reported in parentheses. ***, **, and * signify results significant at the 1, 5, and 10% levels, respectively.

	(1) Model Captive Support	(2) Depreciation Rate
ln(Market Share)	0.03*** (0.01)	Model Captive Support -0.04 (0.06)
		Model Captive Support x High Market Share -0.09** (0.04)
		High Market Share 0.05** (0.02)
Manufacturer Fixed Effects	YES	YES
Equipment Type Fixed Effects	YES	YES
Equipment Size Fixed Effects	YES	YES
Observations	2400	2399
R-squared	0.62	0.46

Table 3: Durability and captive finance. The table documents the relationship between machine durability and captive financing in the primary market. Durability is estimated by model (conditional on having 30 or more resale observations) based on the following model-level regressions:

$$MachineCondition_{i,t} = \alpha_{model} + \theta_{model} \ln(1 + EquipmentAge_{i,t}) + \epsilon_{i,t}$$

where subscript i indexes individual machine and t is the month of the auction. *Machine condition* is an indicator variable set to one if the machine is in good or better condition or zero otherwise. Equipment age is the number of years between the original manufacture date and the date of resale. Model-specific durability is captured by θ_{model} . Columns 1 and 2 report regressions of model durability on the fraction of new machines which are financed by captive finance units for each model, along with controls for equipment type and size,

$$\theta_{model} = \alpha + \beta_1 ModelCaptiveSupport + \beta_{2...k} Controls_{model} + \epsilon$$

Fraction captive financed is reported by model from the UCC filing data and is only included for models which had 30 or more machines financed from 1990-2012. Columns 3 and 4 repeat the regressions from Table 1, this time controlling for the estimates of model durability. Errors are clustered at the manufacturer level, are robust to heteroskedasticity, and are reported in parentheses. ***, **, and * signify results significant at the 1, 5, and 10% levels, respectively.

38

	(1)	(2)	(3)	(4)	(5)	(6)
	Durability	Durability	Depreciation Rate	Depreciation Rate	Depreciation Rate	Depreciation Rate
Model Captive Support	0.15*** (0.04)	0.22*** (0.05)	-0.15*** (0.04)	-0.12*** (0.04)	-0.22*** (0.06)	-0.19*** (0.05)
Durability				-0.19*** (0.04)		-0.16*** (0.04)
Manufacturer Fixed Effects	NO	YES	NO	NO	YES	YES
Equipment Type Fixed Effects	YES	YES	YES	YES	YES	YES
Equipment Size Fixed Effects	YES	YES	YES	YES	YES	YES
Observations	879	879	877	877	877	877
R-squared	0.19	0.32	0.56	0.58	0.64	0.65

Table 4: Captive finance and pledgeability. The table estimates the effect of captive financing support at the model level on the downpayment required for individual machine buyers. The model of interest is

$$\text{Downpayment} = \alpha_{\text{year}} + \beta_1 \text{CaptiveSupport}_{\text{model}} + \beta_{2\dots k} \text{MachineControls} + \beta_{k+1\dots j} \text{BorrowerControls} + \epsilon$$

The variable *Downpayment* is reported as the difference between log ratio of estimated machine value to loan value. Column 1 reports the reduced downpayment when the purchase is financed by a captive. Column 2 reports the reduced downpayment for bank financed purchases of models which have otherwise received strong captive support. Standard errors are clustered at the manufacturer and year level, are robust to heteroskedasticity, and are reported in parentheses. ***, **, and * signify results significant at the 1, 5, and 10% levels, respectively.

	(1) All Purchases	(2) Bank Financed Purchases Only
Downpayment		
Purchase Financed by Captive	-0.05* (0.03)	
Model Captive Support		-0.142** (0.07)
Borrower Controls (state fixed effects, industry fixed effects)	YES	YES
Machine Controls (type fixed effects, ln(age), size fixed effects)	YES	YES
Observations	55,272	23,436
R-squared	0.26	0.27

Table 5: Machine choice and pledgeability in the time series. The table estimates the relationship between the yearly changes in collateral requirements reported by senior loan officers and the machine choice of bank-financed buyers, where machines are characterized based on their full history of captive support. Specially, we estimate

$$ModelCaptiveSupport = \beta_1 \sum_{i=0}^3 CollateralTightening_{t-i} + \beta_{2...k} MachineControls + \beta_{k+1...j} BorrowerControls + \epsilon$$

ModelCaptiveSupport represents the percentage captive financed machines for the model chosen by the buyer. Collateral tightening reflects the net percentage of loan officers responding to the survey reporting tighter collateral requirements on commercial loans to small and medium sized firms during the year of purchase. As in other tables, the measure of captive support is estimated at the model level and does not vary over time. Reported right-hand-side variables are demeaned and given unit standard deviation for ease of interpretation. The sample is limited to purchases of machines financed by banks. Column 2 includes a control for the fraction of machines financed by captives in a given quarter. Standard errors are clustered at the manufacturer and year level, are robust to heteroskedasticity, and are reported in parentheses. ***, **, and * signify results significant at the 1, 5, and 10% levels, respectively.

	(1)	(2)
Chosen Model Captive Support		
Collateral tightening over past year	0.015** (0.006)	0.016*** (0.005)
% machines financed by captives		-0.012** (0.005)
Borrower Controls (state fixed effects, industry fixed effects)	YES	YES
Machine Controls (type fixed effects, ln(age), size fixed effects)	YES	YES
Observations	985,830	985,830
R-squared	0.31	0.31

Table 6: Machine choice and financing constraints. The table estimates the impact of a borrower's available downpayment on her choice of machine, where machines are characterized based on the full history of their captive support

$$ModelCaptiveSupport = \alpha_{year} + \beta_1 DownPayment + \beta_{2...k} MachineControls + \beta_{k+1...j} BorrowerControls + \epsilon$$

ModelCaptiveSupport represents the percentage captive financed machines for the model chosen by the buyer. *DownPayment* reflects the log difference between estimated equipment value and loan amount recorded in the purchase. We instrument for the buyer's downpayment amount using unexpectedly low (high) sale values at recent auctions where the borrower also sold equipment. Specifically, for auctions no more than 365 days prior to the purchase date where the borrower sold used equipment, we estimate the parameter $\mu_{auction}$ from the following regression, where $\mu_{auction}$ reflects the average, unanticipated percentage price shock experienced by sellers at that auction:

$$\ln(AuctionPrice_{machine}) = \mu_{auction} + \gamma_{year} + \gamma_{month} + \gamma_{state} + \gamma_{auctioneer} + \beta_{1...k} MachineControls + \epsilon$$

Column 1 reports the first stage regression of the borrower's percentage downpayment on prior auction sales results. Column 2 reports the 2SLS results of the degree of captive finance support of the machine being purchased on instrumented downpayment. Both regressions include controls for equipment size, age, type, and buyer state, one digit industry and the year of the equipment purchase. Standard errors are clustered at the manufacturer and year level, are robust to heteroskedasticity, and are reported in parentheses. ***, **, and * signify results significant at the 1, 5, and 10% levels, respectively.

Downpayment	(1)	Chosen Model	(2)	(2)
			All Purchases	Bank Financed Purchases Only
<i>μ_{auction}</i>	0.17*** (0.05)	Downpayment	-0.17*** (0.05)	-0.14*** (0.04)
Borrower Controls	YES	Borrower Controls	YES	YES
Machine Controls	YES	Machine Controls	YES	YES
Time Fixed Effects	YES	Time Fixed Effects	YES	YES
Observations	1,591	Observations	1,591	780
R-squared	0.40	R-squared	0.57	0.55
F-test of excluded instruments	11.04			