PHBS WORKING PAPER SERIES

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September 2022

Working Paper 20220906

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Keywords: Leased capital, collateral constraint, capital reallocation, cyclical pattern
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In this paper, we argue that leasing is an important alternative way of capital reallocation. We propose a broader measure of capital reallocation, which not only includes asset purchase and sale, but also considers lease. Empirically, we show that the lease-induced reallocation component is over 50% of the unadjusted measure (Eisfeldt and Rampini, 2006). Moreover, the cyclical patterns of lease-adjusted reallocation become less procyclical, especially for small firms. Theoretically, we develop a general equilibrium model with capital reallocation and a buy versus lease decision to explain these empirical patterns and demonstrate the role of leasing in facilitating capital reallocation.

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I Introduction

It has been well recognized that capital reallocation (i.e., the reallocation of productive assets across firms) is an important part of US corporate investment, and that capital reallocation is procyclical (Eisfeldt and Rampini, 2006). However, the measured capital reallocation and corporate investment has overlooked a large component, i.e., operating lease, despite its extensive usage in factor allocation and production-related activities.[1] In this paper, we argue that leasing is an important alternative way of capital reallocation, complementary to directly purchasing and selling capital on the (owned) capital reallocation market. When firms are financially constrained, the possibility for them to rent capital offers an alternative channel to improve capital reallocation efficiency.[2] We document that the reallocation of leased capital is over 50% of the reallocation of owned capital for US public firms. Explicitly adjusting for lease, we find that the adjusted capital reallocation becomes less procyclical, especially for small firms which tend to lease more.

Our starting point is that firms produce with not only owned physical capital, but also leased capital. However, in the capital reallocation literature, notably Eisfeldt and Rampini (2006), capital reallocation refers to the transfer or sale of owned capital across firms, without recognizing the role of leasing as an important component. Specifically, Eisfeldt and Rampini (2006) use the sum of sales of property, plant, and equipment (PPE) and acquisitions as the amount of capital reallocation. Motivated by this, we construct a broader definition of capital reallocation that includes not only owned capital on the reallocation market but also the investment in leased capital, and we identify it as the lease-adjusted capital reallocation.

We establish two facts about the lease-adjusted capital reallocation. First, and unconditionally, we find that the amount of capital reallocation induced by leasing is considerable, amounting to over 50% of the unadjusted capital reallocation in Eisfeldt and Rampini (2006). Ignoring leased capital in the measurement of capital reallocation leads to an underestimation of the reallocation amount and ratios, and such mismeasurement is disproportionately larger for small firms that rent more capital. Second, and conditionally, explicitly accounting for leased capital as an alternative form of capital reallocation is also important for us to correct for an overestimation of the cyclical pattern of capital reallocation. To do so, we extract the cyclical component of the unadjusted and adjusted capital reallocation (both amount and ratios) and compute the correlation with the cyclical component of GDP. We find that unad-

[1]This is partially due to the previous accounting rule, which treats lease contracts as off-balance-sheet items. Recently, the Financial Accounting Standards Board (FASB) and the International Accounting Standards Board (IASB) issued updates on lease-accounting rule, requiring firms to recognize lease assets and lease liabilities on their balance sheets from 2019 (ASU 2016-02, Topic 842; IFRS 16).

[2]We use "lease" and "rent," "purchase" and "own" interchangeably in this paper.

justed capital reallocation is considerably and significantly procyclical (Eisfeldt and Rampini, 2006, Ai, Li, and Yang, 2020), whereas the lease-adjusted capital reallocation is less procyclical, since the leased capital to owned physical capital ratio is highly countercyclical in the data. Moreover, if we look at small firms, we find that their capital reallocation becomes acyclical or even mildly countercyclical, since these firms rent more capital, in particular, in recessions. We confirm the robustness of these results using firm-level regressions. These facts provide an important caveat to previous evidence on procyclical capital reallocation, when we recognize leasing as an alternative way of capital reallocation.

In order to explain these facts, we consider an explicit buy versus lease decision and capital reallocation in a general equilibrium model with heterogeneous firms and collateral constraints. In so doing, we demonstrate that the ability for firms to lease capital when they are financially constrained serves an alternative capital reallocation channel. Our model setup provides an explicit separation between intertemporal capital investment and capital purchase/sale on the reallocation market, so that we can directly compare capital reallocation measures with and without adjusting for leased capital.

In our setup, leasing is modeled as highly collateralized albeit costly financing, as in Eisfeldt and Rampini (2009) and Rampini and Viswanathan (2013). When an asset is leased, the ownership belongs to the lessor (i.e., the agent providing financing). This strengthens the lessor's claim by facilitating repossession, and hence allows the lessor to extend more credit. Meanwhile, leasing involves a separation of ownership and control, which is costly due to agency problems. Financially constrained firms value the additional debt capacity more and prefer leasing to buying capital, despite of leasing's expensive costs due to the agency problem. Whether a firm chooses to buy or lease capital depends on the firm's initial wealth and its idiosyncratic productivity. The heterogeneity in these two dimensions hence translates into differences in the leased capital ratio in equilibrium: firms with high productivity but low initial wealth lease more of their capital to support their investment and production.

In this theoretical framework, we show that in the cross-section, firms with higher financing needs (i.e., higher idiosyncratic productivity given the same wealth) are more likely to become constrained. Additionally, these firms lease more capital. Their adjusted capital reallocation is thus larger than the traditional measure, which is unadjusted for leased capital. Hence, ignoring leased capital greatly underestimates the true reallocation efficiency under credit constraints. Meanwhile, our model sheds light on the cyclical pattern of capital reallocation in the time series. When firms' initial wealth decreases, the leased capital ratio becomes higher, suggesting that leased capital ratio is countercyclical in equilibrium.

Adjusted for this component, the amount and ratios of capital reallocation become less procyclical, especially for small firms. These results indicate that our simple model with financial constraints and leasing decisions explains well the empirical cyclical nature of unadjusted and adjusted capital reallocation. Both our theory and empirical evidence provide a consistent and important caveat of the new leasing standard from a macroeconomic perspective: the previous off-balance-sheet leased capital should be carefully treated since it adds an additional channel for firms to reallocate resources.

Related literature Our study builds on the theories of corporate leasing decisions. The existing literature has studied tax considerations (Miller and Upton, 1976, Myers, Dill, and Bautista, 1976, Smith Jr and Wakeman, 1985, Lewis and Schallheim, 1992, Graham, 2000), risk-sharing considerations (Li and Tsou, 2019), market power (Coase, 1972, Waldman, 1997, Hendel and Lizzeri, 1999), among others. Closest to our work are papers exploring the role of financial frictions and agency costs associated with the separation of capital ownership and control (e.g., Eisfeldt and Rampini (2009), Rampini and Viswanathan (2013), Gal and Pinter (2017) and Hu, Li, and Xu (2020)). We follow these papers to construct both collateral constraints and a firm's buy versus lease decision. The differences lie in two dimensions. First, with respect to model elements, our model is in a general equilibrium setting, and is the only one that explicitly separates intertemporal capital investment, capital purchase/sale on the reallocation market, and leasing.[3] Second, in terms of the research question, we emphasize a new perspective by arguing that leasing is a source of capital reallocation, and we provide precise measurements.[4]

Our paper belongs to the literature that studies the importance and cyclical properties of capital reallocation. Eisfeldt and Shi (2018) provide an excellent survey. Eisfeldt and Rampini (2006) and Kehrig (2015) empirically show that capital reallocation is procyclical. Eisfeldt and Rampini (2006) develop a model in which capital reallocation is costly. Lanteri (2018) studies a model with endogenous partial irreversibility and used investment goods. Ai, Li, and Yang (2020) analyze the link between financial intermediation activities, capital reallocation, and the real economy. Eisfeldt and Rampini (2008), Kurlat (2013), and Li and Whited (2015) study capital reallocation with adverse selection. Our paper emphasizes the role of leasing as an alternative capital reallocation channel that allows us to correct for an

[3]In terms of the model framework itself, Eisfeldt and Rampini (2009) use a static model, and Rampini and Viswanathan (2010, 2013) and Zhang (2012) are dynamic models with a partial equilibrium framework. Li and Tsou (2019) and Hu, Li, and Xu (2020) study cross-sectional stock returns and the effect of leasing on capital misallocation using dynamic general equilibrium models, respectively.

[4]Kermani and Ma (2020) and Lian and Ma (2021) study asset-based and cash flow-based debt, and operating leases are similar to the asset-based debt. Chu (2020) studies corporate leasing decisions using the anti-recharacterization laws as an exogenous shock.

overestimation of the cyclical pattern of capital reallocation.[5]

Our study contributes to the macroeconomics literature with financial frictions.[6] Specifically, the papers that are most related to our study include Kiyotaki and Moore (1997), Gertler and Kiyotaki (2010), Brunnermeier and Sannikov (2014), He and Krishnamurthy (2013), and Elenev, Landvoigt, and Van Nieuwerburgh (2018). They all emphasize the importance of borrowing constraints and limited contract enforceability. Gomes, Yamarthy, and Yaron (2015) develop a production-based asset pricing model to discuss the impact of financial frictions on risk premia. We differ from these studies by introducing leasing as a strongly collateralized, albeit costly, form of financing and explore the implications with respect to increasing capital reallocation efficiency in the real economy.

The rest of our paper is organized as follows. We discuss the measurements and summarize the facts of capital reallocation induced from leasing in Section II. We explain these facts using an equilibrium model with heterogeneous firms in which firms are subject to collateral constraints and have the option to lease capital in Section III and then analyze our model implications in Section IV. We conclude this paper in Section V. Details on data construction, robustness checks, model solutions, proofs for propositions, and alternative setups are delegated to Appendices A to F.

II Properties of lease-adjusted capital reallocation

In this section, we first describe the data and the measurements of lease-adjusted capital reallocation. We then show summary statistics and present the cyclical patterns of this adjusted measure.

II.A Data

We build our sample from Compustat over the period 1977-2017. The key variables include sales of property, plant, and equipment (SPPE), acquisitions (AQC), and leased capital. We estimate the amount of leased capital using the present value of current and future lease commitments, following Li, Whited, and Wu (2016). We first discount future lease

[5]More broadly, our paper relates to the literature exploring resource misallocation, notable examples of which include Hsieh and Klenow (2009), Restuccia and Rogerson (2008), Buera, Kaboski, and Shin (2011), Moll (2014), Midrigan and Xu (2014), Asker, Collard-Wexler, and De Loecker (2014), Peters (2020), Edmond, Midrigan, and Xu (2018), Haltiwanger, Kulick, and Syverson (2018), David, Schmid, and Zeke (2020), Gopinath et al. (2017), Kehrig and Vincent (2017), and David and Venkateswaran (2019).

[6]See Brunnermeier, Eisenbach, and Sannikov (2012) for a survey.

commitments in years 1-5 (MRC1–MRC5) at the BAA bond rate. We then discount lease commitments beyond year 5 (MRCTA) by assuming that they are evenly spread out in years six to ten. The leased capital is therefore the sum of current rental payment (XRENT) and the present value of future lease commitments as calculated above. Appendix A provides additional details.

II.B Measurements of capital reallocation and summary statistics

Eisfeldt and Rampini (2006) measure the amount of capital reallocation using the sum of sales of property, plant, and equipment (SPPE), and acquisitions (AQC):

$$RA^{unadj.} = SPPE + AQC.$$

This measure captures corporate transactions after which the owned capital is traded and redeployed by a new firm. We denote it as the unadjusted capital reallocation $RA^{unadj.}$.

In reality, however, firms rely on both owned capital and leased capital to invest and produce. Leased capital is an important part of US corporate production and investment, accounting for about 20% of the total productive physical assets used by US publicly listed firms (Hu, Li, and Xu, 2020). Therefore, we construct a broader definition of capital reallocation that further considers the leased capital. We include not only the reallocation of existing owned productive assets across firms, as in Eisfeldt and Rampini (2006), but also the reallocation component from leasing capital. We denote it as the lease-adjusted capital reallocation $RA^{adj.}$. Then, empirically, the amount of adjusted capital reallocation is the sum of sales of PPE, acquisitions, and the leased capital investment:

$$RA^{adj.} = SPPE + AQC + |K^l - (1 - \delta_l)\, K^l_{-1}|,$$

where K^l is the amount of leased capital at the current year, K^l_{-1} is the amount of leased capital in the previous year, and δ_l is the depreciation rate for leased capital.[7] The term "$|K^l - (1 - \delta_l)\, K^l_{-1}|$" captures the "synthetic" investment (i.e., absolute changes) in leased capital. This new empirical measure of capital reallocation captures instances when existing owned capital is sold or acquired, as well as when leased capital is (newly) rented and deployed or returned (to the lessor), by a firm.

Guided by this measure, we present summary statistics of (unadjusted and adjusted) capital reallocation amount and ratios in Table I. We also divide our sample into different

[7] It implicitly includes the monitoring cost, due to the separation of ownership and control.

size groups, where we use total book assets (AT) to determine firm size.

[Place Table I about here]

As shown in Panel A, overall, the amount of capital reallocation induced from leasing is considerable. At the aggregate level, leased capital is around 16% of owned physical capital, and the new reallocation component from leasing is over 50% of the unadjusted capital reallocation amount. In the cross-section, this new component (1.82) is nearly double that of the amount of unadjusted capital reallocation (0.97) within small firms, whereas it is roughly 50% (98.03 vs. 195.38) within large firms.[8]

In Panel B, we report several key ratios. We find that, for the aggregate sample, the ratio of (unadjusted and adjusted) reallocation to capital expenditure is 37% and 57%, respectively. The turnover rate, which is defined as reallocation amount over total assets, is 2.3% and 3.6% for unadjusted and adjusted measures, respectively. In the cross-section, while the unadjusted ratios do not exhibit any obvious patterns across firm size groups, the lease-adjusted ratios do present a downward-sloping pattern from small to large firms.

From these findings in Table I, we recognize that leasing is an important source of capital reallocation, and it can be even more important for small firms.[9] In what follows, we will study the cyclical properties of the two reallocation series separately, and present how explicitly accounting for leasing makes a difference.

II.C Cyclical patterns of capital reallocation

Our adjusted empirical measure explicitly considers the reallocation of leased capital. Hence it is necessary to consider the cyclical pattern of this new component. The cyclical properties of leased capital over the business cycle have been well documented in previous studies (see Zhang (2012), Gal and Pinter (2017), and Hu, Li, and Xu (2020)). That is, leasing is countercyclical - there is an obvious increase in leasing activities whenever there is a recession. The fact that leasing behavior is countercyclical should be manifested in the additional term $|K^l - (1-\delta)\, K^l_{-1}|$, which is likely to make the lease-adjusted reallocation less procyclical. In Table II, we examine the correlations of (unadjusted and adjusted) capital reallocation with real GDP.

[Place Table II about here]

[8] In Appendix A, we consider alternative measures of leased capital, and find that our results are consistent.

[9] Eisfeldt and Rampini (2009) and Rampini and Viswanathan (2013) show that ignoring leased capital brings significant bias in terms of a firm's investment, capital structure, and risk management, and this bias is asymmetric in that it is particularly severe for small firms.

We detrend the raw non-stationary series and focus on the H-P filtered cyclical components (Hodrick and Prescott, 1997). As can be seen from the first two rows in Table II, when leased capital is factored in, the correlation of capital reallocation with output drops from 0.6 to 0.5, representing a 17% reduction. We test the difference of these two correlations using various econometric tests, such as Steiger (1980) and Zou (2007), following Diedenhofen and Musch (2015). All these tests confirm that the two point estimates of correlations are statistically different, suggesting that the adjusted capital reallocation amount is indeed less procyclical than the unadjusted measure.

We further sort firms into size groups. Consistent with the previous literature, the unadjusted capital reallocation amount exhibits strong and consistent procyclicality with output across all subgroups. With respect to the lease-adjusted capital reallocation, the correlation with output is much lower and is even negative in small groups. That is, the less procyclical patterns of lease-adjusted capital reallocation are more salient for small firms.

To alleviate the effects of variations in capital prices, we also study the capital reallocation ratios (defined as reallocation amount normalized by capital expenditure and by total assets). We report these results in the last four rows of Table II. We find that a similar pattern holds: the ratios of capital reallocation become less procyclical, and this effect is more pronounced within small firms.

To further understand the cyclical patterns of firms' capital reallocation, we estimate firm-level regressions. We use first-differenced series and confirm the previous results on cyclical patterns in the aggregate and in the cross-section, which suggests that different aggregation levels and different time-series filtering methods (i.e., HP-filter or first differencing) do not distort the weakening effect of lease on procyclical reallocation.[10]

Altogether, these results show the robustness of our results and provide additional caveat to prior literature on capital reallocation (Eisfeldt and Rampini, 2006, Ai, Li, and Yang, 2020): the proportion of lease-induced capital reallocation is large, and we should not ignore it in studying its business cycle properties.

III A general equilibrium model with heterogeneous firms

In this section, we develop a two-period general equilibrium model of capital reallocation to illustrate the role of leasing and to highlight our mechanism. In order to explain the

[10] Appendix B provides detailed specifications and results.

empirical facts documented earlier, our model consists of collateral constraints, capital reallocation, and leased capital, which distinguishes the intertemporal capital investment and capital purchase/sale on the reallocation market. The economy is populated by a representative household and heterogeneous firms.

III.A The household

We assume that a representative household is endowed with an initial wealth ϵ_0. The household maximizes log utility subject to standard intertemporal budget constraints:

$$\max_{C_0, C_1, B_0, w_0^i, K^l} E\left[\sum_{t=0}^{1} \beta^t u\left(C_t\right)\right], \tag{1}$$

$$s.t.: C_0 + B_0 + \int w_0^i V_0^i di + K_1^l = \epsilon_0, \tag{2}$$

$$\tau_l K_1^l + (1-\delta-h) K_1^l + R_f B_0 + \int w_0^i (V_1^i + D_1^i) di + W = C_1, \tag{3}$$

where β is the discount factor, and R_f is the gross risk-free interest rate. Eqs. (2) and (3) are the budget constraints for the household in period 0 and period 1, respectively. At period 0, the household purchases w_0^i shares of stock from firm i and preserves B_0 amount of cash for purchasing risk-free bonds. He also transforms his initial wealth into K_1^l amount of leased capital and rents to firms. At period 1, the household receives the leasing payment $\tau_l K_1^l$, the debt repayment $R_f B_0$ and the labor income W, collects the dividend and return from holding stock shares $\int w_0^i (V_1^i + D_1^i) di$, as well as gets the resale value of leased capital $(1-\delta-h)K_1^l$.[11] δ is the rate of capital depreciation, and h is the monitoring cost of leased capital due to the separation of ownership and control, as in Eisfeldt and Rampini (2009) and Rampini and Viswanathan (2013). h captures the disadvantages of leased capital related to its faster depreciation rate in production and more costly maintenance.[12] The household uses all these resources to consume at period 1.

We denote M_1 as the stochastic discount factor defined by the household. Under the assumption of log utility, we have $M_1 = \beta \frac{C_0}{C_1}$ and $E\left[M_1 R_f\right] = 1$. The first-order condition of K_1^l indicates that $\tau_l + 1 - \delta - h = R_f$.

[11] Since labor supply is inelastic and normalized to one, the total amount of labor income is W.

[12] Note that we assume firms will return the leased capital to the household after production and the world ends at period 1.

III.B Nonfinancial firms

There are two types of nonfinancial firms in our model: final goods producers and intermediate goods producers.[13]

1 Final goods producers

Final goods are produced by a representative firm using a continuum of intermediate inputs indexed by $i \in [0,1]$. Because a final goods producer does not make intertemporal decisions in our model, we suppress time t in this section to save notation. We normalize the price of final goods to one and write the profit maximization problem of a final goods producer as:

$$\max_{\{y_i\}} \left\{ Y - \int_{[0,1]} p_i y_i di \right\}_{Y=\left[\int_{[0,1]} y_i^{\frac{\eta-1}{\eta}} di\right]^{\frac{\eta}{\eta-1}}},$$

where p_i and y_i are the price and quantity of input i, respectively, and Y stands for the total output of final goods. The parameter η is the elasticity of substitution across input varieties. The optimality condition implies that the demand of the final goods producer is $y_i = {p_i}^{-\eta} Y$.

2 Intermediate goods producers

There is a unit measure of competitive intermediate goods producers, $i \in [0,1]$, each of which produces a different variety of goods.[14] We assume firm i is endowed with initial wealth N_0^i.

In order to motivate an interesting reallocation market, we explicitly split the end of period 0 into two subperiods: the afternoon and the evening. In the afternoon of period 0, before knowing the idiosyncratic productivity z_i and the aggregate productivity A_1, firm i determines its owned capital stock K_1^o. In the evening, firm i observes its idiosyncratic productivity z_i in advance but does not observe the aggregate productivity. This assumption of "observing idiosyncratic shock ahead of time" is standard in the investment literature, as in Moll (2014) and Midrigan and Xu (2014). It is also consistent with the view that managers enjoy information advantages because of their potential insider information. Upon observing the idiosyncratic productivity shock, the market for capital reallocation opens.

[13] We feature perfect competition among intermediate goods producers in our baseline model. We can extend to the monopolistic competition case and a case in which leasing involves additional costs compared to using owned capital. We discuss these extensions in Appendix F.

[14] We use "firm" and "intermediate goods producer" interchangeably in the remainder of the paper.

Firm i's budget constraint in the evening can then be summarized as:

$$D_0^i + K_1^o + qRA_1^i = N_0^i + B_0^i, \tag{4}$$

where q is the market clearing price in the reallocation market.[15] Firm i determines its reallocation amount RA_1^i (i.e., purchasing or selling owned capital) on the reallocation market, through borrowing B_0^i from the household. The amount of borrowing is subject to a collateral constraint:

$$B_0^i \leq \theta(K_1^o + RA_1^i), \tag{5}$$

in which θ is the collateralizability characterizing the collateral constraint. It means that a maximum of θ fraction of the owned capital can be retrieved upon default.

Apart from purchasing or selling owned capital on the reallocation market, firm i can also lease capital (but pays the leasing fee at period 1). D_0^i is the dividend at period 0. Without loss of generality, we assume firms only pay dividends at period 1 (i.e., $D_0^i = 0$).

In the morning of period 1, production occurs. Each firm faces a Cobb-Douglas production technology:

$$y_i = A_1 z_1^i \left(K_1^o + RA_1^i + (K_1^l)^i\right)^\alpha L_i^{1-\alpha}. \tag{6}$$

Here, $\alpha < 1$ is the capital share in production, L_i is labor, and y_i is the output of firm i. K_1^o is the predetermined capital stock before any information of aggregate shock or idiosyncratic shock is revealed. Additionally, firm i relies on RA_1^i and $(K_1^l)^i$ for its production. These components represent two sources of capital reallocation after observing the idiosyncratic productivity: one is the traditional purchasing or selling owned capital on the reallocation market, and the other is leasing. The second source is our focus and differs from the prior literature: we consider leasing to be an alternative capital reallocation channel.

We can write firm i's dividend in period 1, D_1^i, as:

$$D_1^i = p_i y_i - \tau_l (K_1^l)^i - R_f B_0^i + (1-\delta)(K_1^o + RA_1^i) - WL_i, \tag{7}$$

where p_i is taken as given since intermediate goods producers compete perfectly.

After production, both types of capital suffer depreciation. The firm must pay back bond, interest, wage, and leasing fees. It resells owned capital and returns the depreciated leased capital to the lessor.

The timing of events is illustrated in Figure I.

[15] In Appendix C, we prove that q is equal to 1 in equilibrium.

[Place Figure I about here]

As the world finishes at the end of period 1, $V_1^i = 0$. For each firm i, its objective is to maximize:

$$\max_{K_1^o, RA_1^i, B_0^i, (K_1^l)^i, L_i, D_1^i} V_0^i = E\left[M_1 D_1^i\right], \tag{8}$$

by choosing the initial owned capital stock K_1^o, a state-contingent plan for capital reallocation RA_1^i, borrowing from the household B_0^i, leased capital $(K_1^l)^i$, labor L_i, and its dividend D_1^i, subject to the budget constraint (4), the collateral constraint (5), and the law of motion for dividend in period 1 (7).

The firm problem is where our model departs from the frictionless neoclassical setup. The key constraint for borrowing is $B_0^i \leq \theta(K_1^o + RA_1^i)$. Without this collateral constraint, our model reduces to the frictionless neoclassical model.

III.C Market clearing conditions

To complete the specification of the model, we list the market clearing conditions as follows:

$$C_0 + \int w_0^i V_0^i di + \int D_0^i di + \int K_1^o di + K_1^l = \epsilon_0 + \int N_{i,0} di, \tag{9}$$

$$Y + \int (1-\delta)(K_1^o + RA_1^i) di + (1-\delta-h) K_1^l = C_1, \tag{10}$$

$$B_0 = \int (B_0)^i di, \tag{11}$$

$$w_0^i = 1, \; for \;\; all \;\; i, \tag{12}$$

$$K_1^l = \int (K_1^l)^i di, \tag{13}$$

$$\int RA_1^i di = 0, \tag{14}$$

$$\int L_i di = 1. \tag{15}$$

The first two equations are the market clearing conditions for final output at period 0 and period 1, respectively. Eqs. (11) and (12) correspond to the bond and stock market clearing conditions, respectively. Eq. (13) is the leased capital market clearing condition, while Eq. (14) refers to the market clearing condition for capital reallocation. The last equation represents the labor market clearing condition, where we have normalized total labor supply to one.

IV Model implications

For simplicity, we assume there is no aggregate uncertainty (i.e., $A_1 = 1$). We also assume that there are only two possible realizations of idiosyncratic productivity shocks, z_L and z_H, with $Prob(z = z_H) = 1 - Prob(z = z_L) = \pi$. Firms are endowed with the same initial net worth N_0. These assumptions enable us to derive analytical results.[16]

To facilitate discussion, we compute a numerical example and plot the equilibrium results of our two-period model to illustrate the mechanism through which a firm's initial wealth affects macro quantities. The set of plausible parameters are listed in the notes of Figure II.

IV.A Collateral constraint and buy versus lease decision

We use this section to discuss whether a firm becomes constrained and whether it leases capital.

1 Collateral constraint

Given that firms are endowed with the same N_0 but have two types of productivities, they naturally become constrained differently. As high productivity firms have high financing needs relative to low productivity firms, the collateral constraint is more likely to bind for firms with high productivity in the cross-section. Additionally, given the same productivity, the collateral constraint is more likely to bind when firms' initial wealth is low, leading to implications in the time series.

These can be summarized in the following proposition, which states that given the initial wealth N_0, whether a firm is constrained is completely determined.

Proposition 1. *There exist cutoff values $\widehat{N}$ and $\overline{N}$, such that*

- *If $N_0 \geq \widehat{N}$, then the first best allocation is achieved.*
- *If $\overline{N} \leq N_0 < \widehat{N}$, then the collateral constraints for high productivity firms bind.*
- *If $0 < N_0 < \overline{N}$, then the collateral constraints for both types of firms bind.*

Proof. See Appendix E.1.

[16] We provide the definition of the competitive equilibrium in Appendix D.

2 Buy versus lease decision

Next, we study the benefits and costs of leasing. We analyze the user costs to examine firms' decision on whether to lease or to buy owned capital on the capital reallocation market. We set up the Lagrangian of a typical firm, before capital reallocation occurs.[17]

With a slight abuse of notation, we use i to nest both firm types in period 1. The user cost of buying owned capital on the capital reallocation market, $\tilde{\tau}_{o,i}$, equals to the current price, 1, minus the discounted resale value, and also subtract the marginal value of relaxing the collateral constraint for owning this capital:

$$\tilde{\tau}_{o,i} = 1 - \frac{M_1}{\eta_{i0}}(1-\delta) - \theta\xi_{i0}, \tag{16}$$

where M_1 is the SDF, η_{i0} is the marginal value of net worth for firm i at time 0, and ξ_{i0} captures the Lagrangian multiplier for the collateral constraint.

The user cost of leased capital is:

$$\tilde{\tau}_{l,i} = \frac{M_1}{\eta_{i0}}\tau_l, \tag{17}$$

that is, the leasing fee in terms of the marginal value of net worth for firm i η_{i0}, discounted by the SDF M_1.

The difference between two user costs (lease - own) is hence:

$$\tilde{\tau}_{l,i} - \tilde{\tau}_{o,i} = \frac{\eta_{i1}}{\eta_{i0}}h + \theta\xi_{i0} - \xi_{i0}. \tag{18}$$

Eq. (18) states that the cost of leasing includes the additional monitoring cost and the cost of giving up the marginal value of relaxing the collateral constraint when buying this capital, as reflected in the first two terms.

The benefit of leasing is captured by ξ_{i0}. To better interpret this, we denote the premium on internal funds for a firm by Δ_i, and define it implicitly using the firm's $\tilde{M}_i$ as $\Delta_i = \frac{1}{\tilde{M}_i} - R_f$; internal funds command a premium (i.e., $\Delta_i > 0$), as long as the collateral constraint is binding. Hence, the benefit of leasing ξ_{i0} is equal to $\frac{\Delta_i}{R_f + \Delta_i}$, which represents the premium saved on internal funds due to constraints, consistent with Eisfeldt and Rampini (2009) and Rampini and Viswanathan (2013). In the environment of collateral constraint, $\theta < 1$, and $\xi_{i0} \geq 0$. When firms become sufficiently constrained (ξ_{i0} sufficiently large), the benefit of leasing dominates its cost, and firms start to lease.

[17] We provide these details in Appendix C.

The following proposition characterizes the properties of the leasing decisions.

Proposition 2. *There exist cutoff values* $\widehat{N}_L$ *and* $\overline{N}_L$*, such that*

- *If* $N_0 \geq \widehat{N}_L$*, then no firms lease capital.*
- *If* $\overline{N}_L \leq N_0 < \widehat{N}_L$*, then only high productivity firms lease capital.*
- *If* $0 < N_0 < \overline{N}_L$*, then both types of firms lease capital.*
- *Under reasonable parameter values for agency cost,* h*,* $\overline{N}_L < \overline{N} < \widehat{N}_L < \widehat{N}$*.*

Proof. See Appendix E.2.

Proposition 2 implies that given the initial wealth N_0, firms' buy versus lease decisions are completely determined. Compared with Proposition 1, we have $\overline{N}_L < \overline{N} < \widehat{N}_L < \widehat{N}$ under reasonable parameters. That is, firms lease capital only if they become sufficiently constrained. High productivity firms lease before low productivity firms become constrained. Meanwhile, leased capital is more likely to be used when firms' initial wealth is low, indicating that leasing is countercyclical.

3 Graphic illustration

In Figures II(a) and II(b), we plot the collateral constraint multipliers and leased capital ratios, respectively. We denote the thresholds $\widehat{N}$, $\overline{N}$, $\widehat{N}_L$, and $\overline{N}_L$ as in our propositions. We find that when firms are unconstrained (i.e., $N_0 > \widehat{N}$), the capital allocation stays at the first-best level and the collateral multipliers stay constant for any N_0. As N_0 decreases toward $\overline{N}$, only the collateral constraint for high productivity firms binds. When high productivity firms become sufficiently constrained ($N_0 < \widehat{N}_L$), they begin to lease. When N_0 drops below $\overline{N}$, the collateral constraint for both firms binds. Based on our parameter choice, $\overline{N} < \widehat{N}_L$. Thus, high productivity firms lease capital before low productivity firms become financially constrained. Similarly, when low productivity firms become constrained above a certain level ($N_0 < \overline{N}_L$), they start to lease capital.

The fact that leased capital ratio increases when N_0 decreases sheds light on its cyclical pattern. Since N_0 is positively related to the aggregate shock, the leased capital ratio is countercyclical. Another interpretation is that N_0 is isomorphic and positively related to firm size in the cross-section. Thus, when we compare across different N_0, Figure II(b) also implies that small firms lease more, consistent with the facts in Section II and Hu, Li, and Xu (2020).

[Place Figure II about here]

IV.B Capital reallocation

When the initial wealth is high, both types of firms are unconstrained. They optimally and freely reallocate capital across themselves. When some firms become constrained, they cannot achieve the first best outcome by purchasing or selling owned capital on the reallocation market.

We define the total amount of (unadjusted) capital reallocation as the sum of all capital sales plus all capital purchases. We add the sum of the absolute value change in leased capital (compared to period 0) to obtain the lease-adjusted capital reallocation.[18]

In Figure II(c), we plot the capital purchase of high and low productivity firms as functions of firms' initial wealth. In Figure II(d), we plot the aggregate reallocation amount, with and without adjusting for lease. We denote the thresholds $\widehat{N}$, $\overline{N}$, $\widehat{N}_L$, and $\overline{N}_L$ as in our propositions.

We can see that capital reallocates from low productivity firms to high productivity firms when wealth is high (i.e., when $N_0 > \overline{N}$). As initial wealth decreases, the amount of capital reallocation drops. A further decrease in initial wealth below $\overline{N}$ is associated with a zero capital reallocation amount; that is, capital reallocation is procyclical. Our model is consistent with the fact documented in Eisfeldt and Rampini (2006) and Section II. We see that the lease-adjusted reallocation is less procyclical, as shown in the red line of Figure II(d). Note that the reallocation ratios have a one-to-one mapping with respect to reallocation amount, since different firms have the same choice of initial owned capital. Hence, the implications for capital reallocation amount safely carry over to the reallocation ratios.

Similarly, if we take firms with low N_0 as small firms, we draw an implication that there will be a larger difference between unadjusted and adjusted capital reallocation for small firms. This suggests that the weakening effect for procyclicality of capital reallocation is more salient among small firms.

From the equilibrium quantities that we have just discussed, we see that our model generates rich predictions for leased capital ratio, unadjusted and adjusted capital reallocation: 1) the leased capital ratio is countercyclical; 2) adjusting for lease, capital reallocation becomes less procyclical; and 3) the less procyclical properties are more salient for small firms. These testable implications are confirmed in the data, as presented in Section II, which demonstrates

[18] We use the average of leased capital at period 1 to proxy for the leased capital at period 0. While this is more consistent with our empirical measure, we can also directly add leased capital at period 1 to obtain the adjusted capital reallocation. Our qualitative patterns do not change.

the success and explanatory power of our model.

V Conclusion

In this study, we empirically document that leased capital induced reallocation amounts to over 50% of the capital reallocation of owned capital (i.e., purchases, sales, and acquisition of capital) among US publicly listed firms. Through our general equilibrium model with heterogeneous firms and buy versus lease decision, we demonstrate that explicitly accounting for leased capital generates new and interesting features to the cyclical patterns of capital reallocation, as compared to the measure in Eisfeldt and Rampini (2006). The empirical evidence supports our model predictions: as an alternative capital reallocation channel, leasing should be seriously taken into account, and such consideration generates less procyclical business cycle patterns, especially for small firm, lowering the measured costs of business cycles.

References

Ai, Hengjie, Kai Li, and Fang Yang. 2020. "Financial Intermediation and Capital Reallocation." *Journal of Financial Economics*, 138(3): 663–686.

Asker, John, Allan Collard-Wexler, and Jan De Loecker. 2014. "Dynamic Inputs and Resource (Mis)Allocation." *Journal of Political Economy*, 122(5): 1013–1063.

Brunnermeier, Markus K., and Yuliy Sannikov. 2014. "A Macroeconomic Model with a Financial Sector." *American Economic Review*, 104(2): 379–421.

Brunnermeier, Markus K., Thomas Eisenbach, and Yuliy Sannikov. 2012. "Macroeconomics with Financial Frictions: A Survey." *NBER Working Paper*.

Buera, Francisco J., Joseph P. Kaboski, and Yongseok Shin. 2011. "Finance and Development: A Tale of Two Sectors." *American Economic Review*, 101(5): 1964–2002.

Chu, Yongqiang. 2020. "Collateral, Ease of Repossession, and Leases: Evidence from Antirecharacterization Laws." *Management Science*, 66(7): 2951–2974.

Coase, Ronald H. 1972. "Durability and Monopoly." *The Journal of Law and Economics*, 15(1): 143–149.

David, Joel M., and Venky Venkateswaran. 2019. "The Sources of Capital Misallocation." *American Economic Review*, 109(7): 2531–67.

David, Joel M., Lukas Schmid, and David Zeke. 2020. "Risk-Adjusted Capital Allocation and Misallocation." *FRB of Chicago Working Paper*.

Diedenhofen, Birk, and Jochen Musch. 2015. "cocor: A comprehensive solution for the statistical comparison of correlations." *PloS one*, 10(4): e0121945.

Edmond, Chris, Virgiliu Midrigan, and Daniel Yi Xu. 2018. "How Costly are Markups?" *NBER Working Paper*.

Eisfeldt, Andrea L., and Adriano A Rampini. 2006. "Capital Reallocation and Liquidity." *Journal of Monetary Economics*, 53(3): 369–399.

Eisfeldt, Andrea L., and Adriano A. Rampini. 2008. "Managerial Incentives, Capital Reallocation, and the Business Cycle." *Journal of Financial Economics*, 87(1): 177–199.

Eisfeldt, Andrea L., and Adriano A. Rampini. 2009. "Leasing, Ability to Repossess, and Debt Capacity." *Review of Financial Studies*, 22(4): 1621–1657.

Eisfeldt, Andrea L., and Yu Shi. 2018. "Capital Reallocation." *Annual Review of Financial Economics*, 10: 361–386.

Elenev, Vadim, Tim Landvoigt, and Stijn Van Nieuwerburgh. 2018. "A Macroeconomic Model with Financially Constrained Producers and Intermediaries." *NBER Working Paper.*

Gal, Peter N., and Gabor Pinter. 2017. "Capital over the Business Cycle: Renting versus Ownership." *Journal of Money, Credit and Banking*, 49(6): 1299–1338.

Gertler, Mark, and Nobuhiro Kiyotaki. 2010. "Financial Intermediation and Credit Policy in Business Cycle Analysis." *Handbook of Monetary Economics*, 3(3): 547–599.

Gomes, Joao, Ram Yamarthy, and Amir Yaron. 2015. "Carlstrom and Fuerst meets Epstein and Zin: The Asset Pricing Implications of Contracting Frictions." *Working Paper.*

Gopinath, Gita, Şebnem Kalemli-Özcan, Loukas Karabarbounis, and Carolina Villegas-Sanchez. 2017. "Capital Allocation and Productivity in South Europe." *Quarterly Journal of Economics*, 132(4): 1915–1967.

Graham, John R. 2000. "How Big Are the Tax Benefits of Debt?" *Journal of Finance*, 55(5): 1901–1941.

Haltiwanger, John, Robert Kulick, and Chad Syverson. 2018. "Misallocation Measures: The Distortion That Ate the Residual." *NBER Working Paper.*

Hendel, Igal, and Alessandro Lizzeri. 1999. "Adverse Selection in Durable Goods Markets." *American Economic Review*, 89(5): 1097–1115.

He, Zhiguo, and Arvind Krishnamurthy. 2013. "Intermediary Asset Pricing." *American Economic Review*, 103(2): 732–70.

Hodrick, Robert J., and Edward C. Prescott. 1997. "Postwar US Business Cycles: An Empirical Investigation." *Journal of Money, Credit, and Banking*, 1–16.

Hsieh, Chang-Tai, and Peter J. Klenow. 2009. "Misallocation and Manufacturing TFP in China and India." *Quarterly Journal of Economics*, 124(4): 1403–1448.

Hu, Weiwei, Kai Li, and Yiming Xu. 2020. "Leasing as a Mitigation Channel of Capital Misallocation." *Available at SSRN 3719658.*

Kehrig, Matthias. 2015. "The Cyclical Nature of the Productivity Distribution." *US Census Bureau Center for Economic Studies Paper No. CES-WP-11-15.*

Kehrig, Matthias, and Nicolas Vincent. 2017. "Do Firms Mitigate or Magnify Capital Misallocation? Evidence from Plant-Level Data." *US Census Bureau Center for Economic Studies Paper No. CES-WP-17-14, CESifo Working Paper Series.*

Kermani, Amir, and Yueran Ma. 2020. "Two Tales of Debt." *NBER Working Paper.*

Kiyotaki, Nobuhiro, and John Moore. 1997. "Credit Cycles." *Journal of Political Economy*, 105(2): 211–248.

Kurlat, Pablo. 2013. "Lemons Markets and the Transmission of Aggregate Shocks." *American Economic Review*, 103(4): 1463–89.

Lanteri, Andrea. 2018. "The Market for Used Capital: Endogenous Irreversibility and Reallocation over the Business Cycle." *American Economic Review*, 108(9): 2383–2419.

Lewis, Craig M., and James S. Schallheim. 1992. "Are Debt and Leases Substitutes?" *Journal of Financial and Quantitative Analysis*, 27(4): 497–511.

Lian, Chen, and Yueran Ma. 2021. "Anatomy of Corporate Borrowing Constraints." *Quarterly Journal of Economics*, 136(1): 229–291.

Li, Kai, and Chi-Yang Tsou. 2019. "Leasing as a Risk-Sharing Mechanism." *SSRN Working Paper.*

Li, Shaojin, and Toni M. Whited. 2015. "Capital Reallocation and Adverse Selection." *Simon Business School Working Paper.*

Li, Shaojin, Toni M. Whited, and Yufeng Wu. 2016. "Collateral, Taxes, and Leverage." *Review of Financial Studies*, 29(6): 1453–1500.

Midrigan, Virgiliu, and Daniel Yi Xu. 2014. "Finance and Misallocation: Evidence from Plant-Level Data." *American Economic Review*, 104(2): 422–58.

Miller, Merton H., and Charles W. Upton. 1976. "Leasing, Buying, and the Cost of Capital Services." *Journal of Finance*, 31(3): 761–786.

Moll, Benjamin. 2014. "Productivity Losses from Financial Frictions: Can Self-Financing Undo Capital Misallocation?" *American Economic Review*, 104(10): 3186–3221.

Myers, Stewart C., David A. Dill, and Alberto J. Bautista. 1976. "Valuation of Financial Lease Contracts." *Journal of Finance*, 31(3): 799–819.

Newey, Whitney K., and Kenneth D. West. 1987. "A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation." *Econometrica*, 55(3): 703–708.

Peters, Michael. 2020. "Heterogeneous Markups, Growth, and Endogenous Misallocation." *Econometrica*, 88(5): 2037–2073.

Rampini, Adriano A., and S. Viswanathan. 2010. "Collateral, Risk management, and the Distribution of Debt Capacity." *Journal of Finance*, 65: 2293–2322.

Rampini, Adriano A., and S. Viswanathan. 2013. "Collateral and Capital Structure." *Journal of Financial Economics*, 109(2): 466–492.

Restuccia, Diego, and Richard Rogerson. 2008. "Policy Distortions and Aggregate Productivity with Heterogeneous Establishments." *Review of Economic Dynamics*, 11(4): 707–720.

Smith Jr, Clifford W., and L. MacDonald Wakeman. 1985. "Determinants of Corporate Leasing Policy." *Journal of Finance*, 40(3): 895–908.

Steiger, James H. 1980. "Tests for comparing elements of a correlation matrix." *Psychological bulletin*, 87(2): 245.

Waldman, Michael. 1997. "Eliminating the Market for Secondhand Goods: An Alternative Explanation for Leasing." *The Journal of Law and Economics*, 40(1): 61–92.

Zhang, Na. 2012. "Essays on Corporate Leasing." PhD diss. University of British Columbia.

Zou, Guang Yong. 2007. "Toward using confidence intervals to compare correlations." *Psychological methods*, 12(4): 399.

Figures and Tables

Figure I

TIMING OF EVENTS

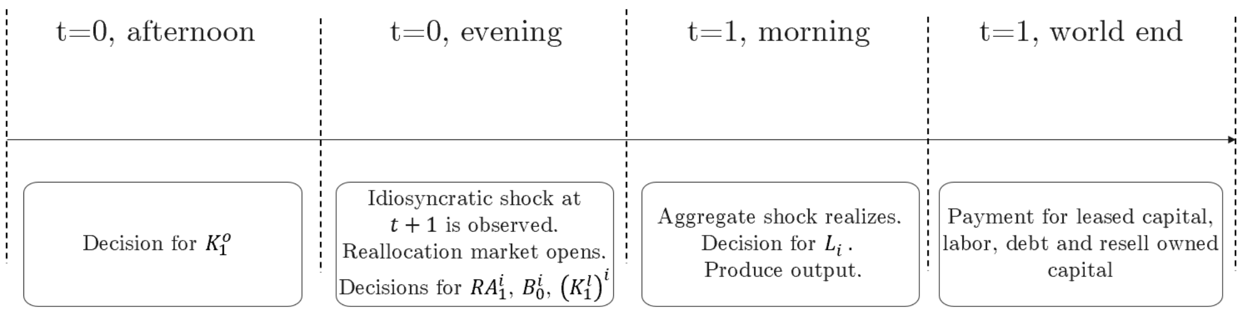
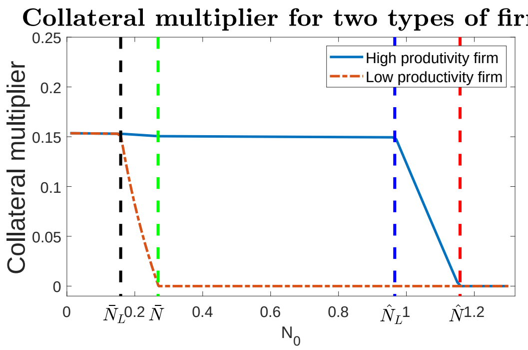
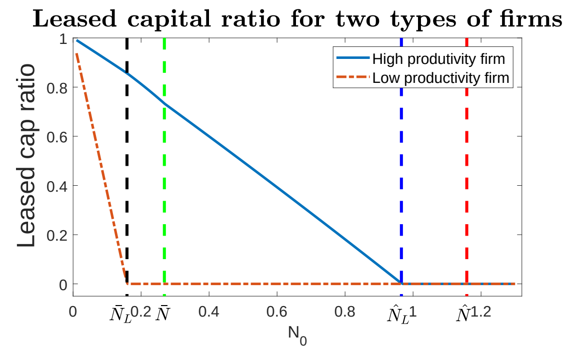


Figure II

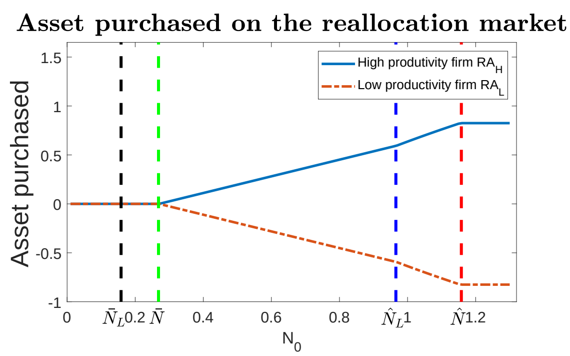
MODEL IMPLICATIONS ON FIRM DECISIONS



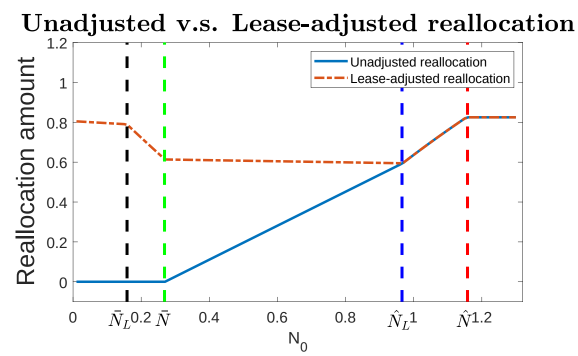
(a) Lagrangian multiplier



(b) leased capital ratio



(c) Asset purchased



(d) Unadjusted and adjusted reallocation

The top left panel plots the lagrangian multiplier of the collateral constraint for high productivity firms (blue) and for low productivity firms (red) as a function of firms' initial wealth. The top right panel plots the leased capital ratio for high productivity firms (blue) and for low productivity firms (red) as a function of firms' initial wealth. The bottom left panel plots the amount of asset purchased on the reallocation market for high productivity firms (blue) and for low productivity firms (red) as a function of firms' initial wealth in our model economy. The bottom right panel plots the unadjusted capital reallocation (blue) and adjusted capital reallocation (red) as a function of firms' initial wealth in our model economy. The unadjusted capital reallocation is defined as the total amount of asset purchased and sold on the reallocation market, while the adjusted capital reallocation explicitly considers leased capital as a source of capital reallocation. Parameter values: Discount factor: $\beta = 0.9$; Capital share in production: $\alpha = 0.3$; Depreciation rate: $\delta = 0.1$; Monitoring cost for leased capital due to the separation of ownership and control: $h = 0.1$; Collateralizability in the collateral constraint: $\theta = 0.4$; Firm idiosyncratic productivity and distribution: $z_L = 0.5$, $z_H = 1.32$, $Prob(z = z_H) = 1 - Prob(z = z_L) = \pi = 0.5$; and Initial wealth that a representative household is endowed with: $\epsilon_0 = 3$.

Table I

SUMMARY STATISTICS

Variables	Aggregate Mean	Size S	Size M	Size L
Panel A: levels				
Sales of PP&E (SPPE)	9.12	0.25	1.70	27.89
Acquisitions (AQC)	54.93	0.72	11.24	167.49
CapEx (CAPX)	170.85	2.72	23.09	536.30
PP&E (PPENT)	936.66	9.99	101.32	2978.76
Rental expense (XRENT)	36.57	1.29	9.47	108.06
Leased capital (KL)	152.64	5.26	41.89	447.92
$\lvert\Delta$ KL$\rvert$	34.36	1.82	11.05	98.03
Assets (AT)	2657.37	46.80	366.19	8327.32
$RA^{unadj.}$ (SPPE+AQC)	64.05	0.97	12.93	195.38
$RA^{adj.}$ (SPPE+AQC+$\lvert\Delta$ KL$\rvert$)	98.41	2.80	23.99	293.41
Panel B: ratios				
$\frac{RA^{unadj.}}{CAPX}$	36.64%	36.82%	51.29%	35.74%
$\frac{RA^{adj.}}{CAPX}$	57.08%	107.12%	97.93%	54.42%
$\frac{RA^{unadj.}}{AT}$	2.32%	2.11%	3.28%	2.27%
$\frac{RA^{adj.}}{AT}$	3.62%	6.23%	6.29%	3.46%

This table presents summary statistics for variables of interest (time series average of the cross-section average) in our sample. In Panel A, level variables are in millions of 2012 US dollars. PP&E stands for property, plant, and equipment and CapEx stands for capital expenditures. Leased capital KL is calculated as the sum of current rental expense and the present value of future lease commitments, following Li, Whited, and Wu (2016). $\lvert\Delta$ KL$\rvert$ is the absolute value of changes in leased capital. $RA^{unadj.}$ is used to abbreviate the sum of acquisitions plus sales of PP&E. $RA^{adj.}$ is used to abbreviate the sum of $RA^{unadj.}$ and $\lvert\Delta$ KL$\rvert$. In parentheses, we show the corresponding Compustat items, except leased capital KL. In Panel B, we report reallocation normalized by capital expenditure and capital stock. The depreciation rate for leased capital δ_l is chosen to be 0.15, consistent with Eisfeldt and Rampini (2009). Size is defined by total assets. We use "S," "M," and "L" to denote small, medium, and large firm groups, respectively. The sample is from 1977 to 2017 and excludes financial, utility, public administrative, and lessor industries from the analysis. Firms that are not incorporated in the US and/or do not report in US dollars are also eliminated.

Table II

CORRELATION OF OUTPUT WITH REALLOCATION

Correlation of output with		**Size**		
Variables	**Aggregate**	**S**	**M**	**L**
$RA^{unadj.}$	0.60	0.35	0.52	0.60
	(0.108)	(0.185)	(0.155)	(0.110)
$RA^{adj.}$	0.50	0.04	0.43	0.50
	(0.130)	(0.256)	(0.174)	(0.132)
$\frac{RA^{unadj.}}{CAPX}$	0.63	0.30	0.45	0.62
	(0.106)	(0.182)	(0.182)	(0.111)
$\frac{RA^{adj.}}{CAPX}$	0.48	-0.03	0.23	0.48
	(0.145)	(0.235)	(0.209)	(0.151)
$\frac{RA^{unadj.}}{AT}$	0.57	0.29	0.45	0.57
	(0.126)	(0.184)	(0.188)	(0.127)
$\frac{RA^{adj.}}{AT}$	0.45	-0.04	0.33	0.46
	(0.146)	(0.260)	(0.202)	(0.147)

This table presents the correlation of output with reallocation measures. Deviations from trend are computed using the Hodrick and Prescott (1997) filter (H-P filter). In each panel, the first two rows focus on level (i.e., the natural logarithm of the level of each variable is used). The next four rows report reallocation ratios, defined as each variable divided by a measure of the capital expenditure and total assets. Unadjusted reallocation $RA^{unadj.}$ is defined as the sum of acquisitions and sales of property, plant, and equipment. Adjusted reallocation $RA^{unadj.}$ is defined as the sum of unadjusted reallocation and the investment in leased capital in each year. Reallocation ratios are computed as the ratio of the sample mean of the numerator to the sample mean of the denominator. Output is the log GDP series obtained from the Federal Reserve Bank of St. Louis. Standard errors are in parentheses, corrected for heteroscedasticity and autocorrelation of the residuals à la Newey and West (1987) and are computed using a GMM approach adapted from the Hansen, Heaton, and Ogaki GAUSS programs. Size is defined by total assets. We use "S," "M," and "L" to denote small, medium, and large firm groups, respectively.

Online Appendix

A Data construction

A.1. Data source

Our sample consists of firms in Compustat, available from WRDS. The sample period ranges from 1977 to 2017. We focus on firms with non-missing standard industrial classification (SIC) codes, and firms trading on NYSE, AMEX, and NASDAQ. We exclude utility firms that have four-digit SIC codes between 4900 and 4999, finance firms that have SIC codes between 6000 and 6999 (finance, insurance, trusts, and real estate sectors), as well as public administrative firms that have SIC codes between 9000 and 9999. We also explicitly drop industries that serve as lessors (i.e., SIC code 7377 and industries whose SIC codes begin with 735 and 751). We exclude firm year observations where total assets (AT) are non-positive, or where the book value of common stock (CEQ) or deferred taxes (TXDB) are negative. We additionally eliminate firms that are not incorporated in the US and/or do not report in US dollars. Macroeconomic data are from the Federal Reserve Economic Data (FRED) maintained by the Federal Reserve Bank in St. Louis.

A.2. Constructing leased capital

1 Benchmark measure

We adopt methods in the previous literature to measure leased capital. We measure leased capital using a discounting method following Li, Whited, and Wu (2016), which is equal to the present value of current and future lease commitments. We discount future lease commitments in years 1-5 (MRC1–MRC5) at the BAA bond rate. We similarly discount lease commitments beyond year 5 (MRCTA) by assuming that they are evenly spread out in years six to ten. The leased capital, then, is the sum of current rental payment and the present value of future lease commitments as calculated above. We treat firms with missing leased capital as zero.

2 Alternative measures

As robustness, we consider other commonly used leased capital measures, which are well summarized in Hu, Li, and Xu (2020). All these measures all rely on a discounting method, in which the leased capital is equal to the present value of current and future lease commitments.

The difference lies in the numerators as well as the denominators. For completeness, we also present the comparison of these methods below. We denote this measure used in the main text as leased capital (benchmark).

Leased capital (commitment 2) For leased capital (commitment 2), we define everything similarly as leased capital (benchmark), except for the treatment of MRCTA. Instead of assuming that lease commitments beyond year 5 (MRCTA) are evenly spread out in years six to ten, we follow Rauh and Sufi (2012) to include the estimated value of the rental commitments due beyond year 5. We first divide MRCTA by the average lease commitments over the first five years, and obtain an estimate of the remaining life of a firm's operating leases after year 5. Then we spread MRCTA evenly over the approximate remaining life of the leases. Eventually, we discount these estimated lease commitments beyond year 5 by the BAA bond rate.

Leased capital (commitment 3) We define everything similarly as leased capital (benchmark), except for the treatment of MRCTA. Since lease commitments beyond year 5 (MRCTA) in Compustat are often missing, especially in earlier years (prior to 2000), we do not include the present value of MRCTA, as in Chu (2020) and Graham, Lemmon, and Schallheim (1998). We denote this measure as leased capital (commitment 3).

Leased capital (commitment 4) We define everything similarly as leased capital (benchmark), except for the discount rate. Here we set the discount rate to a constant value of 10% for all firms, in order to determine the present values. This is in line with Graham, Lemmon, and Schallheim (1998) and Cornaggia, Franzen, and Simin (2013). We denote this measure as leased capital (commitment 4).

Leased capital (commitment 5) We define everything similarly as leased capital (commitment 5), except for the discount rate. Alternatively, we follow Graham and Lin (2018) and employ a firm-specific discount rate. We calculate firm-specific discount rate as the ratio of a firm's interest expense (Compustat annual item XINT) divided by the sum of short-term and long-term debt (Compustat annual items DLC and DLTT, respectively) if possible. If a firm's interest expense is zero or missing, we set it to be the median value of that within the same two-digit SIC code industry. We denote this measure as leased capital (commitment 5).

A.3. Robustness

We report the summary statistics for lease-induced reallocation in Table A.1 under different measures of leased capital. We find that the magnitudes of lease-induced reallocation are within the same ballpark under these different proxies, implying the robustness of our results.

Table A.1

SUMMARY STATISTICS

	Aggregate	Size		
Variables	**Mean**	**S**	**M**	**L**
Panel A: Benchmark				
$\lvert\Delta$ KL$\rvert$	34.36	1.82	11.05	98.03
Panel B: Commitment 2				
$\lvert\Delta$ KL$\rvert$	34.62	1.86	11.01	98.91
Panel C: Commitment 3				
$\lvert\Delta$ KL$\rvert$	26.99	1.59	8.82	76.64
Panel D: Commitment 4				
$\lvert\Delta$ KL$\rvert$	31.22	1.72	9.95	89.12
Panel E: Commitment 5				
$\lvert\Delta$ KL$\rvert$	32.27	1.61	9.67	93.11

This table presents summary statistics for variables of interest (time series average of the cross-section average) in our sample. $\lvert\Delta$ KL$\rvert$ is the absolute value of changes in leased capital. The depreciation rate for leased capital δ_l is chosen to be 0.15, consistent with Eisfeldt and Rampini (2009). Panel A presents the leased capital calculated as the sum of current rental expense and the present value of future lease commitments, following Li, Whited, and Wu (2016). Panels B to E (commitment 2 to commitment 5) use alternative measures for leased capital, following Hu, Li, and Xu (2020). Appendix 2 provides further construction details. Size is defined by total assets. We use "S," "M," and "L" to denote small, medium, and large firm groups, respectively. The sample is from 1977 to 2017 and excludes financial, utility, public administrative, and lessor industries from the analysis. Firms that are not incorporated in the US and/or do not report in US dollars are also eliminated.

B Regression results for cyclical patterns

To further understand the cyclical patterns of firms' capital reallocation, we estimate the following equation at the firm level:

$$y_{i,t} = d_i + \beta_g GDP_t + \beta_1 size_{i,t} \times GDP_t + \gamma_i X_{i,t} + u_{i,t}, \tag{B1}$$

where i denotes a firm, t denotes a year, and $y_{i,t}$ is the variable of interest, consisting of the growth of (unadjusted and adjusted) reallocation ratios (i.e., first differencing). d_i denotes a firm fixed effect. GDP_t is the growth of real GDP at t (i.e., first differencing). $size_{i,t} \times GDP_t$ is the interaction term of firm size and growth of real GDP. $X_{i,t}$ consists of standard control variables, including firm size, leverage, profitability, Tobin's q, book-to-market ratio, tax rate, and dividends.[19] We are interested in β_g and β_1. β_g captures whether the dependent variable is sensitive to GDP growth. If β_g is positive (negative) and statistically significant, then the dependent variable is procyclical (countercyclical). β_1 captures the size effect on dependent variable sensitivity to GDP growth. If β_1 is positive (negative) and statistically significant, it means the correlation of the dependent variable with GDP growth is increasing (decreasing) in firm size.

We first estimate Eq. (B1) by removing the interaction term and the control variables. Then we add these back as a full specification. We present the results in Table B.2. Two facts are noteworthy. First, comparing across the outcomes (Columns 1 vs. 4, Columns 2 vs. 5, Columns 7 vs. 10, Columns 8 vs. 11), the adjusted reallocation measures all become less significantly correlated to growth of GDP. For example, Column 1 is positive and significant at the 1% level. Its magnitude says that when there is one unit increase of GDP growth standard deviation, the unadjusted reallocation to capital expenditure ratio increases by 0.052. However, Column 4 shows a β_g close to 0, and is insignificant. We obtain similar magnitudes when we include control variables, as shown in Columns 2 and 5. This suggests that the capital reallocation ratios do become less procyclical when lease is considered.

Second, when we include the interaction term (Columns 3 vs. 6, Columns 9 vs. 12), the coefficient β_1 is positive and significant at the 5% level for the adjusted measures. This indicates that there is an obvious difference in correlation with GDP growth for different firm sizes - the adjusted reallocation measures are more procyclical for large firms. With respect to the unadjusted measure, no such pattern can be found. This indicates that the less procyclical properties for lease-adjusted capital reallocation is more salient within small firms.[20]

[19] Please refer to Table B.2 notes for a detailed description of these variables.

[20] Relatedly, benefits to reallocation, as measured by MPK dispersion, will become less countercyclical if we adjust by lease, as documented in Hu, Li, and Xu (2020).

Table B.2

CAPITAL REALLOCATION: FIRM-LEVEL REGRESSION RESULTS

	Panel A: $\frac{RA}{CAPX}$						Panel B: $\frac{RA}{AT}$					
Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
GDP growth	0.052	0.053	0.051	0.004	0.001	-0.003	0.099	0.096	0.094	0.051	0.043	0.041
	(0.012)	(0.013)	(0.013)	(0.009)	(0.010)	(0.010)	(0.012)	(0.013)	(0.013)	(0.009)	(0.009)	(0.009)
size*GDP growth			0.016			0.025			0.012			0.021
			(0.013)			(0.010)			(0.013)			(0.010)
Controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of observations	30,429	28,064	28,064	30,429	28,064	28,064	30,429	28,064	28,064	30,429	28,064	28,064
Within R-sq	0.0005	0.0054	0.0054	0.0000	0.0033	0.0035	0.0019	0.0050	0.0051	0.0012	0.0027	0.0028

This table presents results of firm-level panel regressions under the specification in Eq. (B1). The dependent variable is reallocation to capx ratio for Columns 1-3 (unadjusted) and for Columns 4-6 (adjusted), and is reallocation to total asset ratio for Columns 7-9 (unadjusted) and for Columns 10-12 (adjusted). Firm size is measured by a firm's total assets (Compustat item AT), in logs. Leverage is the ratio of the sum of debt in current liabilities (DLC) and long-term debt (DLTT) over total assets. Profitability is measured as net income (Compustat item NI) divided by total assets; Tobin's q is the market value of total assets (Compustat item AT+PRCCF x CSHO -TXDV-CEQ) to total assets; Book-to-market ratio is the ratio of book equity to the market capitalization of the firm, where we measure book equity as the sum of shareholder's equity (SEQ), deferred taxes and investment credit (TXDITC) and the preferred stock liquidating value (PSTKL); Tax rate is measured by the ratio of tax payment (Compustat item TXT) over the sum of tax payment and net income; and Dividend equals 1 if the firm pays out a dividend (DVP + DVC > 0) and equals 0 otherwise. We standardize all control variables for the sake of interpretation. An observation is a firm-year. Standard errors are two-way clustered by firm and industry-year, and are reported in parentheses. The sample is from 1977 to 2017 and excludes financial, utility, public administrative, and lessor industries from the analysis. Firms that are not incorporated in the US and/or do not report in US dollars are also eliminated.

C Lagrangian

To facilitate discussion, we present the Lagrangian of a typical firm under our simplifying assumptions:

$$\begin{aligned}
\mathcal{L} \quad = \quad & \max M_1 \left[\pi D_1^H + (1-\pi) D_1^L\right] \\
& +\pi\eta_{H0}\left[\ N_0 + B_0^H - K_1^o - qRA_1^H\ \right] \\
& +(1-\pi)\eta_{L0}\left[\ N_0 + B_0^L - K_1^o - qRA_1^L\ \right] \\
+ \quad \pi\eta_{H1} & \left[\ p_H y_H - \tau_l (K_1^l)^H - R_f B_0^H - D_1^H + (1-\delta)(K_1^o + RA_1^H) - WL_H\ \right] \\
+ \quad (1-\pi)\eta_{L1} & \left[\ p_L y_L - \tau_l (K_1^l)^L - R_f B_0^L - D_1^L + (1-\delta)(K_1^o + RA_1^L) - WL_L\ \right] \\
& +\pi\xi_{H0}\eta_{H0}\left[\theta(K_1^o + RA_1^H) - B_0^H\right] \\
& +(1-\pi)\xi_{L0}\eta_{L0}\left[\theta(K_1^o + RA_1^L) - B_0^L\right] \\
& +\pi\bar{\nu}_{H0}\eta_{H0}\left[K_1^o + RA_1^H\right] \\
& +(1-\pi)\bar{\nu}_{L0}\eta_{L0}\left[K_1^o + RA_1^L\right] \\
& +\pi\underline{\nu}_{H0}\eta_{H0}\left[\left(K_1^l\right)^H\right] \\
& +(1-\pi)\underline{\nu}_{L0}\eta_{H0}\left[\left(K_1^l\right)^L\right] \\
& +\pi d_{H1}\left[(D_1)^H\right] \\
& +(1-\pi) d_{L1}\left[(D_1)^L\right]
\end{aligned}$$

F.O.C.s:

$$[D_1^H] : \pi M_1 - \pi\eta_{H1} + \pi d_{H1} = 0 \tag{C2}$$

$$[D_1^L] : (1-\pi) M_1 - (1-\pi)\eta_{L1} + (1-\pi) d_{L1} = 0 \tag{C3}$$

$$\begin{aligned}
[K_1^o] : \pi\left[\alpha\frac{p_H y_H}{K_1^o + RA_1^H + (K_1^l)^H} + (1-\delta)\right]\eta_{H1} & \\
+(1-\pi)\left[\alpha\frac{p_L y_L}{K_1^o + RA_1^L + (K_1^l)^L} + (1-\delta)\right]\eta_{L1} & \\
-\pi\eta_{H0} - (1-\pi)\eta_{L0} & \\
+\theta\pi\xi_{H0}\eta_{H0} + \theta(1-\pi)\xi_{L0}\eta_{L0} + \pi\bar{\nu}_{H0}\eta_{H0} + (1-\pi)\bar{\nu}_{L0}\eta_{L0} & = 0
\end{aligned} \tag{C4}$$

$$[RA_1^H] : -q\pi\eta_{H0} + \pi\left[\frac{\alpha p_H y_H}{K_1^o + RA_1^H + (K_1^l)^H} + (1-\delta)\right]\eta_{H1} + \pi\theta\xi_{H0}\eta_{H0} + \pi\bar{\nu}_{H0}\eta_{H0} = 0 \tag{C5}$$

$$[RA_1^L]: -q(1-\pi)\eta_{L0} + (1-\pi)\left[\frac{\alpha p_L y_L}{K_1^o + RA_1^L + (K_1^l)^L} + (1-\delta)\right]\eta_{L1} + (1-\pi)\theta\xi_{L0}\eta_{L0} + (1-\pi)\bar{\nu}_{L0}\eta_{L0} = 0 \tag{C6}$$

$$[(K_1^l)^H]: \pi\alpha\frac{p_H y_H}{K_1^o + RA_1^H + (K_1^l)^H}\eta_{H1} - \pi\tau_l\eta_{H1} + \pi\underline{\nu}_{H0}\eta_{H0} = 0 \tag{C7}$$

$$[(K_1^l)^L]: (1-\pi)\alpha\frac{p_L y_L}{K_1^o + RA_1^L + (K_1^l)^L}\eta_{L1} - (1-\pi)\tau_l\eta_{L1} + (1-\pi)\underline{\nu}_{L0}\eta_{L0} = 0 \tag{C8}$$

$$[B_0^H]: \pi\eta_{H0} - \pi R_f\eta_{H1} - \pi\xi_{H0}\eta_{H0} = 0 \tag{C9}$$

$$[B_0^L]: (1-\pi)\eta_{L0} - (1-\pi)R_f\eta_{L1} - (1-\pi)\xi_{L0}\eta_{L0} = 0 \tag{C10}$$

$$[L_H]: \pi(1-\alpha)\frac{p_H y_H}{L_H} = \pi W \tag{C11}$$

$$[L_L]: (1-\pi)(1-\alpha)\frac{p_L y_L}{L_L} = (1-\pi)W \tag{C12}$$

where d_{L1} and d_{H1} must be zero, since D_1^L and D_1^H must be positive. In our setup, firms must always have owned capital; hence, $\bar{\nu}_{L0}$ and $\bar{\nu}_{H0}$ must be 0. As suggested by this set of optimality conditions, the price q is 1.

D Stationary competitive equilibrium

A stationary competitive equilibrium is a set of prices W, q, R_f, τ_l, and p_i, policy functions for the household's consumption C_0 and C_1 , saving B_0, stock share choice w_0^i, and accumulated leased capital K_1^l, for firms' initial owned capital K_1^o, and a state-contingent plan of dividends, output, labor, (owned) capital reallocation amount, leased capital, and borrowing, D_1^i, y_i, L_i, RA_1^i, $(K_1^l)^i$, B_0^i, where $i = H, L$, for final goods producer Y, that: (i) solve the firm's, the household's, and the final goods producer's optimization problems; and (ii) satisfy the market clearing conditions for the output market, the bond market, the leased capital market, the labor market, and the capital reallocation market, respectively.

E Propositions

Let K_i denote the total amount of capital used by a firm after reallocation. Using the fact that $y_i = {p_i}^{-\eta}Y$, we can write:

$$p_i y_i = y_i^{1-\frac{1}{\eta}} Y^{\frac{1}{\eta}} = \left[z_1^i K_i^\alpha L_i^{1-\alpha}\right]^{1-\frac{1}{\eta}} Y^{\frac{1}{\eta}} \tag{E13}$$

Because firms are perfectly competitive, their decisions on capital don't affect their prices. The price is an equilibrium concept. Hence, we can write the marginal product of capital as:

$$MPK_i = \alpha \left(z_1^i\right)^{1-\frac{1}{\eta}} K_i^{\alpha\left(1-\frac{1}{\eta}\right)-1} L_i^{(1-\alpha)\left(1-\frac{1}{\eta}\right)} Y^{\frac{1}{\eta}} \tag{E14}$$

and write the marginal product of labor as:

$$W = (1-\alpha) \left(z_1^i\right)^{1-\frac{1}{\eta}} K_i^{\alpha\left(1-\frac{1}{\eta}\right)} L_i^{(1-\alpha)\left(1-\frac{1}{\eta}\right)-1} Y^{\frac{1}{\eta}} \tag{E15}$$

This equation implies $L_i \propto [z_1^i K_i^\alpha]^{\frac{1-\frac{1}{\eta}}{1-(1-\alpha)\left(1-\frac{1}{\eta}\right)}}$. Using the resource constraint, $\int L_i di = 1$, we can obtain:

$$L_i = \frac{[z_1^i K_i^\alpha]^{\frac{1-\frac{1}{\eta}}{1-(1-\alpha)\left(1-\frac{1}{\eta}\right)}}}{\int \left[[z_1^i K_i^\alpha]^{\frac{1-\frac{1}{\eta}}{1-(1-\alpha)\left(1-\frac{1}{\eta}\right)}} \right] di} \tag{E16}$$

We denote $\triangledown = \int \left[[z_1^i K_i^\alpha]^{\frac{1-\frac{1}{\eta}}{1-(1-\alpha)\left(1-\frac{1}{\eta}\right)}} \right] di$. Thus, we can write:

$$\begin{aligned} MPK_i &= \alpha \frac{p_i y_i}{K_i} \\ &= \alpha \left(z_1^i\right)^{\frac{\eta-1}{1+\alpha\eta-\alpha}} K_i^{\frac{-1}{1+\alpha\eta-\alpha}} \triangledown^{\frac{\alpha\eta-\alpha+1}{(\eta-1)}-1} \end{aligned} \tag{E17}$$

Under the two period model, we define $\frac{K_H}{K_L} = \phi$. Then the optimal $\hat{\phi} = \left(\frac{z_H}{z_L}\right)^{\eta-1}$.

As a result,

$$\begin{aligned} \triangledown &= \int \left[\left[z_1^i K_i^\alpha\right]^{\frac{1-\frac{1}{\eta}}{1-(1-\alpha)\left(1-\frac{1}{\eta}\right)}} \right] di \\ &= \pi \left[z_H K_H^\alpha\right]^{\frac{1-\frac{1}{\eta}}{1-(1-\alpha)\left(1-\frac{1}{\eta}\right)}} + (1-\pi) \left[z_L K_L^\alpha\right]^{\frac{1-\frac{1}{\eta}}{1-(1-\alpha)\left(1-\frac{1}{\eta}\right)}} \end{aligned}$$

E.1. Proposition 1

To prove Proposition 1, we start with the case in which no firms are constrained. In this case, both types of firms choose optimally, and the economy achieves the first best outcome. Both types of firms have an equalized MPK, $R_{f,u} - 1 + \delta$.

We denote the capital requirement for high productivity and low productivity firms as $\widehat{K}_H$ and $\widehat{K}_L$, respectively. Then in this first best case, we have:

$$\alpha \left(z_1^H\right)^{\frac{\eta-1}{1+\alpha\eta-\alpha}} \left(\widehat{K}_H\right)^{\frac{-1}{1+\alpha\eta-\alpha}} \left\{\int \left[\left[z_1^i \left(\widehat{K}_i\right)^{\alpha}\right]^{\frac{\eta-1}{\alpha\eta-\alpha+1}}\right] di\right\}^{\frac{\alpha\eta-\alpha+1}{(\eta-1)}-1} = R_{f,u} - 1 + \delta$$

$$\alpha \left(z_1^L\right)^{\frac{\eta-1}{1+\alpha\eta-\alpha}} \left(\widehat{K}_L\right)^{\frac{-1}{1+\alpha\eta-\alpha}} \left\{\int \left[\left[z_1^i \left(\widehat{K}_i\right)^{\alpha}\right]^{\frac{\eta-1}{\alpha\eta-\alpha+1}}\right] di\right\}^{\frac{\alpha\eta-\alpha+1}{(\eta-1)}-1} = R_{f,u} - 1 + \delta$$

It is obvious that $\widehat{K}_H > \widehat{K}_L$. As firms' initial wealth N_0 drops, eventually they cannot optimally choose the desired capital level. Intuitively, high productivity firms will become constrained first since they require higher optimal capital. Therefore they require higher initial wealth.

To prove this, we start from a slightly different angle and assume that firms are not endowed with the same initial wealth N_0. Suppose that at initial wealth $\widehat{N}_H$, high productivity firms just become constrained. Similarly, at initial wealth $\widehat{N}_L$, low productivity firms just become constrained. Meanwhile, suppose both types of firms just become constrained at the same time in the same economy. We denote $\lambda = \frac{1}{1-\theta}$. Therefore,

$$\alpha \left(z_1^H\right)^{\frac{\eta-1}{1+\alpha\eta-\alpha}} \left(\lambda\widehat{N}_H\right)^{\frac{-1}{1+\alpha\eta-\alpha}} \left\{\int \left[\left[z_1^i \left(\widehat{K}_i\right)^{\alpha}\right]^{\frac{\eta-1}{\alpha\eta-\alpha+1}}\right] di\right\}^{\frac{\alpha\eta-\alpha+1}{(\eta-1)}-1} = R_{f,c} - 1 + \delta$$

$$\alpha \left(z_1^L\right)^{\frac{\eta-1}{1+\alpha\eta-\alpha}} \left(\lambda\widehat{N}_L\right)^{\frac{-1}{1+\alpha\eta-\alpha}} \left\{\int \left[\left[z_1^i \left(\widehat{K}_i\right)^{\alpha}\right]^{\frac{\eta-1}{\alpha\eta-\alpha+1}}\right] di\right\}^{\frac{\alpha\eta-\alpha+1}{(\eta-1)}-1} = R_{f,c} - 1 + \delta$$

It implies that:

$$\widehat{N}_H > \widehat{N}_L$$

which means that, in the same economy, high productivity firms would require higher net worth to begin with, so that they just switch from being unconstrained to being constrained. Low productivity firms would require lower initial net worth.

We now revert back to the original case in which firms are given the same N_0. Following the above logic, we can clearly see that when N_0 decreases, high productivity firms naturally become constrained earlier than low productivity firms.

We denote this threshold as $\widehat{N}$. When $N_0 > \widehat{N}$, both types of firms are unconstrained. When $N_0 \leq \widehat{N}$, high productivity firms will be constrained while low productivity firms are still unconstrained.

As the initial wealth N_0 further drops, both types of firms will become constrained. We denote this threshold as $\overline{N}$.

E.2. Proposition 2

We denote the threshold that high productivity firms start to use leased capital as $\widehat{N}_L$, and the threshold that low productivity firms start to use leased capital as $\overline{N}_L$.

When firms use leased capital, their MPK is equal to the sum of the net interest rate, depreciation rate, and monitoring cost. Following similar logic in the proof for Proposition 1, we know that high productivity firms will start to use leased capital earlier than low productivity firms. This is because high productivity firms always require higher initial wealth, and thus they will become sufficiently constrained to use leased capital earlier than low productivity firms, when both types are given the same initial wealth. Consequently, $\widehat{N}_L > \overline{N}_L$.

From the user cost comparison in Section 2, we know that only when firms become sufficiently constrained will they begin to lease. Hence, $\widehat{N} > \widehat{N}_L$ and $\overline{N} > \overline{N}_L$.

We next compare $\widehat{N}_L$ and $\overline{N}$. We again use the logic in the proof for Proposition 1. Suppose that firms' initial wealth are not the same. Meanwhile, we focus on the case in which high productivity firms just begin to lease capital and low productivity firms just become constrained. In this scenario, we denote the initial wealth requirement for high productivity firms as $\widehat{n}_L$, and denote the initial wealth requirement for low productivity firms as $\overline{n}$.

From the MPK formulas, we know:

$$\widehat{n}_L = \frac{1}{\lambda}\left(\frac{R_{f,lc} - 1 + \delta + h}{\alpha \left(z_1^H\right)^{\frac{\eta-1}{1+\alpha\eta-\alpha}} \left\{\int \left[\left[z_1^i \left(\widehat{K}_i\right)^{\alpha}\right]^{\frac{\eta-1}{\alpha\eta-\alpha+1}} di\right\}^{\frac{\alpha\eta-\alpha+1}{(\eta-1)}-1}}\right)^{\alpha-1-\alpha\eta}$$

$$\overline{n}=\frac{1}{\lambda}\left(\frac{R_{f,lc}-1+\delta}{\alpha\left(z_1^L\right)^{\frac{\eta-1}{1+\alpha\eta-\alpha}}\left\{\int\left[\left[z_1^i\left(\widehat{K}_i\right)^{\alpha}\right]^{\frac{\eta-1}{\alpha\eta-\alpha+1}}\right]di\right\}^{\frac{\alpha\eta-\alpha+1}{(\eta-1)}-1}}\right)^{\alpha-1-\alpha\eta}$$

The comparison between $\widehat{n}_L$ and $\overline{n}$ can be reduced to:

$$\frac{R_{f,lc}-1+\delta+h}{\alpha\left(z_1^H\right)^{\frac{\eta-1}{1+\alpha\eta-\alpha}}}\text{ versus }\frac{\left(R_{f,lc}-1+\delta\right)\left(\frac{z_H}{z_L}\right)^{\frac{\eta-1}{1+\alpha\eta-\alpha}}}{\alpha\left(z_1^H\right)^{\frac{\eta-1}{1+\alpha\eta-\alpha}}}$$

and hence,

$$h\text{ versus }\left(R_{f,lc}-1+\delta\right)\left(\left(\frac{z_H}{z_L}\right)^{\frac{\eta-1}{1+\alpha\eta-\alpha}}-1\right)$$

Based on our benchmark parameters (and calculated R_f), the former is smaller than the latter one. This suggests that only when high productivity firms are endowed with higher initial wealth will they lease capital at the same time when low productivity firms become constrained (i.e., $\widehat{n}_L > \overline{n}$).

Using this logic, we revert back to our original scenario when firms are given the same N_0. We can conclude that, as N_0 drops, high productivity firms will begin leasing earlier than when low productivity firms become constrained. Therefore, $\widehat{N}_L > \overline{N}$.

F Alternative setups

F.1. Monopolistic competition

The first extension is the framework of monopolistic competition, consistent with Hsieh and Klenow (2009). We keep all else the same as in our baseline model, except that each firm now fully takes into account the impact of its production decision on price.

Setup

Final goods producer:

$$\max_{\{y_i\}} \left\{ Y - \int_{[0,1]} p_i y_i di \right\}_{Y=\left[\int_{[0,1]} y_i^{\frac{\eta-1}{\eta}} di\right]^{\frac{\eta}{\eta-1}}}$$

Intermediate goods producer: For each firm, we specify the profit maximization problem as:

$$\max_{D_t^i, B_0^i, (K_1^l)^i, K_1^o, RA_1^i, p_i} E\left[\sum_{t=0}^{1} M_t D_t^i\right]$$

$$\begin{aligned}
D_0^i + K_1^o + qRA_1^i &= N_0^i + B_0^i \\
D_1^i &= p_i y_i - \tau_l (K_1^l)^i - R_0 B_0^i + (1-\delta)(K_1^o + qRA_1^i) - W L_i \\
B_0^i &\leq \theta(K_1^o + qRA_1^i) \\
K_1^o + RA_1^i &\geq 0 \\
\left(K_1^l\right)^i &\geq 0 \\
D_t^i &\geq 0 \quad (t = 0, 1) \\
y_i &= A_1 z_1^i \left(K_1^o + RA_1^i + (K_1^l)^i\right)^\alpha L_i^{1-\alpha}
\end{aligned}$$

where $i = H, L$. Here firm i maximizes its discounted dividends by choosing the initial owned capital stock K_1^o, a state-contingent plan for capital reallocation RA_1^i, borrowing from household B_0^i, leased capital $(K_1^l)^i$, labor L_i, the price p_i for its output, and its dividend D_1^i, subject to the budget constraint, the collateral constraint, the inverse demand function, and the law of motion for dividend in period 1.

Household:

$$\max_{C_0, C_1, B_0, w_0^i, K^l} E\left[\sum_{t=0}^{1} \beta^t u(C_t)\right]$$

$$s.t.: C_0 + B_0 + \int w_0^i V_0^i di + K_1^l = \epsilon_0$$

$$\tau_l K_1^l + (1-\delta-h) K_1^l + R_0 B_0 + \int w_0^i (V_1^i + D_1^i) di + W = C_1$$

The market clearing conditions are:

$$\begin{aligned}
C_0 + \int w_0^i V_0^i di + \int D_0^i di + \int K_1^o di + K_1^l &= \epsilon_0 + \int N_{i,0} di; \\
\int p_i y_i di + \int (1-\delta)(K_1^o + qRA_1^i) di + (1-\delta-h)K_1^l &= C_1; \\
B_0 &= \int (B_0)^i di; \\
K_1^l &= \int (K_1^l)^i di; \\
w_0^i &= 1, for\ \ all\ \ i \\
\int RA_1^i di &= 0 \\
\int L_i di &= 1
\end{aligned}$$

Lagrangian

Final goods producer:

$$\max_{\{y_i\}} \left\{ Y - \int_{[0,1]} p_i y_i di \right\} = \left[\int_{[0,1]} y_i^{\frac{\eta-1}{\eta}} di \right]^{\frac{\eta}{\eta-1}} - \int_{[0,1]} p_i y_i di$$

F.O.C. implies:

$$p_i = y_i^{-\frac{1}{\eta}} Y^{\frac{1}{\eta}}$$

We next present the Lagrangian of a typical firm under our simplifying assumptions:

$$
\begin{aligned}
\mathcal{L} \quad = \quad & \max M_1 \left[\pi D_1^H + (1-\pi) D_1^L\right] \\
& +\pi\eta_{H0}\Big[\ N_0 + B_0^H - K_1^o - qRA_1^H\ \Big] \\
& +(1-\pi)\eta_{L0}\Big[\ N_0 + B_0^L - K_1^o - qRA_1^L\ \Big] \\
+ \quad \pi\eta_{H1} \quad & \Big[\ y_H^{1-\frac{1}{\eta}} Y^{\frac{1}{\eta}} - \tau_l (K_1^l)^H - R_f B_0^H - D_1^H + (1-\delta)(K_1^o + RA_1^H) - WL_H\ \Big] \\
+ \quad (1-\pi)\eta_{L1} \quad & \Big[\ y_L^{1-\frac{1}{\eta}} Y^{\frac{1}{\eta}} - \tau_l (K_1^l)^L - R_f B_0^L - D_1^L + (1-\delta)(K_1^o + RA_1^L) - WL_L\ \Big] \\
& +\pi\xi_{H0}\eta_{H0}\left[\theta(K_1^o + RA_1^H) - B_0^H\right] \\
& +(1-\pi)\xi_{L0}\eta_{L0}\left[\theta(K_1^o + RA_1^L) - B_0^L\right] \\
& +\pi\bar{\nu}_{H0}\eta_{H0}\left[K_1^o + RA_1^H\right] \\
& +(1-\pi)\bar{\nu}_{L0}\eta_{L0}\left[K_1^o + RA_1^L\right] \\
& +\pi\underline{\nu}_{H0}\eta_{H0}\left[\left(K_1^l\right)^H\right] \\
& +(1-\pi)\underline{\nu}_{L0}\eta_{H0}\left[\left(K_1^l\right)^L\right] \\
& +\pi d_{H1}\left[\left(D_1\right)^H\right] \\
& +(1-\pi) d_{L1}\left[\left(D_1\right)^L\right]
\end{aligned}
$$

F.O.C.s:

$$[D_1^H] : \pi M_1 - \pi\eta_{H1} + \pi d_{H1} = 0 \tag{F18}$$

$$[D_1^L] : (1-\pi) M_1 - (1-\pi)\eta_{L1} + (1-\pi) d_{L1} = 0 \tag{F19}$$

$$
\begin{aligned}
[K_1^o] : \pi & \left[(1-\frac{1}{\eta})\alpha\frac{p_H y_H}{K_1^o + RA_1^H + (K_1^l)^H} + (1-\delta)\right]\eta_{H1} \\
+(1-\pi) & \left[(1-\frac{1}{\eta})\alpha\frac{p_L y_L}{K_1^o + RA_1^L + (K_1^l)^L} + (1-\delta)\right]\eta_{L1} \\
& -\pi\eta_{H0} - (1-\pi)\eta_{L0} \\
+\theta\pi\xi_{H0}\eta_{H0} + \theta(1-\pi)\xi_{L0}\eta_{L0} + \pi\bar{\nu}_{H0}\eta_{H0} + (1-\pi)\bar{\nu}_{L0}\eta_{L0} & \quad = \quad 0
\end{aligned} \tag{F20}
$$

$$[RA_1^H] : -q\pi\eta_{H0} + \pi\left[(1-\frac{1}{\eta})\frac{\alpha p_H y_H}{K_1^o + RA_1^H + (K_1^l)^H} + (1-\delta)\right]\eta_{H1} + \pi\theta\xi_{H0}\eta_{H0} + \pi\bar{\nu}_{H0}\eta_{H0} = 0 \tag{F21}$$

$$
\begin{aligned}
[RA_1^L] : -q(1-\pi)\eta_{L0} + (1-\pi) & \left[(1-\frac{1}{\eta})\frac{\alpha p_L y_L}{K_1^o + RA_1^L + (K_1^l)^L} + (1-\delta)\right]\eta_{L1} \\
& +(1-\pi)\theta\xi_{L0}\eta_{L0} + (1-\pi)\bar{\nu}_{L0}\eta_{L0} \quad = \quad 0
\end{aligned} \tag{F22}
$$

$$[(K_1^l)^H] : \pi(1-\frac{1}{\eta})\alpha\frac{p_H y_H}{K_1^o + RA_1^H + (K_1^l)^H}\eta_{H1} - \pi\tau_l\eta_{H1} + \pi\underline{\nu}_{H0}\eta_{H0} = 0 \tag{F23}$$

$$[(K_1^l)^L] : (1-\pi)(1-\frac{1}{\eta})\alpha\frac{p_L y_L}{K_1^o + RA_1^L + (K_1^l)^L}\eta_{L1} - (1-\pi)\tau_l\eta_{L1} + (1-\pi)\underline{\nu}_{L0}\eta_{L0} = 0 \tag{F24}$$

$$[B_0^H] : \pi\eta_{H0} - \pi R_f\eta_{H1} - \pi\xi_{H0}\eta_{H0} = 0 \tag{F25}$$

$$[B_0^L] : (1-\pi)\eta_{L0} - (1-\pi)R_f\eta_{L1} - (1-\pi)\xi_{L0}\eta_{L0} = 0 \tag{F26}$$

$$[L_H] : \pi(1-\frac{1}{\eta})\,(1-\alpha)\,\frac{p_H y_H}{L_H} = \pi W \tag{F27}$$

$$[L_L] : (1-\pi)(1-\frac{1}{\eta})\,(1-\alpha)\,\frac{p_L y_L}{L_L} = (1-\pi)W \tag{F28}$$

where d_{L1} and d_{H1} must be zero since D_1^L and D_1^H must be positive. In our setup, firms must always have owned capital, meaning that $\bar{\nu}_{L0}$ and $\bar{\nu}_{H0}$ must be 0.

F.2. Fixed cost

In our second extension, we consider the model with a fixed cost of leasing. The fixed cost represents any additional cost relative to using owned capital, which is not included in rental fees. For example, the extra decoration costs for leased items could be one potential source. For simplicity's sake, we model it in a reduced form f_i for each unit of leased capital.

Setup

Final goods producer:

$$\max_{\{y_i\}}\left\{Y - \int_{[0,1]} p_i y_i di\right\}_{Y=\left[\int_{[0,1]} y_i^{\frac{\eta-1}{\eta}} di\right]^{\frac{\eta}{\eta-1}}}$$

Intermediate goods producer: For each firm, we specify the profit maximization problem as:

$$\max_{D_t^i, B_0^i, (K_1^l)^i, K_1^o, RA_1^i} E\left[\sum_{t=0}^{1} M_t D_t^i\right]$$

$$\begin{aligned}
D_0^i + K_1^o + qRA_1^i &= N_0^i + B_0^i \\
D_1^i &= p_i y_i - (\tau_l + f_i)(K_1^l)^i - R_0 B_0^i + (1-\delta)(K_1^o + qRA_1^i) - W L_i \\
B_0^i &\leq \theta(K_1^o + qRA_1^i) \\
K_1^o + RA_1^i &\geq 0 \\
\left(K_1^l\right)^i &\geq 0 \\
D_t^i &\geq 0 \quad (t = 0, 1) \\
y_i &= A_1 z_1^i \left(K_1^o + RA_1^i + (K_1^l)^i\right)^{\alpha} L_i^{1-\alpha}
\end{aligned}$$

where $i = H, L$. Firm i's objective is to maximize the discounted dividends by choosing the initial owned capital stock K_1^o, a state-contingent plan for capital reallocation RA_1^i, borrowing from household B_0^i, leased capital $(K_1^l)^i$, labor L_i, and its dividend D_1^i, subject to the budget constraint, the collateral constraint, the inverse demand function, and the law of motion for dividend in period 1.

Household:

$$\max_{C_0, C_1, B_0, w_0^i, K^l} E\left[\sum_{t=0}^{1} \beta^t u\left(C_t\right)\right]$$

$$s.t.: C_0 + B_0 + \int w_0^i V_0^i di + K_1^l = \epsilon_0$$

$$\tau_l K_1^l + (1-\delta-h)K_1^l + R_0 B_0 + \int w_0^i (V_1^i + D_1^i) di + W = C_1$$

The market clearing conditions are:

$$C_0 + \int w_0^i V_0^i di + \int D_0^i di + \int K_1^o di + K_1^l = \epsilon_0 + \int N_{i,0} di;$$

$$\int p_i y_i di + \int (1-\delta)(K_1^o + qRA_1^i) di + (1-\delta-h)K_1^l - \int f_i (K_1^l)^i = C_1;$$

$$B_0 = \int (B_0)^i di;$$

$$K_1^l = \int (K_1^l)^i di;$$

$$w_0^i = 1, for\ \ all\ \ i$$

$$\int RA_1^i di = 0$$

$$\int L_i di = 1$$

Lagrangian

We present the Lagrangian of a typical firm under our simplifying assumptions:

$$\begin{aligned}
\mathcal{L} \quad = \quad & \max M_1 \left[\pi D_1^H + (1-\pi) D_1^L\right] \\
& + \pi\eta_{H0} \left[\ N_0 + B_0^H - K_1^o - qRA_1^H\ \right] \\
& + (1-\pi)\eta_{L0} \left[\ N_0 + B_0^L - K_1^o - qRA_1^L\ \right] \\
+ \quad \pi\eta_{H1} \quad & \left[\ p_H y_H - (\tau_l + f_H)(K_1^l)^H - R_f B_0^H - D_1^H + (1-\delta)(K_1^o + RA_1^H) - WL_H\ \right] \\
+ \quad (1-\pi)\eta_{L1} \quad & \left[\ p_L y_L - (\tau_l + f_L)(K_1^l)^L - R_f B_0^L - D_1^L + (1-\delta)(K_1^o + RA_1^L) - WL_L\ \right] \\
& + \pi\xi_{H0}\eta_{H0} \left[\theta(K_1^o + RA_1^H) - B_0^H\right] \\
& + (1-\pi)\xi_{L0}\eta_{L0} \left[\theta(K_1^o + RA_1^L) - B_0^L\right] \\
& + \pi\bar{\nu}_{H0}\eta_{H0} \left[K_1^o + RA_1^H\right] \\
& + (1-\pi)\bar{\nu}_{L0}\eta_{L0} \left[K_1^o + RA_1^L\right] \\
& + \pi\underline{\nu}_{H0}\eta_{H0} \left[\left(K_1^l\right)^H\right] \\
& + (1-\pi)\underline{\nu}_{L0}\eta_{H0} \left[\left(K_1^l\right)^L\right] \\
& + \pi d_{H1} \left[(D_1)^H\right] \\
& + (1-\pi) d_{L1} \left[(D_1)^L\right]
\end{aligned}$$

F.O.C.s:

$$[D_1^H] : \pi M_1 - \pi\eta_{H1} + \pi d_{H1} = 0 \tag{F29}$$

$$[D_1^L] : (1-\pi)M_1 - (1-\pi)\eta_{L1} + (1-\pi)d_{L1} = 0 \tag{F30}$$

$$\begin{aligned}[K_1^o] : \pi\left[\alpha\frac{p_H y_H}{K_1^o + RA_1^H + (K_1^l)^H} + (1-\delta)\right]\eta_{H1} \\ +(1-\pi)\left[(\alpha\frac{p_L y_L}{K_1^o + RA_1^L + (K_1^l)^L} + (1-\delta)\right]\eta_{L1} \\ -\pi\eta_{H0} - (1-\pi)\eta_{L0} \\ +\theta\pi\xi_{H0}\eta_{H0} + \theta(1-\pi)\xi_{L0}\eta_{L0} + \pi\bar{\nu}_{H0}\eta_{H0} + (1-\pi)\bar{\nu}_{L0}\eta_{L0} &= 0\end{aligned} \tag{F31}$$

$$[RA_1^H] : -q\pi\eta_{H0} + \pi\left[\frac{\alpha p_H y_H}{K_1^o + RA_1^H + (K_1^l)^H} + (1-\delta)\right]\eta_{H1} + \pi\theta\xi_{H0}\eta_{H0} + \pi\bar{\nu}_{H0}\eta_{H0} = 0 \tag{F32}$$

$$\begin{aligned}[RA_1^L] : -q(1-\pi)\eta_{L0} + (1-\pi)\left[\frac{\alpha p_L y_L}{K_1^o + RA_1^L + (K_1^l)^L} + (1-\delta)\right]\eta_{L1} \\ +(1-\pi)\theta\xi_{L0}\eta_{L0} + (1-\pi)\bar{\nu}_{L0}\eta_{L0} &= 0\end{aligned} \tag{F33}$$

$$[(K_1^l)^H] : \pi\alpha\frac{p_H y_H}{K_1^o + RA_1^H + (K_1^l)^H}\eta_{H1} - \pi(\tau_l + f_H)\eta_{H1} + \pi\underline{\nu}_{H0}\eta_{H0} = 0 \tag{F34}$$

$$[(K_1^l)^L] : (1-\pi)\alpha\frac{p_L y_L}{K_1^o + RA_1^L + (K_1^l)^L}\eta_{L1} - (1-\pi)(\tau_l + f_L)\eta_{L1} + (1-\pi)\underline{\nu}_{L0}\eta_{L0} = 0 \tag{F35}$$

$$[B_0^H] : \pi\eta_{H0} - \pi R_f\eta_{H1} - \pi\xi_{H0}\eta_{H0} = 0 \tag{F36}$$

$$[B_0^L] : (1-\pi)\eta_{L0} - (1-\pi)R_f\eta_{L1} - (1-\pi)\xi_{L0}\eta_{L0} = 0 \tag{F37}$$

$$[L_H] : \pi\,(1-\alpha)\,\frac{p_H y_H}{L_H} = \pi W \tag{F38}$$

$$[L_L] : (1-\pi)\,(1-\alpha)\,\frac{p_L y_L}{L_L} = (1-\pi)W \tag{F39}$$

where d_{L1} and d_{H1} must be zero since D_1^L and D_1^H must be positive. In our setup, firms must always have owned capital, meaning that $\bar{\nu}_{L0}$ and $\bar{\nu}_{H0}$ must be 0.

References for Online Appendix

Chu, Yongqiang. 2020. "Collateral, Ease of Repossession, and Leases: Evidence from Antirecharacterization Laws." *Management Science*, 66(7): 2951–2974.

Cornaggia, Kimberly J., Laurel A. Franzen, and Timothy T. Simin. 2013. "Bringing Leased Assets onto the Balance Sheet." *Journal of Corporate Finance*, 22: 345–360.

Eisfeldt, Andrea L., and Adriano A. Rampini. 2009. "Leasing, Ability to Repossess, and Debt Capacity." *Review of Financial Studies*, 22(4): 1621–1657.

Graham, John R., Michael L. Lemmon, and James S. Schallheim. 1998. "Debt, Leases, Taxes, and the Endogeneity of Corporate Tax Status." *Journal of Finance*, 53(1): 131–162.

Graham, Roger C., and KC Lin. 2018. "How will the New Lease Accounting Standard Affect the Relevance of Lease Asset Accounting?" *Advances in Accounting*, 42: 83–95.

Hsieh, Chang-Tai, and Peter J. Klenow. 2009. "Misallocation and Manufacturing TFP in China and India." *Quarterly Journal of Economics*, 124(4): 1403–1448.

Hu, Weiwei, Kai Li, and Yiming Xu. 2020. "Leasing as a Mitigation Channel of Capital Misallocation." *Available at SSRN 3719658*.

Li, Shaojin, Toni M. Whited, and Yufeng Wu. 2016. "Collateral, Taxes, and Leverage." *Review of Financial Studies*, 29(6): 1453–1500.

Rauh, Joshua D., and Amir Sufi. 2012. "Explaining Corporate Capital Structure: Product Markets, Leases, and Asset Similarity." *Review of Finance*, 16(1): 115–155.