The Leased Capital Premium

Kai Li and Chi-Yang Tsou*

June 3, 2018

Abstract

This paper argues that firms' capital lease versus buy decision is a key determinant of firms' equity returns in the cross-section. In a typical operating lease contract, the lessee, who borrows the capital, effectively obtains an insurance against the risk of capital price fluctuations, from the lessor, who owns the asset and bears such a risk. Hence our theory predicts that the leased capital is *less* risky than the owned capital from lessee firms' perspective. We provide strong empirical evidence to support this prediction. Among financially constrained stocks, firms with a low leased capital ratio earn average returns that are 7.14% higher than firms with a high leased capital ratio. We develop a general equilibrium model with heterogenous firms and financial frictions to quantitatively account for the negative leased capital premium.

JEL Codes: E2, E3, G12

Keywords: Leased capital, Operating lease, Secured debt, Collateral, Financial constraint, Cross-section of returns

First Draft: November 1, 2017

*Kai Li (kaili@ust.hk) is an assistant professor of finance at Hong Kong University of Science and Technology; and Chi-Yang Tsou (bentsou1@connect.hku.hk) is a PhD student of finance at the Faculty of Business and Economics, University of Hong Kong. We thank Hengjie Ai, Doron Avramov, Utpal Bhattacharya, Hui Chen, Max Croce, Vidhan Goyal, Po-Hsuan Hsu, Shiyang Huang, Yan Ji, Jun Li, Tse-Chun Lin, Hanno Lustig, Andrey Malenko, Abhiroop Mukherjee, Adriano Rampini, Dragon Yongjun Tang, John Wei, Amir Yaron, Haifeng You, Jialin Yu, Chu Zhang and Harold Zhang, as well as the seminar participants at the First World Symposium on Investment Research, Hong Kong University of Science and Technology, University of Hong Kong, Chinese University of Hong Kong for their helpful comments. The usual disclaimer applies.

1 Introduction

Lease contracts are extensively used in capital markets, and lease is one of the major sources of external financing for firms. In this paper, we emphasize that the leased capital, the amount of capital that firm rents, is not only an important determinant of firms' liability, but also a key predictor of firms' equity returns on the asset side. In particular, we argue that, from the perspective the firms who rent the capital, the leased capital is *less* risky than the owned/purchased capital[1], and provide empirical evidence supporting this claim.

In a typical operating lease contract, the owner of the asset (the lessor) grants to another party (the lessee) the exclusive right to use the capital for an agreed period of time, in return for periodic payments, and the capital reverts to the lessor at the end of the lease term.[2] It is important to notice the ownership of the capital never changes the hand in such a contract and it is the owner who bears the risk of capital price fluctuations during the contract term. Hence our key intuition is that the lessor, the capital owner, effectively provides an insurance to the lessee, who rents the capital, against the risks of capital price fluctuations. In another word, the lessee obtains a future's contract from the lessor to sell back the capital at current price on the maturity date, and thus she is fully hedged against the capital price risks. Therefore, from the lessee firms' perspective, the leased capital is less risky than the purchased capital, is expected to earn a lower average return.

To examine the empirical relationship between the leased capital and risk premia, we first construct a novel measure of firm's leased capital ratio. Guided by the standard accounting practice, we capitalize the rental expense to obtain a gauge of the amount of leased capital, and then we construct a leased capital ratio by dividing the leased capital with respect to the total physical capital used in firm production. We document that there is a large firm heterogeneity in firms' leased capital ratios. The leased capital ratio measure is correlated with a number of firm characteristics in a manner that is consistent with our theory. We find that financially constrained firms tend to have higher leased capital ratio, implying that constrained firms lease more of their capital. High leased capital firms have lower debt leverage, but higher lease adjusted leverage, suggesting that the lease becomes a more

[1] In this paper, we use "purchased capital" and "owned capital", "leased capital" and "rented capital" interchangeably.

[2] There is another type of lease – capital lease, in which the lessee acquires ownership of the asset at the end of lease's term. However, operating lease is much larger in magnitude than capital lease in the data, and therefore is our main focus.

important external financing channel than debt for these firms, consistent with the finding in Rampini and Viswanathan (2013). This evidence motivates us to focus on the financially constrained firms in the portfolio-sorting exercise, as the asset pricing implication of the leased capital is expected to be more pronounced among this subset of firms.

We further sort financially constrained firms into quintile portfolios according to the leased capital ratio and document an economically large and statistically significant return spread of 7.14% per year for low leased capital ratio firms versus high leased capital ratio firms. We call it a negative leased capital premium. A low-minus-high strategy based on the leased capital ratio delivers an annualized Sharpe ratio of 0.66, higher than that of the market portfolio. Moreover, in the asset pricing test shown in Appendix A, the alphas remain significant even after controlling for Hou, Xue, and Zhang (2015) (HXZ hereafter) q-factors or Fama and French (2015) five factors. The evidence on the leased capital spread strongly supports our theoretical prediction that the leased capital is less risky and therefore earn a lower expected return than the purchased capital.

To further support our theory, we manually identified the lessor firms at the narrowly defined SIC (Standard Industrial Classification) 4 digit level and then study their average returns and firm characteristics. We find that the lessor firms earn higher average excess returns and higher profitability, and are less financially constrained than the lessee firms with high leased capital ratio. This is consistent with the theoretical prediction that the lessor firms enjoy a risk compensation by providing the lessee firms the insurance against the capital price fluctuations.

To formalize the above intuition and quantify the effect of leasing on the cross-section of expected returns, we develop a general equilibrium model with heterogeneous firms in which financing is subject to collateral constraints derived from limited enforcement and firms choose between purchasing and renting assets. In our model, lease is modelled as highly collateralized albeit costly financing. When capital is leased, the financier retains ownership which facilitates repossession and strengthens the collateralization of the financier's claim. Leasing is costly since the lessor incurs monitoring costs to avoid agency problems due to the separation of ownership and control. Whether firms choose to lease or buy assets depends on the equity owner's internal net worth, which is determined by the historical returns of the firms they invest in, and these firms are subject to idiosyncratic shocks. As a result, the heterogeneity in net worth and financing needs translate into differences in the leased capital ratio in equilibrium: equity owners with high need for capital but low net worth lease more of their capital to support its production. In this theoretical setup, we show that, at the aggregate level, the leased capital requires lower expected returns in equilibrium than the purchased capital through a collateralized loan, that is, a negative leased capital premium. In the cross-section, firms with a higher leased capital ratio earn lower risk premia.

We calibrate our model by allowing for negatively correlated productivity and financial shocks. Our calibrated model matches the conventional asset pricing moments and macroeconomic quantity dynamics well and is able to quantitatively account for the empirical relationship between the leased capital ratio, size, leverage, and expected returns.

Related literature Our paper builds on the corporate finance literature that emphasizes the importance of asset collateralizability for the capital structure decisions of firms. Albuquerque and Hopenhayn (2004) study dynamic financing with limited commitment, Rampini and Viswanathan (2010, 2013) develop a joint theory of capital structure and risk management based on asset collateralizability, and Schmid (2008) considers the quantitative implications of dynamic financing with collateral constraints. Falato et al. (2013) provide empirical evidence for the link between asset collateralizability and leverage in aggregate time series and in the cross section. Our paper departs from the above literature in two dimensions: First, this literature mainly study the financing role of collateral on the firm's liability, while we study the implications on the asset side, in particular, through the lens of cross-section of stock returns. Second, most of the papers, with the exceptions of Rampini and Viswanathan (2010, 2013), do not explicitly allow firms to rent capital, while we explicitly model firms' dynamic lease versus buy decision, in the same spirit of Rampini and Viswanathan (2010, 2013) in a general equilibrium asset pricing model framework.

Our study is closely related to theories of corporate decisions to lease.[3] The papers most related to our's are Eisfeldt and Rampini (2009) and Rampini and Viswanathan (2010, 2013). The nature of the collateral constraints and firm's dynamic decision on lease versus buy are built based on these papers. The differences lie in two dimensions: first, Eisfeldt and Rampini (2009) is a static model, and Rampini and Viswanathan (2010, 2013) are dynamic model in partial equilibrium framework, while our model is set up in a general equilibrium framework with heterogenous firms. A general equilibrium is useful for modelling the competitive lessor's problem and for endogenizing the leasing fee so that it depends on fundamental shocks, while in previous papers the leasing fee and its volatility are exogenous. Second, we focus on the asset pricing implications of the leased capital, and focus on implications of it on firms' asset side.

Our study builds on the large macroeconomics literature studying the role of credit market

[3]There is a large literature on theories of lease, but we do not attempt to summarize it here. Eisfeldt and Rampini (2009) provides a comprehensive review of this literature.

frictions in generating fluctuations across the business cycle (see Quadrini (2011) and Brunnermeier et al. (2012) for extensive reviews). The papers that are most related to ours are those emphasizing the importance of borrowing constraints and contract enforcements, such as Kiyotaki and Moore (1997, 2012), Gertler and Kiyotaki (2010), He and Krishnamurthy (2013), Brunnermeier and Sannikov (2014), and Elenev et al. (2017). Gomes et al. (2015) studies the asset pricing implications of credit market frictions in a production economy. We allow firm to lease capital as a highly collateralized albeit costly financing, and study the implications of leasing versus secured lending on the cross-section of expected returns.

Our paper belongs to the literature of production-based asset pricing, for which Kogan and Papanikolaou (2012) provide an excellent survey. From the methodological point of view, our general equilibrium model allows for a cross section of firms with heterogeneous productivity and is related to previous work including Gomes et al. (2003), Gârleanu et al. (2012), Ai and Kiku (2013), and Kogan et al. (2017). Compared to the above papers, our model incorporates financial frictions, and we suggest a novel aggregation technique. In this regard, our paper is closest related Ai, Li, Li, and Schlag (2017a), which use a similar model framework and the aggregation technique to study the asset collateralizabiilty and stock returns. Our paper differs from Ai, Li, Li, and Schlag (2017a) by further introducing the firm's option to lease capital and focus on the risk profile and therefore expected return of the leased capital.

Our paper is also connected to the broader literature linking investment to the cross-section of expected returns. Zhang (2005) provides an investment-based explanation for the value premium. Li (2011) and Lin (2012) focus on the relationship between R&D investment and expected stock returns. Eisfeldt and Papanikolaou (2013) develop a model of organizational capital and expected returns. Belo, Lin, and Yang (2017) study implications of equity financing frictions on the cross-section of stock returns.

The rest of the paper is organized as follows. We summarize some empirical stylized facts on the relationship between financial constraint, the leased capital ratio and expected returns in Section 2. We describe a general equilibrium model with heterogenous firms in which firms are subject to collateral constraints and have the option to lease capital in Section 3 and analyze its asset pricing implications in Section 4. In Section 5, we provide a quantitative analysis of our model. Section 6 provides additional supporting evidence of the model. In Appendix A, we further provide some additional empirical evidence to establish the robustness. Section 7 concludes. Details on data construction are delegated to the Appendix B.

2 Empirical Facts

This section provides some aggregate and cross-sectional evidence that highlight the importance of leasing as a source of external finance and as an important determinant of the cross-section of stock returns, in particular, for financially constrained firms.

2.1 Leased Capital Ratio and Leverage

We follow Rampini and Viswanathan (2013) to capitalize rental expense from operating lease and refer this capitalized item to leased capital.[4] We use Property, Plant and Equipment-Total (Net), i.e. PPENT, to measure purchased tangible capital and further define leased capital ratio as leased capital divided by the sum of leased and purchased capital. Excluding intangible capital, leased capital ratio measures the proportion of total capital input in a firm's production obtained from leasing activity. Table 1 reports summary statistics of leased capital ratio and leverage for the aggregate and the cross-sectional firms in Compustat.

Table 1: **Summary Statistics**

This table presents summary statistics for the main outcome variables and control variables of our sample. Leased capital ratio is the ratio of leased capital over the sum of leased capital and purchased capital (PPENT), where leased capital is defined as 10 times rental expense (XRENT). Debt leverage is the ratio of long-term debt (DLTT) over the sum of leased capital and total assets (AT). Rental leverage is the ratio of leased capital over the sum of leased capital and total assets (AT). Leased capital leverage is the sum of debt leverage and rental leverage. In Panel A we split the whole sample into constrained and unconstrained firms at the end of every June, as classified by WW index, according to Whited and Wu (2006). We report pooled means of these variables value-weighted by firm market capitalization at fiscal year end. In Panel B we report the time-series averages of the cross-sectional averages of firm characteristics across five portfolios sorted on leased capital ratio relative to their industry peers according to the Fama-French 49 industry classifications. The detailed definition of the variables is listed in Appendix B. The sample period is 1987 to 2014 and excludes financial, utility, public administrative, and lessor industries from the analysis.

	Panel A: Pooled Statistics		**Panel B: Firm Characteristics**				
	Constrained	**Unconstraned**	**Portfolios**				
Variables	**Mean**	**Mean**	**L**	**2**	**3**	**4**	**H**
Lease	0.56	0.31	0.30	0.54	0.68	0.77	0.83
Debt Leverage	0.08	0.15	0.12	0.08	0.06	0.05	0.05
Rental Leverage	0.17	0.10	0.10	0.17	0.21	0.26	0.30
Lease adjusted Leverage	0.24	0.25	0.21	0.25	0.27	0.32	0.35

Panel A reports the statistics of the financially constrained firm group versus its unconstrained counterpart. The constraint is measured by the Whited-Wu index (Whited and Wu

[4]According to Rampini and Viswanathan (2013), the capitalization is to use multiplies of 5, 6, 8, and 10 × rental expense, depending on the industry. We use 10 in this paper.

(2006), Hennessy and Whited (2007), WW index hereafter).[5] Panel A presents two salient observations. First, the average leased capital ratio of financially constrained firms (0.56) is significantly higher than that of the unconstrained firms (0.31); that is to say, financially constrained firms lease more. Second, the average debt leverage of constrained firms (0.08) is lower than that of unconstrained group (0.15), while the average rental leverage of financially constrained firms is higher than that of unconstrained firms. Defined as the sum of debt and rental leverage, lease adjusted leverage ratio between two groups is comparable to each other (0.24 versus 0.25). This implies that leasing is an important source of external finance for financially constrained firms, and complements the financial debt.

In panel B, we further sort financially constrained firms in the Compustat into five quintiles based on their leased capital ratios relative to their industry peers as Fama-French 49 industry classifications, and report firm characteristics across five quintiles. First, we observe a large dispersion in the average leased capital ratio, ranging from 0.30 in the lowest quintile (Quintile L) to a ratio as much as 0.83 in the highest quintile (Quintile H). Second, the debt leverage is downward sloping from the lowest to the highest leased capital ratio sorted quintile, while rental leverage is upward sloping across quintiles. Overall, the leased adjusted leverage increases with leased capital ratio across quintiles. This upward sloping pattern again confirms the importance of leasing in financially constrained firms as an alternative external financing source.

From these findings in Table 1, we recognize that leasing can be an even more important channel of external financing activities for the constrained group, and it is the first-order determinant of the capital structure on the firms' liability side. In the next section, we will present evidence to show that leasing also plays an important role on firms' asset side, as reflected by equity returns across firms with different leased capital ratio.

2.2 Negative Leased Capital Premium

In this section, we provide empirical evidence on the relation between leased capital ratio and expected return. Motivated by the previous empirical evidence that financially constrained firms lease more, we focus on financially constrained non-lessor firms [6] and construct portfolios sorted on these firms' leased capital ratios. Following the literature, we use three proxies for financial constraint: WW index, credit rating, and non-dividend payer. Financially

[5] We tried other financial constrained measures, including credit rating, SA index, and dividend payment dummy. These four proxies show consistent results empirically.

[6] We eliminate the lessor firms as identified in Section 6.2. There are on average 134 firms per year, and therefore, this firm group constitutes a small fraction of the Compustat firm universe.

constrained firms are firms with their implied WW indexes larger than the cross-sectional median, zero credit ratings, or non-dividend payments. Detailed criteria of credit rating refers to Appendix B. After classifying all firms into financially constrained versus unconstrained groups at an annual frequency, we implement the standard procedure and sort these constrained firms into quintile portfolios based on these firms' leased capital ratios within Fama-French 49 industries. At the end of June of year t from 1988 to 2015[7], we rank firms' leased capital ratios by using 49 industry-specific breaking points based on Fama and French (1997) classifications and construct portfolios as follows. We sort firms with a positive leased capital ratio in year $t-1$ into five groups from low to high. To examine the leased capital ratio-return relation, we form a long-short portfolio that takes a long position in the lowest quintile and a short position in the highest quintile portfolio sorted on leased capital ratio. After six portfolios (from low to high and long-short portfolios) are determined, we calculate the value-weighted monthly returns annualized by multiplying 12 and hold these portfolios over the next twelve months (July in year t to June in year $t+1$).

Table 2 reports the average annualized excess returns and Sharpe ratios in five quintile portfolios and long-short portfolio in Panel A, B, and C, each corresponding to a specific measure of financial constraint. Our benchmark is on the low-minus-high return spread based on financially constrained firms classified by WW index, and we consider the portfolio sorting based on other alternative financial constraint measures as the robustness check. The spread is economically large (7.14% per annum) and statistically significant at 1% level with t-statistics above 3. The annualized Sharpe ratio is economically sizable, amounting to 0.66, which is about 30% higher than that of the aggregate stock market index (around 0.5). We call the return spread as the negative leased capital premium. And the premium is robust to different measures of financial constraints as in remaining panels for alternative financial constraint measures.

The second panel (Panel B) shows that, among the constrained sub-sample as classified by credit rating, the lowest leased capital ratio portfolio (Quintile L) and the highest leased capital ratio portfolio (Quintile H) deliver a comparable magnitude of return spread amounting to 6.15% with a t-statistic 2.72 significant at 1% level. When we refer to the third panel (Panel C), the low-minus-high portfolio, among the constrained sub-sample classified by div-

[7]Lease data is available only after 1973. Given our study focuses on operating lease, we have to choose a sample period with explicit definition in operating leasing. According to Financial Accounting Standard (FASB) No. 13 issued in 1976, firms recognize capital leases as a liability item and sperate them from operating leases. Considering for substantial impacts, including contractual violations and managerial compensations, firms were allowed to transit within 5 years and to delay for the adoption of new standard if more time was necessary to avoid any violation. Therefore, we drop the transitional period to support our theoretical predictions. Our results remain robust if we extend our sample to early 80s.

Table 2: **Univariate Portfolio Sorting on Leased Capital Ratio**

This table shows asset pricing test for five portfolios sorted on leased capital ratio relative to their industry peers, where we use the Fama-French 49 industry classifications and rebalence portfolios at the end of every June. The results are used monthly data, where the sample period is from July 1988 to December 2015 and excludes financial, utility, public administrative, and lessor industries from the analysis. We split the whole sample into financially constrained and unconstrained firms at the end of every June, as classified by WW index (Panel A), credit rating (Panel B), and dividend payment dummy (Panel C). We report average excess returns over the risk-free rate E[R]-R_f, standard deviations Std, and Sharpe ratios SR across five portfolios across constrained subsamples from Panel A to C. Standard errors are estimated by using Newey-West correction. We include t-statistics in parentheses and annualize portfolio returns by multiplying 12. All portfolios returns correspond to value-weighted returns by firm market capitalization.

	Constrained Subsample					
Variables	**L**	**2**	**3**	**4**	**H**	**L-H**
			Panel A: WW			
E[R]-R_f (%)	10.15	9.50	7.82	5.81	3.01	7.14
[t]	2.05	1.86	1.61	1.10	0.56	3.60
Std (%)	26.6	26.27	26.63	26.89	27.41	10.85
SR	0.38	0.36	0.29	0.22	0.11	0.66
			Panel B: Rating			
E[R]-R_f (%)	10.57	8.77	7.35	6.29	4.42	6.15
[t]	2.64	1.76	1.81	1.61	0.96	2.72
Std (%)	21.03	22.68	22.09	21.51	23.91	10.93
SR	0.5	0.39	0.33	0.29	0.18	0.56
			Panel C: DIV			
E[R]-R_f (%)	9.54	10.25	9.82	5.29	4.38	5.16
[t]	2.40	2.10	2.09	1.26	1.05	2.26
Std (%)	21.59	23.49	23.57	23.47	23.43	11.22
SR	0.44	0.44	0.42	0.23	0.19	0.46

idend payment, consistently shows a positively significant but slightly smaller return spread amounting to 5.16% at 5% significance level.

As a summary, we document an economically large and statistically significant negative leased capital premium for financially constrained firms, robust to different measures of financial constraint. In the next section, we develop a general equilibrium model to formalize the above intuition and to quantitatively account for the (negative) leased capital premium that we document in the data.

3 A General Equilibrium Model

This section describes the ingredients of our quantitative general equilibrium model to understand the important role of leased capital for firms' expected returns. The aggregate aspect of the model is intended to follow standard macro models with collateral constraints such as Kiyotaki and Moore (1997) and Gertler and Kiyotaki (2010). The key additional elements in the construction of our theory are firms' ability to lease capital, referring to Eisfeldt and Rampini (2009) and Rampini and Viswanathan (2013), idiosyncratic productivity shocks and firm entry and exit. These features allow us to generate quantitatively plausible firm dynamics and the negative leased capital premium in the cross-section.

3.1 Households

Time is infinite and discrete. The representative household consists of a continuum of workers and a continuum of entrepreneurs. Workers and entrepreneurs receive their incomes every period and submit them to the planner of the household, who make decisions for consumption for all members of the household. Entrepreneurs and workers make their financial decisions separately.[8]

The household ranks her utility according to the following recursive preference as in Epstein and Zin (1989):

$$U_t = \left\{ (1-\beta) C_t^{1-\frac{1}{\psi}} + \beta (E_t[U_{t+1}^{1-\gamma}])^{\frac{1-\frac{1}{\psi}}{1-\gamma}} \right\}^{\frac{1}{1-\frac{1}{\psi}}},$$

where β is the time discount rate, ψ is the intertemporal elasticity of substitution, and γ is

[8]According to Gertler and Kiyotaki (2010), we make the assumption that household members make joint decisions on their consumptions to avoid the need to keep track of the joint distribution of entrepreneurs' incomes as the state variable.

the relative risk aversion. As we will show later in the paper, together with the endogenous growth and long run risk, the recursive preference in our model generates a volatile pricing kernel and a sizable equity premium as in Bansal and Yaron (2004).

In every period t, the household purchases the amount $B_t(i)$ of risk-free bonds from entrepreneur i, from which she will receive $B_t(i)R_{f,t+1}$ next period, where $R_{f,t+1}$ denotes the risk-free interest rate from period t to $t+1$. In addition, she receives capital income $\Pi_t(i)$ from entrepreneur i and labor income $W_t L_t(j)$ from worker j. Without loss of generality, we assume that all workers are endowed with the same number of hours per period, and suppress the dependence of $L_t(j)$ on j. The household budget constraint at time t can therefore be written as

$$C_t + \int B_t(i)\, di = W_t \int L_t(j) dj + R_{f,t} \int B_{t-1}(i)\, di + \int \Pi_t(i)\, di.$$

Let M_{t+1} denote the the stochastic discount factor implied by household consumption. Under recursive utility, the stochastic discount factor denotes as, $M_{t+1} = \beta \left(\frac{C_{t+1}}{C_t}\right)^{-\frac{1}{\psi}} \left(\frac{U_{t+1}}{E_t[U_{t+1}^{1-\gamma}]^{\frac{1}{1-\gamma}}}\right)^{\frac{1}{\psi}-\gamma}$, and the optimality of the intertemporal saving decisions implies that the risk-free interest rate must satisfy

$$E_t[M_{t+1}]R_{f,t+1} = 1.$$

3.2 Entrepreneurs

Entrepreneurs are agents born with productive ideas. An entrepreneur who starts at time 0 draws an idea with an initial productivity $\bar{z}$ and begins his operation with an initial net worth N_0. Under our convention, N_0 is also the total net worth of all entrepreneurs at time 0 because the total measure of all entrepreneurs is normalized to one.

Let $N_{i,t}$ denote the net worth of an entrepreneur i at time t, and let $B_{i,t}$ denote the total amount of risk-free bond the entrepreneur issues to the household. Then the time-t budget constraint for the entrepreneur is given as

$$q_{K,t}K_{i,t+1}^{o} + \tau_{l,t}K_{i,t+1}^{l} = N_{i,t} + B_{i,t}. \tag{1}$$

Capital Lease versus Buy Decision

In equation (1) we assume that the entrepreneur can either purchase or lease the capital. The purchased capital and leased capital are denoted as K^o and K^l, respectively. Given the total budget $N_{i,t}+B_{i,t}$, the entrepreneur i chooses the amount of capital $K^o_{i,t+1}$ and $K^l_{i,t+1}$ to purchase or lease at the end of period t. Both two types of capital will be used for production in period $t+1$ and are perfect substitute in the production, as shown in section 3.3. The total amount of capital is defined as $K_{i,t+1}=K^o_{i,t+1}+K^l_{i,t+1}$. We further use $q_{K,t}$ to denote the capital price at time t and use $\tau_{l,t}$ to denote the leasing fee (or user cost) per period. Moreover, there exists a competitive lessor to charge the leasing fee per unit of leased capital. Given the constraint of enforcement, the user cost of the leased capital to be used in period $t+1$ is charged at the end of period t and hence the entrepreneur pays $\tau_{l,t}$ upfront.

Collateral Constraint

We assume that at time t, the entrepreneur has an opportunity to default on his lending contract and abscond with a fraction of $1-\theta$ of the purchased capital. Because lenders can retrieve a θ fraction of the purchased capital upon default, borrowing is limited by

$$B_{i,t} \leq \theta q_{K,t} K^o_{i,t+1}, \tag{2}$$

in which θ measures the collateralizability of the asset.

Note that the asymmetry of purchased versus leased capital in the above limited commitment constraint reflects the repossession advantage of the leased capital. To be concrete, we assume that entrepreneurs cannot abscond with leased capital $K^l_{i,t+1}$, as the argument in Eisfeldt and Rampini (2009) and Rampini and Viswanathan (2013). That is to say, leased capital enjoys a repossession advantage. It is easier for a lessor, who retains the ownership of an asset, to repossess that asset, than for a secured lender, who only has a security interest, to recover the collateral backing the loan. The repossession advantage means, by leasing, the firm can effectively borrow against the full resale value of the assets, whereas, secured lending allows the firm to borrow only against a fraction θ of the resale value. The benefit of leasing is to enlarge firms' debt capacity. However, we will explain leasing is a costly way of borrowing in the lessor's problem in section 3.3.

We use $\pi\left(\bar{A}_{t+1}, z_{i,t+1}, K^o_{i,t+1}, K^l_{i,t+1}\right)$ to denote the entrepreneur i's equilibrium profit at time $t+1$, where $\bar{A}_{t+1}$ is aggregate productivity in period $t+1$ and $z_{i,t+1}$ is the entrepreneur i's idiosyncratic productivity shock at time $t+1$. From time t to $t+1$, the productivity of entrepreneur i evolves according to the law of motion

$$z_{i,t+1} = z_{i,t} e^{\mu+\sigma\varepsilon_{i,t+1}}, \tag{3}$$

where $\varepsilon_{i,t+1}$ is a Gaussian shock assumed to be i.i.d. across agents i and over time.

In each period, after production, the entrepreneur experiences a liquidation shock with probability λ, upon which he loses his idea and needs to liquidate his net worth to return it back to the household.[9] If the liquidation shock happens, the entrepreneur restarts with a draw of a new idea with an initial productivity $\bar{z}$ and an initial net worth χN_t in period $t+1$, where N_t is the total (average) net worth of the economy in period t, and χ is a parameter that determines the ratio of the initial net worth of entrepreneurs relative to that of the economy-wide average. Conditioning on not receiving a liquidation shock, the net worth $N_{i,t+1}$ of entrepreneur i at time $t+1$ evolves as

$$N_{i,t+1} = \pi\left(\bar{A}_{t+1}, z_{i,t+1}, K^o_{i,t+1}, K^l_{i,t+1}\right) + (1-\delta)\, q_{K,t+1} K^o_{i,t+1} - R_{f,t+1} B_{i,t}. \tag{4}$$

The interpretation is that the entrepreneur receives $\pi\left(\bar{A}_{t+1}, z_{i,t+1}, K^o_{i,t+1}, K^l_{i,t+1}\right)$ from production. His capital holdings depreciate at a rate δ, and he needs to pay back the debt borrowed last period plus an interest, amounting to $R_{f,t+1}B_{i,t}$. Note that at time $t+1$, the entrepreneur can only receive the resale value of purchased capital after depreciation, but not that of the leased capital, which is actually owned and claimed by the lessor.

Because whenever a liquidity shock realizes, entrepreneurs submit their net worth to the household who chooses consumption collectively for all members, they value their net worth using the same pricing kernel as the household. Let $V^i_t\left(N_{i,t}\right)$ denote the value function of entrepreneur i. It must satisfy the following Bellman equation

$$V^i_t\left(N_{i,t}\right) = \max_{K^o_{i,t+1}, K^l_{i,t+1}, N_{i,t+1}, B_{i,t}} E_t\left[M_{t+1}\{(1-\lambda)N_{i,t+1} + \lambda V^i_{t+1}\left(N_{i,t+1}\right)\}\right], \tag{5}$$

subject to the budget constraint (1), the collateral constraint (2), and the law of motion of $N_{i,t+1}$ given by (4).

We suppress the i subscript to denote economy-wide aggregate quantities. The aggregate net worth in the entrepreneurial sector satisfies

$$N_{t+1} = (1-\lambda)\left[\pi\left(\bar{A}_{t+1}, K^o_{t+1}, K^l_{t+1}\right) + (1-\delta)\, q_{K,t+1} K^o_{t+1} - R_{f,t+1} B_t\right] + \lambda \chi N_t, \tag{6}$$

where $\pi\left(\bar{A}_{t+1}, K^o_{t+1}, K^l_{t+1}\right)$ denotes the aggregate profit of all entrepreneurs.

[9]This assumption effectively makes entrepreneurs less patient than the household and prevents them from saving their way out of the financial constraint.

3.3 Production

Final Output With $z_{i,t}$ denoting the idiosyncratic productivity for firm i at time t, the output $y_{i,t}$ of firm i at time t is assumed to be generated through the following production technology

$$y_{i,t} = \bar{A}_t \left[z_{i,t}^{1-\nu} \left(K_{i,t}^o + K_{i,t}^l \right)^\nu \right]^\alpha L_{i,t}^{1-\alpha}. \tag{7}$$

In our formulation, α is capital share, and ν is the span of control parameter as in Atkeson and Kehoe (2005). Note that purchased capital and leased capital are perfect substitutes in production.

Firm i's profit at time t, $\pi\left(\bar{A}_t, z_{i,t}, K_{i,t}^o, K_{i,t}^l\right)$ is given as

$$\begin{aligned} \pi\left(\bar{A}_t, z_{i,t}, K_{i,t}^o, K_{i,t}^l\right) &= \max_{L_{i,t}} y_{i,t} - W_t L_{i,t}, \\ &= \max_{L_{i,t}} \bar{A}_t \left[z_{i,t}^{1-\nu} \left(K_{i,t}^o + K_{i,t}^l \right)^\nu \right]^\alpha L_{i,t}^{1-\alpha} - W_t L_{i,t}, \end{aligned} \tag{8}$$

where W_t is the equilibrium wage rate, and $L_{i,t}$ is the amount of labor hired by entrepreneur i at time t.

It is convenient to write the profit function explicitly by maximizing out labor in equation (8) and using the labor market clearing condition $\int L_{i,t} di = 1$ to get

$$L_{i,t} = \frac{z_{i,t}^{1-\nu} \left(K_{i,t}^o + K_{i,t}^l \right)^\nu}{\int z_{i,t}^{1-\nu} \left(K_{i,t}^o + K_{i,t}^l \right)^\nu di}, \tag{9}$$

and

$$\pi\left(\bar{A}_t, z_{i,t}, K_{i,t}^o, K_{i,t}^l\right) = \alpha \bar{A}_t z_{i,t}^{1-\nu} \left(K_{i,t}^o + K_{i,t}^l \right)^{1-\nu} \left[\int z_{i,t}^{1-\nu} \left(K_{i,t}^o + K_{i,t}^l \right)^\nu di \right]^{\alpha-1}. \tag{10}$$

Given the output of firm i, $y_{i,t} = \bar{A}_t \left[z_{i,t}^{1-\nu} \left(K_{i,t}^o + K_{i,t}^l \right)^\nu \right]^\alpha L_{i,t}^{1-\alpha}$, the total output in the economy is the aggregation of individual output across firms and denoted as

$$\begin{aligned} Y_t &= \int y_{i,t} di, \\ &= \bar{A}_t \left[\int z_{i,t}^{1-\nu} \left(K_{i,t}^o + K_{i,t}^l \right)^\nu di \right]^\alpha. \end{aligned} \tag{11}$$

Capital Goods We assume that capital goods are produced from a constant-return-to-scale and convex adjustment cost function $G(I, K)$. Namely, one unit of the investment good costs $G(I, K)$ units of consumption goods. Without loss of generality, we impose the functional form of $G(I_t, K_t) = g\left(\frac{I_t}{K_t}\right) K_t$, and a quadratic function $g\left(\frac{I_t}{K_t}\right) = \frac{I_t}{K_t} + \frac{\zeta}{2}\left(\frac{I_t}{K_t} - \frac{I_{ss}}{K_{ss}}\right)^2$,where X_{ss} denotes the steady state value for $X = I, K$.

The aggregate capital stock of the economy satisfies

$$\begin{aligned} K_{t+1} &= (1-\delta) K_t + I_t, \\ K_t &= K_t^o + K_t^l. \end{aligned}$$

Capital Lessor A competitive lessor maximizes profits taking the equilibrium leasing fee τ_l and capital price q_K as given. To provide an amount of capital K_{t+1}^l to the entrepreneur as the lessee, the lessor needs to purchase the capital K_{t+1}^l at the price $q_{K,t}$ at time t. Since there is no deadweight cost when the lessor repossesses the capital, we can assume that all leased capital is repossessed without loss of generality and the lessor will be able to sell the amount of capital $K_{t+1}^l(1-\delta)$ at a price of $q_{K,t+1}$ at the end of the next period, $t+1$. We further assume the lessor needs to pay the monitoring cost $q_{K,t} H\left(K_{t+1}^l, K_{t+1}\right)$ upfront at time t to make sure the lessee takes good care of leased capital K_{t+1}^l in period $t+1$. This is consistent with the agency problem due to the separation of ownership and control rights, which goes back to at least Alchian and Demsetz (1972), and is highlighted in Eisfeldt and Rampini (2009) and Rampini and Viswanathan (2013).

Discounting future cash flows over the lessor's entire life time, the lessor's optimization problem is characterized as follows:

$$\max_{\{K_{j+1}^l\}_{j=t}^{\infty}} E_t \sum_{j=t}^{\infty} M_{t,j} \left(\tau_{l,j} K_{j+1}^l - q_{K,j} K_{j+1}^l - q_{K,j} H\left(K_{t+j}^l, K_{t+j}\right) + E_j \left\{M_{j,j+1} q_{K,j+1} K_{j+1}^l \left[1-\delta\right]\right\}\right). \tag{12}$$

We assume a convex monitoring cost function $H\left(K^l, K\right)$, and without loss of generality, we impose the functional form of $H\left(K^l, K\right) = h\left(\frac{K^l}{K}\right) K$ and a quadratic function $h\left(\frac{K^l}{K}\right) = \frac{d}{2}\left(\frac{K^l}{K}\right)^2$ [10]. We clearly see $h'(\cdot) > 0$ and $h''(\cdot) > 0$. The convexity means that the effective monitoring cost not only increases but also increases with a higher speed with respect to the leased capital ratio, $\frac{K^l}{K}$.

[10] In the quantitative analysis, we calculate parameter d to match the volatility of a relatively smooth leased capital ratio at the aggregate level.

The first order conditions implies:

$$\begin{aligned}\tau_{l,t} &= q_{K,t} + q_{K,t} H'\left(K_{t+1}^{l}, K_{t+1}\right) - \{1-\delta\} E_t\left[M_{t,t+1} q_{K,t+1}\right], \\ &= q_{K,t}\left[1 + h'\left(\frac{K_{t+1}^{l}}{K_{t+1}}\right)\right] - \{1-\delta\}\left\{\frac{1}{R_{f,t}} E_t\left[q_{K,t+1}\right] - Cov_t\left(M_{t,t+1}, q_{K,t+1}\right)\right\},\end{aligned}$$

The leasing fee per unit of capital, or the user cost of leasing, is equal to the current price, $q_{K,t}$, and the marginal monitoring cost $q_{K,t} h'\left(\frac{K_{t+1}^{l}}{K_{t+1}}\right)$, minus the discounted resale value after discount, $\left\{1-\delta\left(\frac{K_{t+1}^{l}}{K_{t+1}}\right)\right\} E_t\left[M_{t,t+1} q_{K,t+1}\right]$. As illustrated further, the discounted resale value is decomposed into the risk-free discount value, $\frac{1}{R_{f,t}} E_t\left[q_{K,t+1}\right]$, and the risk adjustment, $-Cov_t\left(M_{t,t+1}, q_{K,t+1}\right) > 0$. Combined with the agency cost argument due to the separation of ownership and control rights, the cost of leasing is expensive and driven by two sources. First, it embodies an additional monitoring cost. Second, the lessor charges a risk premium for bearing the risk of asset price fluctuations.

Putting all sectors together, the economy-wide resource constraint is:

$$C_t + I_t + G\left(I_t, K_t\right) + H(K_{t+1}^{l}, K_{t+1}) = Y_t. \tag{13}$$

where the total output of the economy, Y_t, is used for consumption C_t, investment I_t, and capital adjustment cost $G\left(I_t, K_t\right)$ and the monitoring cost $H(K_{t+1}^{l}, K_{t+1})$ on the leasing market.

4 Equilibrium Asset Pricing

4.1 Aggregation

Our economy is one with both aggregate productivity and financial shocks, as well as idiosyncratic productivity shocks. The standard solution to a heterogenous-agent model is to track the joint distribution of capital and net worth as an infinite-dimensional state variable in order to characterize the equilibrium recursively. In this section, we present an aggregation result and show that the aggregate quantities and prices of our model can be characterized without any reference to distributions. Given aggregate quantities and prices, quantities and shadow prices at the individual firm level can be constructed under equilibrium conditions.

Distribution of Idiosyncratic Productivity In our model, the law of motion of idiosyncratic productivity shocks, $z_{i,t+1} = z_{i,t} e^{\mu+\sigma\varepsilon_{i,t+1}}$, is time invariant, implying that the cross-sectional distribution of the $z_{i,t}$ will eventually converge to a stationary distribution.[11] At the macro level, the heterogeneity of idiosyncratic productivity can be conveniently summarized by a simple statistic: $Z(t) = \int z_{i,t} di$. It is useful to compute this integral explicitly.

Given the law of motion of $z_{i,t}$, we have:

$$Z_{t+1} = (1-\lambda) \int z_{i,t} e^{\varepsilon_{i,t+1}} di + \lambda \bar{z}$$

The interpretation is that only a fraction $(1-\lambda)$ of entrepreneurs will survive until the next period, while a fraction λ of entrepreneurs will restart with productivity of $\bar{z}$. Note that based on the assumption that $\varepsilon_{i,t+1}$ is independent of $z_{i,t}$, therefore, we can integrate out $\varepsilon_{i,t+1}$ first and write the above equation as

$$\begin{aligned} Z_{t+1} &= (1-\lambda) \int z_{i,t} E\left[e^{\varepsilon_{i,t+1}}\right] di \; + \lambda \bar{z}, \\ &= (1-\lambda) Z_t e^{\mu + \frac{1}{2}\sigma^2} + \lambda \bar{z}, \end{aligned}$$

where the last line exploits the property of the log-normal distribution. It is straightforward to see that if we choose the normalization $\bar{z} = \frac{1}{\lambda}\left[1 - (1-\lambda) e^{\mu+\frac{1}{2}\sigma^2}\right]$ and start the economy at $Z_0 = 1$, then $Z_t = 1$ for all t. This will be the assumption we maintain for the rest of the paper.

Firm Profit We assume that $\varepsilon_{i,t+1}$ is observed at the end of period t when the entrepreneurs plan for the next period capital. This implies that entrepreneur will choose $K^o_{i,t+t} + K^l_{i,t+1}$ to be proportional to $z_{i,t+1}$. Because $\int z_{i,t+1} di = 1$, we must have

$$K^o_{i,t+t} + K^l_{i,t+1} = z_{i,t+1}\left(K^o_{t+1} + K^l_{t+1}\right), \tag{14}$$

where K^o_{t+1} and K^l_{t+1} are aggregate quantities.

The assumption that capital is chosen after $z_{i,t+1}$ is observed implies that total output does not depend on the joint distribution of idiosyncratic productivity and capital. Therefore, we can write $Y_t = \bar{A}_t \left(K^o_{t+1} + K^l_{t+1}\right)^\alpha \int z_{i,t} di = \bar{A}_t \left(K^o_{t+1} + K^l_{t+1}\right)^\alpha$. In addition, the profit at the firm level is proportional to productivity, i.e.,

$$\pi\left(\bar{A}_t, z_{i,t}, K^o_{i,t}, K^l_{i,t}\right) = \alpha \bar{A}_t z_{i,t}\left(K^o_t + K^l_t\right)^\alpha,$$

[11]In fact, the stationary distribution of $z_{i,t}$ is a double-sided Pareto distribution. Our model is therefore consistent with the empirical evidence of the power law distribution of firm size.

and the marginal products of capital are equalized across firms and between the two types of capital

$$\frac{\partial}{\partial K_{i,t}^{o}}\Pi\left(\bar{A}_t, z_{i,t}, K_{i,t}^{o}, K_{i,t}^{l}\right) = \frac{\partial}{\partial K_{i,t}^{l}}\Pi\left(\bar{A}_t, z_{i,t}, K_{i,t}^{o}, K_{i,t}^{l}\right) = \alpha \bar{A}_t \left(K_t^{o} + K_t^{l}\right)^{\alpha\nu-1}. \tag{15}$$

Intertemporal Optimality Having simplified the profit functions, we can derive the optimality conditions for the entrepreneur's maximization problem in equation (5). Note that given equilibrium prices, the objective function and the constraints are linear in net worth. Therefore, the value function V_t^i must be linear as well. We conjecture and verify that $V_t^i\left(N_{i,t}\right) = \mu_t^i N_{i,t}$, where μ_t^i can be interpreted as the marginal value of net worth for entrepreneur i. Furthermore, let η_t^i be the Lagrangian multiplier of the collateral constraint in equation (2). The first order condition with respect to $B_{i,t}$ implies

$$\mu_t^i = E_t\left[\widetilde{M}_{t+1}^i\right] R_{t+1}^f + \eta_t^i, \tag{16}$$

where we use the notation:

$$\widetilde{M}_{t+1}^i = M_{t+1}[(1-\lambda)\,\mu_{t+1}^i + \lambda]. \tag{17}$$

The interpretation is that one unit of net worth allows the entrepreneur to reduce one unit of borrowing, the present value of which is $E_t\left[\widetilde{M}_{t+1}^i\right] R_{t+1}^f$, and relaxes the collateral constraint, the benefit of which is measured by η_t^i.

Similarly, the first order condition for $K_{i,t+1}^p$ is

$$\mu_t^i = E_t\left[\widetilde{M}_{t+1}^i \frac{\Pi_{K^o}\left(\bar{A}_{t+1}, z_{i,t+1}, K_{i,t+1}^{o}, K_{i,t+1}^{l}\right) + (1-\delta)\, q_{K,t+1}}{q_{K,t}}\right] + \theta\eta_t^i. \tag{18}$$

An additional unit of purchased capital allows the entrepreneur to purchase $\frac{1}{q_{K,t}}$ units of capital, which generates a profit of $\frac{\partial\pi}{\partial K^p}\left(\bar{A}_{t+1}, z_{i,t+1}, K_{i,t+1}^{o}, K_{i,t+1}^{l}\right)$ over the next period before it depreciates at rate δ_K. In addition, a fraction θ of purchased capital can be used as the collateral to relax the borrowing constraint.

Finally, optimality with respect to the choice of leased capital implies

$$\mu_t^i \tau_{l,t} = E_t\left[\widetilde{M}_{t+1}^i \Pi_{K^l}\left(\bar{A}_{t+1}, z_{i,t+1}, K_{i,t+1}^{o}, K_{i,t+1}^{l}\right)\right]. \tag{19}$$

An additional unit of leased capital costs $\tau_{l,t}$ units of net worth as the leasing fee that needs to be paid upfront, and it generates a profit of $\frac{\partial\pi}{\partial K^o}\left(\bar{A}_{t+1}, z_{i,t+1}, K_{i,t+1}^{o}, K_{i,t+1}^{l}\right)$ over the next period. Unlike that of purchased capital, the resale value of leased capital after depreciation goes to the lessor, the owner for the asset.

Recursive Construction of the Equilibrium Note that in our model, firms differ in their net worth. First, the net worth depends on the entire history of idiosyncratic productivity shocks, as can be seen from equation (4), since, due to (3), $z_{i,t+1}$ depends on $z_{i,t}$, which in turn depends on $z_{i,t-1}$ etc. Furthermore, the net worth also depends on the need for capital which relies on the realization of next period's productivity shock. Therefore, in general, the marginal benefit of net worth, μ_t^i, and the tightness of the collateral constraint, η_t^i, depend on the individual firm's entire history. Below we show that despite the heterogeneity in net worth and capital holdings across firms, our model allows an equilibrium in which μ_t^i and η_t^i are equalized across firms, and aggregate quantities can be determined independently of the distribution of net worth and capital.

Remember we assume that owned and leased capitals are perfect substitutes and that the idiosyncratic shock $z_{i,t+1}$ is observed before the decisions on $K_{i,t+1}^o$ and $K_{i,t+1}^l$ are made. These two assumptions imply that the marginal product of both types of capital are equalized within and across firms, as shown in equation (15). As a result, equations (16) to (19) permit solutions where μ_t^i and η_t^i are not firm-specific. Intuitively, because the marginal product of capital depends only on the sum of $K_{i,t+1}^o$ and $K_{i,t+1}^l$, but not on the individual summands, entrepreneurs will choose the total amount of capital to equalize its marginal product across firms. This is also because $z_{i,t+1}$ is observed at the end of period t. Depending on his borrowing need, an entrepreneur can then determine $K_{i,t+1}^o$ to satisfy the collateral constraint. Because capital can be purchased on a competitive market, entrepreneurs will choose $K_{i,t+1}^o$ to equalize its price to its marginal benefit, which includes the marginal product of capital and the Lagrangian multiplier η_t^i. Because both the prices and the marginal product of capital are equalized across firms, so is the tightness of the collateral constraint.

We formalize the above observation by providing a recursive characterization of the equilibrium. We make one final assumption, namely, that the aggregate productivity is given by $\bar{A}_t = A_t {K_t}^{1-\nu\alpha}$, where $\{A_t\}_{t=0}^{\infty}$ is an exogenous Markov productivity process. On one hand, this assumption follows Frankel (1962) and Romer (1986) and is a parsimonious way to generate an endogenous growth. On the other hand, combined with recursive preferences, this assumption increases the volatility of the pricing kernel, as in the stream of long-run risk model (see, e.g., Bansal and Yaron (2004) and Kung and Schmid (2015)). From a technical point of view, thanks to this assumption, equilibrium quantities are homogenous of degree one in the total capital stock, K, and equilibrium prices do not depend on K. It is therefore convenient to work with normalized quantities. Let lower case variables denote aggregate quantities normalized by the current capital stock, so that, for instance, n_t denotes aggregate net worth N_t normalized by the total capital stock K_t. The equilibrium objects are consumption, $c(s,n)$, investment, $i(s,n)$, the marginal value of net worth, $\mu(s,n)$, the Lagrangian multiplier on the collateral constraint, $\eta(s,n)$, the price of purchased capital, $q_K(s,n)$, the leasing fee per unit of capital, $\tau_l(s,n)$, and the risk-free interest rate, $R_f(s,n)$ as functions of the state variables s and n. Here we use s to denote a vector of exogenous state variables. In the simple case where the economy only has one source of exogenous shock – the aggregate productivity shock, then $s = \{A\}$.

To introduce the recursive formulation, we denote a generic variable in period t as X and in period $t+1$ as X'. Given the above equilibrium functionals, we can define

$$\Gamma(s,n) = \frac{K'}{K} = (1-\delta) + i(s,n),$$

as the growth rate of the aggregate capital stock, and define the normalized owned and leased capital as

$$k^o(s,n) = \frac{(K^o)'}{K'}, k^l(s,n) = \frac{\left(K^l\right)'}{K'},$$

respectively. Furthermore, we construct the law of motion of the endogenous state variable n from equation (6):

$$n' = (1-\lambda)\left[\begin{array}{c} \alpha A' + (1-\delta) q_K(s',n')\left[1-k^l(s,n)\right] \\ -\theta q_K(s,n)\left[1-k^l(s,n)\right] R_f(s,n) \end{array}\right] + \lambda\chi\frac{n}{\Gamma(s,n)}. \tag{20}$$

Following the law of motion of the state variables, we can construct the normalized utility of the household as the fixed point of:

$$u(s,n) = \left\{(1-\beta)c(s,n)^{1-\frac{1}{\psi}} + \beta\Gamma(s,n)^{1-\frac{1}{\psi}}\left(E[u(s',n')^{1-\gamma}]\right)^{\frac{1-\frac{1}{\psi}}{1-\gamma}}\right\}^{\frac{1}{1-\frac{1}{\psi}}}.$$

The stochastic discount factors can then be written as:

$$\begin{aligned} M' &= \beta\left[\frac{c(A',n')\Gamma(A,n)}{c(A,n)}\right]^{-\frac{1}{\psi}}\left[\frac{u(A',n')}{E\left[u(A',n')^{1-\gamma}\right]^{\frac{1}{1-\gamma}}}\right]^{\frac{1}{\psi}-\gamma}, & (21) \\ \widetilde{M}' &= M'[(1-\lambda)\mu(A',n') + \lambda]. & (22) \end{aligned}$$

Formally, an equilibrium in our model consists of a set of aggregate quantities, $\left\{C_t, B_t, \Pi_t, K_t^o, K_t^l, I_t, N_t\right\}$, individual entrepreneur choices, $\left\{K_{i,t}^{o}, K_{i,t}^{l}, L_{i,t}, B_{i,t}, N_{i,t}\right\}$, and prices $\left\{M_t, \widetilde{M}_t, W_t, q_{K,t}, \tau_{l,t}, \mu_t, \eta_t, R_{f,t}\right\}$ such that, given prices, quantities satisfy the household's and the entrepreneurs' optimality conditions, the market clearing conditions, and the relevant resource constraints. Below, we present a procedure to construct a Markov equilibrium where all prices and quantities are functions of the state variables (s, n). We assume that the initial idiosyncratic productivity across all firms satisfies $\int z_{i,1} di = 1$, the initial aggregate net worth is N_0, and firm's initial net worth satisfies

$$n_{i,0} = z_{i,1} N_0.$$

To save notation, we use x to denote a generic normalized quantity, and X to denote the corresponding non-normalized quantity. For example, c denotes normalized aggregate consumption, while C is the original value.

Proposition 1. *(Markov equilibrium)*

Suppose there exists a set of equilibrium functionals $\{c(s,n), i(s,n), k^o(s,n), k^l(s,n), \mu(s,n), \eta(s,n), q_K(s,n), \tau_l(s,n), R_f(s,n)\}$ *satisfying the following set of functional equations:*

$$E\left[M' \middle| s\right] R_f(s,n) = 1,$$

$$\mu(s,n) = E\left[\widetilde{M}' \middle| s\right] R_f(s,n) + \eta(s,n),$$

$$\mu(s,n) = E\left[\widetilde{M}' \frac{\alpha A' + (1-\delta) q_K(s',n')}{q_K(s,n)} \middle| s\right] + \theta \eta(s,n),$$

$$\tau_l(s,n) \mu(s,n) = E\left[\widetilde{M}' \alpha A' \middle| s\right],$$

$$\frac{n}{\Gamma(s,n)} = (1-\theta) q_K(s,n) \left[1 - k^l(s,n)\right] + \tau_l(s,n) k^l(s,n),$$

$$G'(i(s,n)) = q_K(s,n),$$

$$c(s,n) + i(s,n) + g(i(s,n)) + h\left(k^l(s,n)\right) \Gamma(s,n) = A,$$

$$\tau_l(s,n) = q_K(s,n) \left[1 + h'\left(k^l(s,n)\right)\right] - E\left[M' q_K(s',n')(1-\delta) \middle| s\right].$$

$$k^o(s,n) + k^l(s,n) = 1$$

where the law of motion of n is given by (20), and the stochastic discount factors M' and $\widetilde{M}'$ are defined in (21) and (22). Then the equilibrium prices and quantities can be constructed as follows:

1. *Given the sequence of exogenous shocks $\{s_t\}$, the sequence of n_t can be constructed using*

the law of motion in (20), the normalized policy functions are constructed as:

$$
\begin{aligned}
x_t &= x(s_t, n_t), \ \ for \ x = c, i, \mu, \eta, q_K, \tau_l, R_f, \\
k^l_{t+1} &= k^l(s_t, n_t), \\
k^o_{t+1} &= k^o(s_t, n_t).
\end{aligned}
$$

2. *Given the sequence of normalized quantities, aggregate quantities are constructed as:*

$$
\begin{aligned}
K_{t+1} &= K_t[1 - \delta + i_t] \\
X_t &= x_t K_t
\end{aligned}
$$

for $x = c, i, b, n, k^l, k^o$, $X = C, I, B, N, K^l, K^o$, *and all* t.

3. *Given the aggregate quantities, the individual entrepreneurs' net worth follows from (4). Given the sequences* $\{N_{i,t}\}$, *the quantities* $B_{i,t}, K^o_{i,t}$ *and* $K^l_{i,t}$ *are jointly determined by equations (1), (2), and (14). Finally,* $L_{i,t} = z_{i,t}$ *for all* i, t.

The above proposition says that we can solve for aggregate quantities first, and then use the firm-level budget constraint and the law of motion of idiosyncratic productivity in to construct the cross-section of net worth and capital holdings.

4.2 Asset Pricing Implications

As mentioned in Proposition 1, the aggregate quantities and prices do not depend on the joint distribution of individual entrepreneur level capital and net worth. In this section we first focus on the asset pricing implications of the model at the aggregate level.

Given the financially constrained firms with a binding collateral constraint, the minimum down payment per unit of purchased capital is: $q_{K,t}(1-\theta)$. The user cost of purchased capital, $\tau_{o,t}$ is determined as:

$$
\tau_{o,t} = q_{K,t}(1-\theta) - E_t\left[\widetilde{M}_{t+1}\left\{(1-\delta)\, q_{K,t+1} - R_{f,t+1}\theta q_{K,t}\right\}\right]. \tag{23}
$$

The interpretation is that the user cost of capital is equal to the minimum down payment per unit of capital paid upfront minus the present value of the fractional resale value next period that cannot be pledged. The similar interpretation applies to the user cost of leased capital, $\tau_{l,t}$, as we demonstrate in equation (12).

Now we define the returns on the purchased capital and leased capital respectively, and discuss their different risk profiles. The purchased capital delivers a levered return

$$\begin{aligned} R_{t+1}^{Lev} &= \frac{\alpha A_{t+1} + (1-\delta)\, q_{K,t+1} - R_{f,t+1}\theta q_{K,t}}{q_{K,t}\,(1-\theta)}, \\ &= \frac{1}{1-\theta}\,(R_{t+1} - R_{f,t+1}) + R_{f,t+1}. \end{aligned} \tag{24}$$

The denominator $q_{K,t}\,(1-\theta)$ denotes the amount of internal net worth required to buy one unit of capital, and it can be interpreted as the minimum down payment per unit of capital. The numerator $\alpha A_{t+1} + (1-\delta)\, q_{K,t+1} - R_{f,t+1}\theta q_{K,t}$ is tomorrow's payoff per unit of capital, after subtracting the debt repayment. Therefore, R_{t+1}^{Lev} is a levered return. In the second equality, we denote $R_{t+1} = \frac{\alpha A_{t+1}+(1-\delta)q_{K,t+1}}{q_{K,t}}$ as the un-levered return on owned capital. Clearly, the collateralizability implied leverage ratio is $\frac{1}{1-\theta}$.

On the other hand, the return on leased capital is

$$R_{t+1}^{l} = \frac{\alpha A_{t+1}}{\tau_{l,t}}, \tag{25}$$

in which $\tau_{l,t}$ is the per-period leasing fee that needs to pay upfront, and αA_{t+1} is the marginal product of capital by operating the capital for one period.

Undoubtedly, risk premiums are determined by the covariances of the payoffs with respect to the stochastic discount factor. Given that the components representing the marginal products of capital in the payoff are identical for the two types of capital, the key to understand the leased capital premium is that R_{t+1}^{Lev} contains the depreciated resale value of the purchased capital $(1-\delta)\, q_{K,t+1}$ that is exposed to aggregate shocks. However, R_{t+1}^{l} does not contain this additional exposure, since the lessor will repossess the capital at the end of the contract and bear the exposure. Or put it in another way, the lessee effectively obtains an insurance through an implicit future's contract from the lessor to hedge against the risk of capital price fluctuations. It is well known that most of return variations comes from the resale price $(1-\delta)\, q_{K,t+1}$ rather than the marginal product of capital component, hence, the fact that R_{t+1}^{l} does not expose to the resale price fluctuations in $(1-\delta)\, q_{K,t+1}$ makes it to be less covariated with the stochastic discount facter, and therefore, less risky than its counterparty R_{t+1}^{Lev}.

Combine the two Euler equations, (16) and (18), and eliminate η_t, we have

$$E_t\left[\widetilde{M}_{t+1} R_{t+1}^{Lev}\right] = \mu_t,$$

and the rearrangement in the equation (19) gives

$$E_t\left[\widetilde{M}_{t+1}R^l_{t+1}\right] = \mu_t.$$

Therefore, the expected return spread is equal to

$$E_t\left(R^{Lev}_{t+1} - R^l_{t+1}\right) = -\frac{1}{E_t\left(\widetilde{M}_{t+1}\right)}\left(Cov_t\left[\widetilde{M}_{t+1}, R^{Lev}_{t+1}\right] - Cov_t\left[\widetilde{M}_{t+1}, R^l_{t+1}\right]\right). \tag{26}$$

Undoubtedly, risk premiums are determined by the covariances of the payoffs with respect to the stochastic discount factor, as shown in equation (26). Given that the components representing the marginal products of capital in the payoff are identical for the two types of capital, the key to understand the leased capital premium is that R^{Lev}_{t+1} contains the depreciated resale value of the purchased capital $(1-\delta)\, q_{K,t+1}$ that is exposed to aggregate shocks. However, R^l_{t+1} does not contain this additional exposure, since the lessor will repossess the capital at the end of the contract and bear the exposure.

As argued above, R^{Lev}_{t+1} is more procyclical than R^l_{t+1}, and therefore, R^{Lev}_{t+1} becomes more negatively correlated with the stochastic discount factor $\widetilde{M}_{t+1}$, for two reasons: first, R^{Lev}_{t+1} is more exposed to aggregate shocks through resale value of the purchased capital $(1-\delta)\, q_{K,t+1}$; second, R^{Lev}_{t+1} is levered up with a factor of $\frac{1}{1-\theta}$, as shown in equation (24). Overall, the right hand side of equation (26) is positive, that is, the owned capital earn a higher expected return than the leased capital, or equivalently, there is a negative leased capital premium at the aggregate level.

5 Quantitative Model Predictions

In this section, we calibrate our model at the annual frequency and evaluate its ability to replicate key moments of both macroeconomic quantities and asset prices at the aggregate level. More importantly, we investigate its performance in terms of quantitatively accounting for key features of firm characteristics and producing a leased capital premium in the cross-section. For macroeconomic quantities, we focus on a long sample of U.S. annual data from 1930 to 2016. All macroeconomic variables are real and per capita. Consumption, output and physical investment data are from the Bureau of Economic Analysis (BEA). In order to obtain the time series of total amount of leased capital, we firstly aggregate the total amount of the leased capital across all U.S. Compustat firms for each year. The aggregate leased capital ratio is the time series of the aggregate leased capital divided by the sum of (owned) physical capital and leased capital. For the purpose of cross-sectional analyses we make use of several data sources at the micro-level, which is summarized in Appendix B.

5.1 Specification of Aggregate Shocks

In this section, we formalize the specification of the exogenous aggregate shocks in this economy. First, log aggregate productivity $a \equiv \log(A)$ follows

$$a_t = a_{ss}(1-\rho_A) + \rho_A a_{t-1} + \sigma_A \varepsilon_{A,t}, \tag{27}$$

where a_{ss} denotes the steady-state value of a. Second, as in Ai, Li, and Yang (2017b), we also introduce a aggregate shock to entrepreneurs' liquidation probability λ. We interpret it as a shock originating directly from the financial sector, in a spirit similar to Jermann and Quadrini (2012). We introduce this extra source of shocks mainly to improves the quantitative performance of the model. As in all standard real business cycle models, with just an aggregate productivity shock, it is hard to generate large enough variations in capital prices and the entrepreneurs' net worth so that they become consistent with the data.

Importantly, however, our general model intuition that leased capital is less risky than owned capital holds for both productivity and financial shocks. The shock to the entrepreneurs' liquidation probability directly affects the entrepreneurs' discount rate, as can be seen from (22), and thus allows to generate stronger asset pricing implications.[12]

Note that technically $\lambda \in (0,1)$. For parsimony, we set

$$\lambda_t = \frac{\exp(x_t)}{\exp(x_t) + \exp(-x_t)},$$

and x_t itself follows and autocorrelated process:

$$x_t = x_{ss}(1-\rho_x) + \rho_x x_{t-1} + \sigma_x \varepsilon_{x,t}.$$

We assume the innovations:

$$\begin{bmatrix} \varepsilon_{A,t+1} \\ \varepsilon_{x,t+1} \end{bmatrix} \sim Normal\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 1 & \rho_{A,x} \\ \rho_{A,x} & 1 \end{bmatrix} \right),$$

in which the parameter $\rho_{A,x}$ captures the correlation between these two shocks. In the

[12] Macro models with financial frictions, for instance, Gertler and Kiyotaki (2010) and Elenev et al. (2017), use a similar device for the same reason.

benchmark calibration, we assume the correlation coefficient $\rho_{A,x} = -1$. First, a negative correlation indicates that a negative productivity shock is associated with a positive discount rate shock. This assumption is necessary to quantitatively generate a positive correlation between consumption and investment growth that is consistent with the data. If only the financial shock innovation, $\varepsilon_{x,t+1}$, is open, such an innovation will not affect the contemporaneous output. The resource constraint in equation (13) implies a contractually negative correlation between consumption and investment growth. Second, the assumption of a perfectly negative correlation is for parsimony and enables the economy to effectively narrow down to one shock.

5.2 Calibration

We calibrate our model at the annual frequency. Table 3 reports the list of parameters and the corresponding macroeconomic moments in our calibration procedure. We group our parameters into four blocks. In the first block, we list the parameters which can be determined by the previous literature. In particular, we set the relative risk aversion γ to be 10 and the intertemporal elasticity of substitution ψ to be 2. These are parameter values in line with the long-run risks literature, e.g., Bansal and Yaron (2004). The capital share parameter, α, is set to be 0.26, close to the number used in the standard RBC literature. The span of control parameter ν is set to be 0.85, consistent with Atkeson and Kehoe (2005).

The parameters in the second block are determined by matching a set of first moments of quantities and prices to their empirical counterparts. We set the average economy-wide productivity growth rate $E(A_{ss})$ to match a mean growth rate of U.S. economy of 2% per year. The time discount factor β is set to match the average real risk free rate of 1% per year. The capital depreciation rate for the purchased capital is set to match a 10% annual capital depreciation rate in the data. The average depreciation rate, $\overline{\delta}_l$, is set to be 0.13, to match the average leased capital ratio for financially constrained firm group. The average entrepreneur exit probability $E(\lambda)$ is calibrated to be 0.12, roughly matching to an average Compustat age of 8.5 years for financially constrained firms. We calibrate the remaining two parameters related to financial frictions, namely, the collateralizability parameter, θ, and the transfer to entering entrepreneurs, χ, by jointly matching two moments. The average lease adjusted leverage ratio is 0.31 and the average consumption to investment ratio $E(C/I)$ is 4. The targeted leverage ratio is broadly in line with the median of U.S. non-financial firms in Compustat.

The parameters in the third block are not directly related to the first moment of the econ-

Table 3: **Calibration**

We calibrate the model at the monthly frequency. This table reports the parameter values and the corresponding moments (annalized) we used in the calibration procedure.

Parameter	Symbol	Value	Target/Source	Moments (Annual)
Relative risk aversion	γ	10	Bansal and Yaron (2004)	-
IES	ψ	2	Bansal and Yaron (2004)	-
Capital share	α	0.26	RBC Literature	-
Span of control parameter	ν	0.85	Atkeson and Kehoe (2005)	-
Mean productivity growth rate	$E(\tilde{A})$	0.68	Mean GDP growth rate	2%
Time discount factor	β	0.98	Avg. risk-free rate	1%
Purchased capital dep. rate	δ	0.1	Annual capital depreciation	10%
Leased capital dep. rate	$\bar{\delta}_l$	0.13	Avg. leased capital ratio	0.53
Death rate of entrepreneurs	$E(\lambda)$	0.12	Avg. age of constrained firm	8.5
Collateralizability parameter	θ	0.42	Avg. lease adj. leverage	0.31
Transfer to entering entrepreneurs	χ	0.38	Avg. C/I ratio	4
Persistence of TFP shock	ρ_A	0.96	Autocorrelation of cons. growth	0.46
Persistence of λ shock	ρ_x	0.96	Autocorrelation of GDP growth	0.49
Vol. of λ shock	σ_x	0.13	Volatility of cons. growth	2.80%
Vol. of productivity shock	σ_A	0.025	Corr. of cons. and inv. growth	39%
Inv. adj. cost parameter	ζ	15	Vol. of investment growth	10%
Dep. rate δ_l parameter	d	4	Vol. of leased capital ratio	3.30%
Mean idio. productivity growth	μ_Z	0.02	Mean idio. productivity growth	2%
Vol. of idio. productivity growth	σ_Z	0.05	Vol. of idio. productivity growth	5%

omy, but they are determined by the second moments in the data. The persistence parameter ρ_A and ρ_x are calibrated to be the same at 0.96, roughly matching the autocorrelation of consumption and output growth. The standard deviation of the λ shock, σ_x, and that of the productivity shock, σ_A, are jointly calibrated to match the volatility of consumption growth and the correlation between consumption and investment growth. The elasticity parameter of the investment adjustment cost functions, ζ, is set to allow our model to achieve a sufficiently high volatility of investment, in line with the data. And the parameter for the effective leased capital depreciation rate, d, is calibrated to match the time series volatility of the median leased capital ratio in financially constrained firm group in our sample.

The last block contains the parameters related to idiosyncratic productivity shocks. We calibrate them to match the mean and standard deviation of the idiosyncratic productivity growth of financially constrained firms in the U.S. Compustat database.

5.3 Numerical Solution and Simulation

As we shown in Section 2.1, financially constrained firm use more lease, and the leased capital premium is mainly driven by financially constrained firms. Therefore, we intensionally calibrate our model parameters and thus render the collateral constraint to be binding at the steady state. As a result, our model implications mainly focus on financially constrained firms. This feature of the calibration also simplifies our computation. To be specific, we follow the prior macroeconomic literature, for instance, Gertler and Kiyotaki (2010), to assume the constraint is binding over the narrow region around the steady state. Thus, the local approximation solution method is a good approximation. We solve the model using a second-order local approximation around the risky steady state, and the solution is computed by using the `Dynare++` package.

We report the model simulated moments in the aggregate and the cross-section, and compare them to the data. We simulate the model at the annual frequency. Each simulation has a length of 60 years. We drop the first 10 years of each simulation to avoid dependence on initial values and repeat the process 100 times. At the cross-sectional level, each simulation contains 5,000 firms.

5.4 Aggregate Moments

In this section, we focus on the quantitative performance of the model at the aggregate level and document the success of our model to match a wide set of conventional moments in macroeconomic quantities and asset prices. More importantly, our model delivers a sizable leased capital spread at the aggregate level.

Table 4 reports the key moments of macroeconomic quantities (top panel) and those of asset returns (bottom panel), respectively, and compares them to their counterparts in the data where available. The top panel shows that the model simulated data are broadly consistent with the basic features of the aggregate macro-economy in terms of volatilities, correlations, and persistence of output, consumption, and investment. Moreover, our model also matches well to the mean and volatility of the leased capital ratio in the data. In sum, our model maintains the success of neoclassical growth models in accounting for the dynamics of macroeconomic quantities.

Table 4: **Model Simulations and Aggregate Moments**

This table presents the moments from the model simulation. The market return R_M corresponds to the return on entrepreneurs' net worth and embodies an endogenous financial leverage. R_K^L, R_H^L denotes the levered capital returns, by the average financial leverage in the economy. We simulate the economy at monthly frequency, then aggregate the monthly observations to annual frequency. The moments reported are based on the annual observations. Number in parenthesis are standard errors of the calculated moments.

Moments	**Data**	**Model**
$\sigma(\Delta y)$	3.05 (0.60)	3.32
$\sigma(\Delta c)$	2.53 (0.56)	2.88
$\sigma(\Delta i)$	10.30 (2.36)	6.15
$corr(\Delta c, \Delta i)$	0.39(0.29)	0.77
$AC1(\Delta c)$	0.49(0.15)	0.45
$E(K^l/K)$	0.53(0.01)	0.53
$\sigma(K^l/K)$	0.03(0.01)	0.03
$E[R_M - R_f]$	5.71 (2.25)	6.82
$\sigma(R_M - R_f)$	20.89 (2.21)	16.04
$E[R_f]$	1.10 (0.16)	1.15
$\sigma(R_f)$	0.97 (0.31)	0.80
$E[R^{Lev} - R_f]$		11.80
$E[R^l - R_f]$		2.52
$E[R^{Lev} - R^l]$		9.28

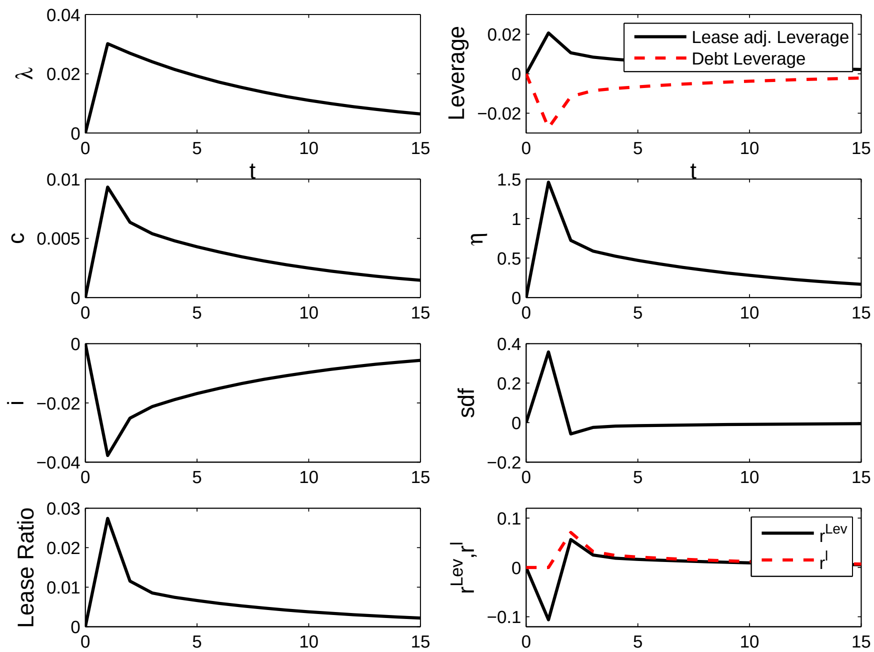
Focusing on the asset pricing moments (bottom panel), we make two observations. First, our model is reasonably successful in generating asset pricing moments at the aggregate level. In particular, it replicates a low and smooth risk free rate, with a mean of 0.82% and a volatility of 1.05%. The equity premium in this economy is 6.82%, broadly consistent with the empirical target of 5.7% in the data. Second and more importantly, our model is also able to generate a sizable average return spread between levered return on purchased capital and return on leasing, $E[R^{Lev} - R^l]$, of around 9.28%.

5.5 Impulse Response Functions

The asset pricing implications of our model are best illustrated with impulse response functions.

Figure 1: **Impulse Responses to the Financial shock**

This figure plots the log-deviations from the steady state for quantities and prices with respect to a one-standard deviation shock to the λ. One period is a year. All parameters are calibrated as in Table 3.



In Figure 1, we plot the percentage deviations of quantities and prices from the steady state in response to a one-standard deviation financial shock, i.e. the shock to λ. The used parameters are corresponding to Table 3. The only one exception in the above figure is that the financial shock, ε_x, is orthogonal to the productivity shock, ε_A. In the other words, $\rho_{A,x} = 0$. Our motivation to shut down the correlation is to highlight the separate effect from a purely financial shock and we also want to point out the major departure of the model with an orthogonal financial shock from the benchmark model with correlated shocks.

Four observations are summarized as follows. First, a positive shock to λ (first panel in the left column) works as a positive discount rate shock to entrepreneurs, and the shock leads to a tightening of the collateral constraint as reflected by a spike in the Lagrangian multiplier, η (second panel in the right column).

Second, a tightening of the collateral constraints translate into a lower investment (third panel in the left column). However, a financial shock does not affect contemporaneous period output, according to the resource constraint equation (13), consumption responds oppositely to investment (second panel in the left column). The outcome presents a counterfactually negative correlation between consumption and investment, as the main departure of an single orthogonal financial shock. To solve the negative correlation problem, in our benchmark calibration, we calibrate a negative correlation between the productivity shock and financial shock, i.e. $\rho_{A,x} = -1$. A positive financial shock is perfectly associated with a negative productivity shock, which directly affect the current period output on impact. In the end, the negative correlation between two shocks delivers a positive correlation between consumption and investment.

Third, as the collateral constraint tightened, the leased capital ratio increases (fourth panel in the left column). Although the debt leverage ratio reduces, the increase in the leased capital gives rise to an increase in the lease adjusted leverage ratio (first panel in the right column). This observation is consistent with the empirical evidence that leasing is an important external financing channel, in particular, for financially constrained firms to further relax their debt capacity.

Lastly and most importantly, the different risk profiles are reflected in different responses of the levered return on purchased capital, r^{Lev}, and the return on leasing, r^l. As we emphasized in equation (24) and (25), the former return includes an exposure to the price fluctuations of the resale value of the asset, while the latter does not due to the separate of use and ownership. As a discount rate shock, the shock to λ only affects the resale price $q_{K,t+1}$, but not the dividend, αA_{t+1}. Different reactions explains that at period $t = 1$ (on impact), r^l stays flat, while r^{Lev} sharply declines due to a decline of resale price $q_{K,t+1}$ upon a positive discount rate shock. In summary, the levered return on purchased capital, r^{Lev} responds much stronger than the return on leasing, r^l and creates a large expected return spread at the aggregate level.

5.6 Leased Capital Spread

In the following two sections, we present model simulation in the cross-section. Specifically, we simulate firms and sort them into quintiles in the same manner as we sort firms in the data. The result turns out that our model performs well in generating the right heterogeneity across leased capital ratio sorted portfolios in terms of firm characteristics and average returns.

In Table 5, we document that the cross-sectional difference in their leased capital ratios are related to other firm characteristics in the data (Panel A, financially constrained firms) and in the model (Panel B). We report the time-series average of the cross-sectional averages firm characteristics in each quintile portfolio.

Table 5: **Firm Characteristics, Data, and Model Comparison**

This table reports time-series averages of the cross-sectional averages of firm characteristics across five portfolios. Panel A reports the five quintile portfolios sorted on leased capital ratio relative to their industry peers for financially constrained firms, as classified by WW index. Panel B reports five quintile portfolios sorted on leased capital ratio for simulated firms. In both Panels, purchased capital from quintile '2' to 'H' display their relative sizes to quintile 'L', which is normalized to be 1. In the model, we do not consider intangible capital for parsimony. Therefore, when we report the leverage ratios from the model simulation, we adjust them by considering an average tangibility (PPENT/AT ratio) of 0.4.

Variables	**L**	**2**	**3**	**4**	**H**
			Panel A: Data		
Leased Capital Ratio	0.3	0.54	0.68	0.77	0.83
Purchased Capital	1	0.62	0.48	0.51	0.27
Debt Leverage	0.12	0.08	0.06	0.05	0.05
Rental Leverage	0.1	0.17	0.21	0.26	0.30
Leased adj. Leverage	0.21	0.25	0.27	0.32	0.35
			Panel B: Model		
Leased Capital Ratio	0.21	0.51	0.68	0.80	0.89
Purchased Capital	1	0.60	0.39	0.25	0.14
Debt Leverage	0.15	0.09	0.06	0.04	0.02
Rental Leverage	0.08	0.20	0.27	0.32	0.36
Leased adj. Leverage	0.24	0.30	0.33	0.36	0.38

We make several observations from the data (Panel A). First, firms with a higher leased capital ratio are expected to have lower purchased capital. Second, firms with a higher leased capital ratio display a declining pattern in debt leverage but an increasing pattern in rental leverage. Overall, lease adjusted leverage ratio increases across quintiles. These findings imply that for financially constrained firms, leasing deserves to an even more important than debt as an external financing channel.

Turning the attention to the model (Panel B), we observe the model performs reasonably well in quantitatively replicating those patterns in the data (Panel A). In particular, the model not only generates the right slope pattern of purchased capital size and various measures of leverage ratio, but also broadly matches the magnitudes in firm characteristics across quintiles in the data (Panel A).

Table 6 demonstrates the model's ability to generate return spreads across leased capital ratio sorted portfolios, which are quantitatively comparable to the data. Panel A reports the portfolio returns in the data, while Panel B presents the model counterparts. We observe that the model can generate a return spread of low minus high leased capital ratio sorted portfolios at 7.84% per year, which almost fully accounts the return spread (7.14%) shown in the data under the value-weighted scheme.

Table 6: **Leased Capital Spread, Data, and Model Comparison**

This table reports average excess returns over the risk-free rate E[R]-R_f, standard deviations Std, and Sharpe ratios SR across portfolios. Panel A reports the five quintile portfolios sorted on leased capital ratio relative to their industry peers for financially constrained firms, as classified by WW index. We include t-statistics in parentheses. Panel B reports five quintile portfolios sorted on leased capital ratio for simulated firms. Standard errors are estimated by using Newey-West correction. All portfolios returns correspond to value-weighted returns by firm market capitalization, and are annualized by multiplying 12.

Variables	**L**	**2**	**3**	**4**	**H**	**L-H**
			Panel A: Data			
E[R]-R_f (%)	10.15	9.50	7.82	5.81	3.01	7.14
[t]	2.05	1.86	1.61	1.10	0.56	3.60
Std (%)	26.6	26.27	26.63	26.89	27.41	10.85
SR	0.38	0.36	0.29	0.22	0.11	0.66
			Panel B: Model			
E[R]-R_f (%)	13.64	11.45	9.56	7.73	5.80	7.84
[t]	23.95	21.84	20.26	18.95	17.76	10.89
SR	0.57	0.52	0.47	0.41	0.33	0.72

5.7 Size, Leverage and Return Spread

In this section, we show that our model is able to capture relations among size, leverage, and average returns in the cross-section. Our model is not designed to capture the size profile of leverage and average return. The fact that our model can account for this can be considered as an external validity of our model, and it directly supports our model mechanism. In our model, idiosyncratic productivity shocks drive the firm heterogeneity. Entrepreneurs differ in their borrowing capacity, because their net worth are determined by the historical returns of the firms subject to idiosyncratic shocks. As a result, the heterogeneity in net worth and financing translates into differences in leased capital ratio in equilibrium. Entrepreneurs with a low net worth (a low internal cash flow) yet a high financing needs as reflected by a high realization in the next period's productivity are prone to rely on more capital leasing to relax their debt constraints and further expand their production scales. In contrast, entrepreneurs with a low net worth are the result of a series of low idiosyncratic shocks in past history. By construction, they display smaller size as measured by owned capital. To sum up, in our model, the idiosyncratic productivity shocks endogenously generate a pattern that smaller firms tend to have higher leased capital ratio and lower average returns. In Table 8, we find supportive evidence for financially constrained firms in the data, where we sort constrained

Table 7: **Firm Characteristics on Size Portfolios, Data, and Model Comparison**

This table reports time-series averages of the cross-sectional averages of firm characteristics across five portfolios. Panel A reports five quintile portfolios sorted on total assets relative to their industry peers for financially constrained firms, as classified by WW index. Panel B reports the five quintile portfolios sorted on purchased capital relative to their industry peers for financially constrained firms, as classified by WW index. Panel C reports five quintile portfolios sorted on owned capital for simulated firms. In the model, we do not consider intangible capital for parsimony. Therefore, when we report the leverage ratios from the model simulation, we adjust them by considering an average tangibility (PPENT/AT ratio) of 0.4.

Variables	**L**	**2**	**3**	**4**	**H**
	Panel A: Data (AT)				
Leased Capital Ratio	0.52	0.45	0.42	0.38	0.30
Debt Leverage	0.06	0.09	0.12	0.15	0.15
Rental Leverage	0.20	0.17	0.15	0.14	0.10
Leased adj. Leverage	0.26	0.25	0.28	0.29	0.26
	Panel B: Data (K)				
Leased Capital Ratio	0.64	0.53	0.46	0.38	0.29
Debt Leverage	0.06	0.09	0.12	0.15	0.15
Rental Leverage	0.15	0.15	0.15	0.13	0.11
Leased adj. Leverage	0.21	0.25	0.27	0.28	0.26
	Panel C: Model				
Leased Capital Ratio	0.89	0.79	0.67	0.50	0.23
Debt Leverage	0.02	0.04	0.06	0.10	0.15
Rental Leverage	0.36	0.32	0.27	0.20	0.09
Leased adj. Leverage	0.38	0.36	0.33	0.30	0.24

firms by two proxies of size, i.e. total assets (Panel A) and physical capital (Panel B). Both panels show that small firms tend to have higher leased capital ratios, implying that smaller firms use more leasing. Debt leverage decreases with firm size. Overall, the leased adjusted leverage ratio is close to be flat across different size quintiles, consistent with the empirical evidence documented by Rampini and Viswanathan (2013). Panel C (model) shows that our model can replicate the substitutability between debt and rental financing across different size quintiles reasonably well. Since in the model size and leased capital ratio are perfectly correlated with each other and driven by the same fundamental shocks, this feature makes the model display an increasing pattern in leased adjusted leverage with respect to size, while in the data the pattern is flat.

Our model predicts that small and constrained firms that use more leasing tend to have lower return because the leased capital is less risky. We find a strong empirical support from the data to support this prediction. In Table 8, we sort the financially constrained firms by size, proxied by total assets (Panel A) and purchased assets (Panel B). As we can see, among financially constrained firms, there is a negative size premium. We obtain the evidence that smaller firms earn lower average returns among financially constrained firms. This provides

Table 8: **Return Spreads on Size Portfolios, Data, and Model Comparison**

This table reports average excess returns over the risk-free rate E[R]-R_f, standard deviations Std, and Sharpe ratios SR across portfolios. Panel A reports five quintile portfolios sorted on total assets relative to their industry peers for financially constrained firms, as classified by WW index. Panel B reports the five quintile portfolios sorted on purchased capital relative to their industry peers for financially constrained firms, as classified by WW index. Standard errors are estimated by using Newey-West correction. We include t-statistics in parentheses. Panel C reports five quintile portfolios sorted on physical capital for simulated firms. All portfolios returns correspond to value-weighted returns by firm market capitalization, and are annualized by multiplying 12.

Variables	**L**	**2**	**3**	**4**	**H**	**H-L**
			Panel A: Data (AT)			
E[R]-R_f (%)	1.76	5.71	6.55	7.61	8.15	6.39
[t]	0.41	1.55	1.90	2.41	2.65	2.08
Std (%)	24.87	22.92	19.91	18.03	14.81	17.73
SR	0.07	0.25	0.33	0.42	0.55	0.36
			Panel B: Data (K)			
E[R]-R_f (%)	1.51	5.89	6.57	7.50	8.16	6.65
[t]	0.35	1.54	1.80	2.36	2.68	2.36
Std (%)	25.03	23.39	20.94	17.93	14.69	17.35
SR	0.06	0.25	0.31	0.42	0.56	0.38
			Panel C: Model			
E[R]-R_f (%)	5.84	7.77	9.60	11.47	13.53	7.68
[t]	17.79	18.97	20.29	21.86	23.85	10.74
SR	0.33	0.41	0.47	0.53	0.57	0.72

a strong support for our model. As shown in Panel C (model), our model can generate the same return pattern and account for the observed average return spread among size quintiles reasonably well.

6 Additional Supporting Evidence of the Model

In this section, we provide several supporting evidence of the model.

6.1 Lessor Firms: The Other Side of the Story

The key argument of our model is that the lessor firms, who take possession of the capital and provide it as a leasing object, effectively provide lessee firms an insurance mechanism, by charging a high leasing fee, which embodies the risk premium and monitoring cost. In another word, the lessor firms are the ones that bears the risk of capital price fluctuations, and hence are expected to demand for higher average returns. In this section, we provide direct evidence on this implication.

In particular, we manually identified the lessor firms at the narrowly defined SIC (Standard Industrial Classification) 4 digit level and then study their average returns and firm characteristics. [13] Table B.4 presents the detailed description of business across SIC 4 digit classifications as lessors.

Table 9: **Comparison of Lessor and Lessee Firms**

This table shows asset pricing test for lessor and lessee firms. We use SIC 4 digit industry classifications to identify lessor firms and assign the rest of firms as lessee firms, where we further exclude financial, utility, and public administrative industries from the analysis. The remaining sample of lessee firms are split into financially constrained and unconstrained firms at the end of every June, as classified by WW index. We report the pooled portfolio of lessor firms, and report the bottom (L) and top (H) quintile portfolios of constrained lessee firms sorted on leased capital ratio relative to their industry peers, where we use the Fama-French 49 industry classifications and rebalance portfolios at the end of every June. The results are used monthly data, where the sample period is from July 1988 to December 2015. We report average excess returns over the risk-free rate E[R]-R_f and standard deviations Std in Panel A, and report time-series averages of the cross-sectional averages of firm characteristics in Panel B. Standard errors are estimated by using Newey-West correction. We include t-statistics in parentheses and annualize portfolio returns by multiplying 12. All portfolios returns correspond to value-weighted returns by firm market capitalization.

	Lessor	**Lessee**	
Variables	**All**	**L**	**H**
Panel A: Portfolio Returns			
E[R] - R_f (%)	9.92	10.15	3.01
[t]	2.26	2.05	0.56
Std (%)	17.88	26.60	27.41
Panel B: Firm Characteristics			
Leased Capital Ratio	0.34	0.30	0.83
OI/AT	0.15	0.1	-0.02
SA	-3.52	-0.69	-0.21
WW	-0.32	-0.21	-0.18
DIV	0.44	0.02	0.04
Rating	1.29	0.09	0.06
Number of Firms	134	281	262

Table 9 presents the average return and some key firm characteristics of the portfolio of identified lessor firms, and make comparison with the quintile portfolios of lessee firms with lowest and highest leased capital ratios as in Table 2. We make several observations that strongly support our model. First, the lessor firms indeed earn a high average excess returns of 9.92% per annum, about 7% higher than the portfolio of lessee firms with high leased capital ratio. This is consistent with the model implication that the lessor firms enjoy a risk compensation to insure the lessee firms from the capital price fluctuations. Second,

[13] We searched the U.S. Census Bureau (`https://www.census.gov/`) and SICCODE (`https://siccode.com/en/pages/what-is-a-sic-code`), using the following criteria with keyword phrases: "lease", "leasing", "lessor", "lessee", "rent", "rental", "renting", and "tenant". For robustness, we identify a lessor industry if its description of business mentioned to a key phrase in our criteria.

the lessor firms feature a higher average profitability (OI/AT) than the lessee firms with high leased capital ratio. This is also coherent to the model implication that the lessee firms pay a expensive leasing fee to the lessor firms, which embodies both the risk premium and agency cost. Finally, we also observe the lessor firms are less financially constrained than the lessee firms with the high leased capital ratio, in each of the four financial constraint measures, including SA index, WW index, the dividend paying dummy, and the bond rating. This justifies the model assumption that the competitive lessor sector is not financially constrained. To sum up, in this subsection, we document that the lessor firms earn higher average excess returns and higher profitability, and are less financially constrained than the lessee firms with high leased capital ratios, which are strongly consistent with the model implications.

6.2 Firm-level Return Predictability Regressions

We next review the ability of lease capital ratio to predict the cross-sectional stock returns using monthly Fama and MacBeth (1973) regressions. This analysis allows us to control for an extensive list of firm characteristics that predict stock returns and to verify whether the negative leased capital ratio-return relation is driven by other known predictors.

The specification of regression is as follows:

$$R_{i,t+1} - R_{f,t+1} \quad = \quad a + b \times \mathit{Leased\ Capital\ Ratio}_{i,t} + \gamma \times \mathit{Controls}_{i,t} + \varepsilon_{it}. \qquad (28)$$

Following Fama and French (1992), for each month from July of year t to June of year t+1, we regress monthly returns of individual stock returns (annualized by multiplying 12) on leased capital ratio of year t-1, different sets of control variables that are known by the end of June of year t, and industry fixed effects. Control variables include the logarithm of market capitalization scaled by CPI index at the end of each June (Size), the natural logarithm of book-to-market ratio (B/M), return on total assets (ROA), investment rate (I/K), organization capital ratio (OC/AT),the R&D intensity (R&D/AT), Default probability, inflexibility (INFLEX) and operating leverage (QFC), following Gu, Hackbarth, and Johnson (2017), Redeployability as in Kim and Kung (2016), and industry dummies based on Fama and French (1997) 49 industry classifications. All independent variables are normalized to zero mean and one standard deviation after winsorization at the 1th and 99th percentile to reduce the impact of outliers, and adjusted for standard errors by using Newey-West adjustment.

Table 10 reports the results from cross-sectional predictability regressions performed at a monthly frequency. The reported coefficient is the average slope from monthly regressions

Table 10: **Fama-Macbeth Regressions**

This table reports the of Fama-Macbeth regressions of individual stock excess returns on their leased capital ratios and other firm characteristics. The sample period is July 1988 to December 2015 and excludes financial, utility, public administrative, and lessor industries from the analysis. We split the whole sample into financially constrained and unconstrained firms, as classified by the dividend payment dummy, and report the result of regression in the financially constrained subsample. For each month from July of year t to June of year t+1, we regress monthly excess returns of individual stock on leased capital ratio with different sets of variables that are known by the end of June of year t, and control for industry fixed effects based on Fama-French 49 industry classifications. We present the time-series average and heteroscedasticity-robust t-statistics of the slopes (i.e., coefficients) estimated from the monthly cross-sectional regressions for different model specifications. All independent variables are normalized to zero mean and one standard deviation after winsorization at the 1th and 99th percentile of their empirical distribution. We include t-statistics in parentheses and annualize individual stock excess returns by multiplying 12. Standard errors are estimated using Newey-West correction with ***, **, * indicate significance at the 1, 5, and 10% levels.

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Lease Capital Ratio	-1.09**	-1.04**	-0.98**	-1.01**	-0.96*
[t]	-2.44	-2.11	-2.17	-2.01	-1.71
Default Probability		-4.40**			-4.32*
[t]		-2.00			-1.90
Redeployability			-0.35		-0.63
[t]			-0.71		-1.01
INFLEX				-0.24	-0.31
[t]				-0.57	-0.67
QFC				-1.30**	-1.56**
[t]				-2.00	-2.05
INFLEX x QFC				-0.51	-0.96
[t]				-1.06	-1.62
Log ME	2.41*	2.61**	2.46*	1.94	2.22*
[t]	1.85	2.05	1.89	1.49	1.72
Log B/M	5.09***	5.43***	5.11***	4.86***	5.12***
[t]	8.27	7.61	8.23	7.36	6.77
ROA	7.19***	7.49***	7.21***	7.05***	7.11***
[t]	8.34	8.54	8.31	7.36	6.98
I/K	-0.55	-0.96*	-0.53	-0.49	-0.63
[t]	-1.27	-1.85	-1.22	-1.02	-1.13
O/K	1.44***	1.43**	1.47***	1.36**	1.09
[t]	2.72	2.35	2.72	2.16	1.53
R&D/K	4.63***	4.45***	4.69***	4.74***	4.87***
[t]	4.38	3.87	4.47	3.96	3.87
Constant	-10.17	9.02	-10.01	11.33	3.44
[t]	-1.06	0.88	-1.09	1.13	0.34
Observations	308,794	235,564	303,406	259,576	198,557
Industry FE	Yes	Yes	Yes	Yes	Yes

and the corresponding t-statistics is the average slope divided by its time-series standard error. The results of Fama-Macbeth regression are consistent with the results of portfolio sorted on leased capital ratio. In Specification 1, leased capital ratio significantly and negatively predicts future stock returns with a slope coefficient of -1.09, which is 2.44 standard errors from zero, after controlling for size, book-to-market, investment, ROA, organizational capital ratio and R&D intensity. It implies that one standard deviation increase in leased capital ratio leads to a significant decrease of 1.09% in the annualized stock return. The difference in average leased capital ratio between firms in the top and bottom quintile is around 3.63 standard deviations. The coefficient in Column 1 implies a difference in the annualized return to 3.97%, which is lower than the value-weighted leased capital premium 7.14% reported in Table 2. The Fama-Macbath regressions suggest that leased capital ratio negatively predicts average returns. Such a regression weights each observation equally, and thus puts substantially weight on the small firms. However, our finding for the leased capital premium is mainly based on value-weighted rather than equal-weighted portfolios. Therefore, the difference between valued- and equal-weighted portfolios reflects on the discrepancy between the implied return from the Fama-Macbath regression and the valued-weighted portfolio return.

From Specification 2 to 5, leased capital ratio negatively predicts stock returns with statistically significant slope coefficient when we further control for the default probability, redeployability, inflexibility (INFLEX) and operating leverage (QFC), and their interaction term of inflexibility and operating leverage. The estimated leased capital ratio slope coefficients remain comparable and range from -1.04 (Specification 2) to -0.96 (Specification 5). All the estimated values are statistically significant at 5% levels. Overall, Table 10 suggests that the negative leased capital ratio-return relation cannot be attributed to other known predictors and that the leased capital ratio has its unique return predictive power.

7 Conclusion

This paper studies the implications of leasing on the risk profile and thus the expected return of the leased capital as compared with the owned capital. Compared with directly purchasing capital through a collateralized loan, obtaining the use of capital through leasing is predicted to be less risky, because it is not the lessee but the lessor, the owner of the capital, who bears the risk of asset price fluctuations. We provide strong empirical evidence to support the above prediction. We create a novel leased capital ratio measure for the fraction of the leased capital with respect to the total physical capital used in firm production. Among financially constrained firms, there is a large dispersion in firms' leased capital ratio. Firms with a low leased capital ratio earn average returns that are 7.14% higher than firms with a high leased capital ratio. We develop a general equilibrium model with heterogeneous firms which features the collateral constraint and the dynamic lease versus buy decision to formalize the intuition and quantitatively account for the negative leased capital premium.

References

Ai, H. and D. Kiku (2013): "Growth to value: Option exercise and the cross section of equity returns," *Journal of Financial Economics*, 107, 325–349.

Ai, H., J. Li, K. Li, and C. Schlag (2017a): "The collateralizability premium," .

Ai, H., K. Li, and F. Yang (2017b): "Financial Intermediation and Capital Reallocation," Tech. rep., Working Paper.

Albuquerque, R. and H. Hopenhayn (2004): "Optimal Lending Contracts and Firm Dynamics," *Review of Economic Studies*, 71, 285–315.

Atkeson, A. and P. J. Kehoe (2005): "Modeling and Measuring Organization Capital," *Journal of Political Economy*, 113, 1026–53.

Bansal, R. and A. Yaron (2004): "Risks for the Long Run: A Potential Resolution," *Journal of Finance*, 59, 1481–1509.

Belo, F., X. Lin, and F. Yang (2017): "External equity financing shocks, financial flows, and asset prices," .

Bharath, S. T. and T. Shumway (2008): "Forecasting default with the Merton distance to default model," *The Review of Financial Studies*, 21, 1339–1369.

Brunnermeier, M. K., T. Eisenbach, and Y. Sannikov (2012): "Macroeconomics with Financial Frictions: A Survey," Working paper.

Brunnermeier, M. K. and Y. Sannikov (2014): "A macroeconomic model with a financial sector," *American Economic Review*, 104, 379–421.

Eisfeldt, A. L. and D. Papanikolaou (2013): "Organization capital and the cross-section of expected returns," *Journal of Finance*, 68, 1365–1406.

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

Elenev, V., T. Landvoigt, and S. Van Nieuwerburgh (2017): "A Macroeconomic Model with Financially Constrained Producers and Intermediaries," Tech. rep., Working Paper.

Epstein, L. G. and S. E. Zin (1989): "Substitution, risk aversion, and the temporal behavior of consumption and asset returns: A theoretical framework," *Econometrica*, 57, 937–969.

Falato, A., D. Kadyrzhanova, J. W. Sim, A. Falato, and J. W. Sim (2013): "Rising Intangible Capital, Shrinking Debt Capacity, and the US Corporate Savings Glut," Working Paper 2013-67, Finance and Economics Discussion Series, Divisions of Research & Statistics and Monetary Affairs, Federal Reserve Board, Washington, D.C.

Fama, E. F. and K. R. French (1992): "The cross-section of expected stock returns," *the Journal of Finance*, 47, 427–465.

——— (1993): "Common risk factors in the returns on stocks and bonds," *Journal of Financial Economics*, 33, 3–56.

——— (1997): "Industry costs of equity," *Journal of Financial Economics*, 43, 153 – 193.

——— (2015): "A five-factor asset pricing model," *Journal of Financial Economics*, 116, 1–22.

Fama, E. F. and J. D. MacBeth (1973): "Risk, return, and equilibrium: Empirical tests," *Journal of political economy*, 81, 607–636.

Frankel, M. (1962): "The Production Function in Allocation and Growth: A Synthesis," *The American Economic Review*, 52.

Gârleanu, N., L. Kogan, and S. Panageas (2012): "Displacement risk and asset returns," *Journal of Financial Economics*, 105, 491–510.

Gertler, M. and N. Kiyotaki (2010): "Financial intermediation and credit policy in business cycle analysis," *Handbook of monetary economics*, 3, 547–599.

Gomes, J., L. Kogan, and L. Zhang (2003): "Equilibrium Cross Section of Returns," *Journal of Political Economy*, 111, 693–732.

Gomes, J., R. Yamarthy, and A. Yaron (2015): "Carlstrom and Fuerst meets Epstein and Zin: The Asset Pricing Implications of Contracting Frictions," *Working paper*.

Gu, L., D. Hackbarth, and T. C. Johnson (2017): "Inflexibility and Stock Returns," *Review of Financial Studies*.

Hadlock, C. J. and J. R. Pierce (2010): "New evidence on measuring financial constraints: Moving beyond the KZ index," *Review of Financial Studies*, 23, 1909–1940.

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

Hennessy, C. a. and T. M. Whited (2007): "How costly is external financing? Evidence from a structural estimation," *Journal of Finance*, 62, 1705–1745.

Hou, K., C. Xue, and L. Zhang (2015): "Digesting Anomalies: An Investment Approach," *Review of Financial Studies2*, 28, 650–705.

Jermann, U. and V. Quadrini (2012): "Macroeconomic Effects of Financial Shocks," *American Economic Review*, 102, 238–271.

Kim, H. and H. Kung (2016): "The asset redeployability channel: How uncertainty affects corporate investment," *The Review of Financial Studies*, 30, 245–280.

Kiyotaki, N. and J. Moore (1997): "Credit cycles," *Journal of Political Economy*, 105, 211–248.

——— (2012): "Liquidity, business cycles, and monetary policy," NBER Working Paper.

Kogan, L. and D. Papanikolaou (2012): "Economic Activity of Firms and Asset Prices," *Annual Review of Financial Economics*, 4, 1–24.

Kogan, L., D. Papanikolaou, and N. Stoffman (2017): "Winners and Losers: Creative Destruction and the Stock Market," Working paper.

Kung, H. and L. Schmid (2015): "Innovation, growth, and asset prices," *Journal of Finance*, 70, 1001–1037.

Li, D. (2011): "Financial constraints, R&D investment, and stock returns," *Review of Financial Studies*, 24, 2974–3007.

Lin, X. (2012): "Endogenous technological progress and the cross-section of stock returns," *Journal of Financial Economics*, 103, 411–427.

Ohlson, J. A. (1980): "Financial ratios and the probabilistic prediction of bankruptcy," *Journal of accounting research*, 109–131.

Quadrini, V. (2011): "Financial Frictions in Macroeconomic Fluctuations," *Economic Quarterly*, 209–254.

Rampini, A. and S. Viswanathan (2010): "Collateral, risk management, and the distribution of debt capacity," *Journal of Finance*, 65, 2293–2322.

——— (2013): "Collateral and capital structure," *Journal of Financial Economics*, 109, 466–492.

Romer, P. M. (1986): "Increasing Returns and Long-run Growth," *Journal of Political Economy*, 94, 1002 – 1037.

Schmid, L. (2008): "A Quantitative Dynamic Agency Model of Financing Constraints," Working paper.

Whited, T. M. and G. Wu (2006): "Financial constraints risk," *Review of Financial Studies*, 19, 531–559.

Zhang, L. (2005): "The value premium," *Journal of Finance*, 60, 67–103.

Appendix A: Additional Empirical Evidence

In this section, we provide additional empirical evidence on the leased capital premium.

A.1. Leased Capital Premium, Flexibility and Operating Leverage

In this section, we conduct double sorting to address several competing hypothesis or counter-argument to our theory.

First, a potentially alternative explanation for lower riskiness of leased capital is that it offers operational flexibility. In Panel A of Table A.1, we construct three by five portfolios dependent double sorted on industry-specific redeployability and then leased capital ratio. We want to show that, even for firms with high asset redepolyability as measured by Kim and Kung (2016) for which the operational flexility is not a big concern, the leased capital premium remains there. The empirical results confirm this conjecture. Panel A shows that the leased capital spread remains statistically significant in every redeployability tercile. This finding implies, despite that the operational flexibility channel is probably in effect, our channel is still quantitatively important.

Second, a potential counter-argument to our theory is the operating leasing induces operating leverage, and therefore, tends to make firm equity to be more risky. In Panel B of Table A.1, we sort leased capital ratio for the lower right (HH) and the upper left (LL) corner portfolio from the two by two independently double sort on inflexibility (INFLEX) and operating leverage (QFC), following Gu, Hackbarth, and Johnson (2017). The key message from the table is that, even among firms with high operating leverage and high inflexibility (HH), the negative leased capital premium is still there and significant.

[Insert Table A.1 Here]

A.2. Asset Pricing Test

In this section, we investigate the extent to which the variation in average returns of the leased capital ratio sorted portfolios can be explained by existing risk factors. We then examine whether the lease-return relation reported in Table A.2 reflects firms' exposures to the existing systematic risk factors by preforming time-series regressions of leased capital ratio sorted portfolios' excess returns on the Fama and French (2015) five-factor model (the market factor-MKT, the size factor-SMB, the value factor-HML, the profitability factor-RMW, and the investment factor-CMA) in Panel A and on the Hou, Xue, and Zhang (2015) q-factor model (the market factor-MKT, the size factor-SMB, the investment factor-I/A, and the profitability factor-ROE) in Panel B, respectively.[14] Such time-series regressions enable us to estimate the betas (i.e., risk exposures) of each portfolio's excess return on various risk factors and to estimate each portfolio's risk-adjusted return (i.e., alphas in %).

[Insert Table A.2 Here]

We make several observations. First, the risk-adjusted returns (intercepts) of the leased capital ratio sorted low-minus-high portfolio remain large and significant, ranging from 7.69% for Fama and French (2015) five-factor model to 6.40% from the Hou, Xue, and Zhang (2015) q-factor model, and these intercepts are 3.81 and 3.31 standard errors away from zero, as reported in the t-statistics far above 1% statistical significant level. Second, the alpha implied by the Fama-French five-factor model is slightly higher than the the leased capital ratio spread in the univariate sorting (Table 2), while the alpha implied by HXZ q-factor model remains comparable to the long-short portfolio sorted on leased capital ratio. Third, our low-minus-high portfolio have insignificantly negative betas with respect to the Fama and French (2015) five factors or to the Hou, Xue, and Zhang (2015) q factors. The low-minus-high portfolio presents negative loadings on market, size, profitability, and investment factors for Fama-French five-factor model (Panel A), and on market and investment factors for HXZ q-factor model (Panel B). Although insignificant, these negative loadings on corresponding factors are inconsistent with the higher average returns (risk) of the low leased capital ratio firms. In summary, results from asset pricing tests in Table A.2 suggest that the cross-sectional return spread across leased capital ratio sorted portfolios cannot be explained by either the Fama and French (2015) five-factor or the HXZ q-factor model (Hou et al. (2015)).

[14] Data on the Fama-French five factors are from Kenneth French's website. We thank Kewei Hou, Chen Xue, and Lu Zhang for sharing the q-factor returns.

Table A.1: **Double Sorting with Redeployability and Operating Leverage**

This table reports average excess returns across three by five portfolios dependently double sorted on redeployability and then leased capital ratio in Panel A, across five portfolios sorted on leased capital ratio for the lower right (HH) and the upper left (LL) corner portfolio from the two by two independently double sort on inflexibility (INFLEX) and operating leverage (QFC) in Panel B, and across three by five portfolios dependently double sorted on operating lease commitment ratio (OL/AT) and then leased capital ratio in Panel C. All breaking points for financially constrained firms, as classified by WW index, are relative to their industry peers. Redeployability refer to Kim and Kung (2016). Data on redeployability is from Howard Kung's website. Inflexibility (INFLEX) and operating leverage (QFC) refer to Gu, Hackbarth, and Johnson (2017). The sample period is from July 1988 to December 2015 and excludes financial, utility, and public administrative firms from the analysis. Standard errors are estimated using Newey-West correction with ***, **, and * to indicate statistical significance at the 1, 5, and 10% levels. We include t-statistics in parentheses and annualize the portfolio returns by multiplying 12. All portfolios returns correspond to value-weighted returns by firm market capitalization.

	L	**2**	**3**	**4**	**H**	**L-H**
			Panel A: Redeployability			
L	10.42***	9.96***	10.61***	6.36***	6.32**	4.10***
[t]	3.71	4.91	3.73	2.61	2.23	2.80
2	8.33***	11.99***	9.08***	3.40	2.22	6.11***
[t]	3.46	4.13	3.54	1.28	0.68	2.66
H	9.06***	5.22***	6.48**	5.44	3.15	5.91**
[t]	3.02	2.62	2.41	1.17	1.22	2.06
			Panel B: Inflexibility and Operating Leverage			
HH	11.34***	8.12**	5.86	4.89	3.45	7.90***
[t]	3.26	2.30	1.06	1.04	0.98	3.31
LL	10.34***	12.44***	8.38***	5.72*	6.17**	4.17**
[t]	3.36	4.57	2.67	1.94	2.04	2.10

Table A.2: **Asset Pricing Tests**

This table shows asset pricing test for five portfolios sorted on leased capital ratio relative to their industry peers, where we use the Fama-French 49 industry classifications and rebalence portfolios at the end of every June. The results are used monthly data, where the sample period is from July 1988 to December 2015 and excludes financial, utility, public administrative, and lessor industries from the analysis. We split the whole sample into financially constrained and unconstrained firms, as classified by WW index, and report five portfolios across the financially constrained subsample. In Panel A we report the portfolio alphas and betas by the Fama-French five-factor model, including MKT, SMB, HML, RMW, and CMA factors. In Panel B we report portfolio alphas and betas by the HXZ q-factor model, including MKT, SMB, I/A, and ROE factors. Data on the Fama-French five-factor model are from Kenneth French's website. Data on I/A and ROE factor are provided by Kewei Hou, Chen Xue, and Lu Zhang. Standard errors are estimated using Newey-West correction with ***, **, and * to indicate statistical significance at the 1, 5, and 10% levels. We include t-statistics in parentheses and annualize the portfolio alphas by multiplying 12.

	Panel A: Fama-French Five-Factor Model					
Variables	**L**	**2**	**3**	**4**	**H**	**L-H**
α_{FF5}	4.50**	3.36*	0.78	-0.69	-3.31*	7.81***
[t]	2.33	1.77	0.50	-0.44	-1.88	3.75
MKT_Rf	1.00***	1.01***	1.10***	1.07***	1.05***	-0.05
[t]	26.13	29.29	25.57	23.72	31.32	-1.04
SMB	1.06***	1.02***	1.01***	1.02***	1.09***	-0.03
[t]	16.64	18.74	11.83	13.87	15.30	-0.29
HML	-0.46***	-0.51***	-0.52***	-0.52***	-0.44***	-0.02
[t]	-5.45	-8.30	-7.51	-6.08	-5.22	-0.17
RMW	-0.55***	-0.55***	-0.32***	-0.41***	-0.52***	-0.03
[t]	-4.34	-7.38	-3.08	-5.77	-6.23	-0.22
CMA	-0.04	0.13	-0.09	-0.09	-0.03	-0.01
[t]	-0.26	1.09	-0.91	-0.77	-0.26	-0.06
	Panel B: HXZ q-Factor Model					
α_{HXZ}	4.99**	4.38	2.46	0.83	-1.58	6.57***
[t]	2.15	1.54	1.06	0.33	-0.67	3.26
MKT_Rf	0.98***	0.98***	1.07***	1.05***	1.01***	-0.03
[t]	18.16	14.74	17.19	14.90	19.92	-0.55
SMB	1.16***	1.11***	0.98***	1.02***	1.10***	0.06
[t]	7.24	11.11	13.10	16.36	15.03	0.42
I/A	-0.78***	-0.64***	-0.76***	-0.77***	-0.68***	-0.10
[t]	-5.93	-5.55	-6.34	-6.19	-5.53	-0.67
ROE	-0.32***	-0.38***	-0.33***	-0.37***	-0.48***	0.16*
[t]	-3.66	-3.53	-3.85	-3.50	-4.38	1.86

Appendix B: Data Construction

Our sample consists of firms in the intersection of Compustat and CRSP (Center for Research in Security Prices). We obtain accounting data from Compustat and stock returns data from CRSP. Our sample firms include those with positive rental expenditure data and non-missing SIC codes and those with domestic common shares (SHRCD = 10 and 11) trading on NYSE, AMEX, and NASDAQ, except utility firms that have four-digit standard industrial classification (SIC) codes between 4900 and 4949, finance firms that have SIC codes between 6000 and 6999 (finance, insurance, trusts, and real estate sectors), and public administrative firms that have SIC codes between 9000 and 9999. Following Fama and French (1993), we further drop closed-end funds, trusts, American Depository Receipts, Real Estate Investment Trusts, and units of beneficial interest. To mitigate backfilling bias, firms in our sample must be listed on Compustat for two years before including them in our sample. Macroeconomic data are from the Federal Reserve Economic Data (FRED) maintained by Federal Reserve in St. Louis.

B.1. More Detailed Firm Characteristics

Table B.3 documents how differences in firms' leased capital ratios are related to their characteristics. We report average leased capital ratios and other characteristics across five quintiles sorted on leased capital ratio for financially constrained firms.

[Insert Table B.3 Here]

Averaging speaking, our sample contains 987 firms. Five portfolios sorted on leased capital ratio from the lowest to the highest quintile are evenly distributed, with the average number of firms ranging from 194 to 208. The cross-sectional variations in leased capital ratios are large, ranging from 0.29 to 0.81 across five portfolios. Book-to-market ratio (B/M) and Tobin's q do not vary a lot across five portfolios. However, firms with a higher leased capital ratio are prone to have a higher investment rate (I/K) to reflect more investment opportunities, but we notice a reverse pattern in the investment rate adjusted for leased capital when leased capital is taken into account of total capital. In addition, intangibilities, as measured by organization capital ratio (OC/AT) and R&D intensity, across five portfolios suggest that a lease-intensive firm holds a relatively higher share of R&D and organization capital. On the other hand, there is a negative relationship between leased capital ratio and tangibility. When leased capital is included in total capital, lease adjusted tangibility, like investment rate, presents a flat pattern across leased capital ratio sorted portfolios.

Consistent with debt leverage across five portfolios, book leverage is downward sloping from the lowest to the highest leased capital ratio sorted portfolio. Downward sloping in the profitability (OI/AT) across five portfolios is consistent to our model that the lessee firms essentially pay the insurance premium and high leasing fee to the lessors. These two empirical facts imply that these firms tend to be more financially constrained, so we can observe upward sloping patterns in the SA index and a downward sloping pattern in credit ratings from the lowest to the highest quintiles. All these firm characteristics mentioned above are coherent and point out to one implication that leasing is as an important financing channel in particular for the constrained firms, in particular, when they are deeply entangled in a tight place to finance their projects via internal fund or debt. Lastly, low profitability and debt financing capacity also suggest that these firms are difficult to acquire refinancing and thus on the brink of bankruptcy. Therefore, the O index increases from 0.45 to 1.73 across five portfolios, and this finding supports a positive relation between financial distress and leasing. However, we do not observe a salient pattern for Z index in the untabulated result.

In summary, firms with a high leased capital ratio tend to have higher intensity in organization and R&D capital, higher investment rates (if not adjusted for leased capital in total capital), lower profits, and closer to financially distress status.

Table B.3: **Firm Characteristics**

This table reports time-series averages of the cross-sectional averages of firm characteristics in five portfolios sorted on leased capital ratio,relative to their industry peers, where we use the Fama-French 49 industry classifications and rebalence portfolios at the end of every June. The sample period is from July 1988 to December 2015 and excludes financial, utility, and public administrative, and lessor industries from the analysis. We split the whole sample into financially constrained and unconstrained firms at the end of every June, as classified by WW index according to Whited and Wu (2006), and report five portfolios across the financially constrained subsample. Book-to-market ratio (B/M) is the book value of equity divided by market value at the end of fiscal year. Tobin's q is the ratio of market equity at the end of year plus the book value of preferred shares minus inventories over the total assets. Investment rate (I/K) is investment (CAPX) over purchased capital (PPENT). Investment rate adjusted for leased Capital (I/K adj.) is investment (CAPX) over the sum of leased and purchased capital (PPENT). Profitability (OI/AT) is the ratio of operating income before depreciation (OIBDP) over total assets (AT). Organization capital ratio (OC/AT) is the ratio of organization capital to total assets (AT), referring to Eisfeldt and Papanikolaou (2013). R&D intensity is the ratio of R&D capital to total assets (AT). Tangibility is the ratio of purchased capital (PPENT) to total assets (AT). Tangibility adjusted for leased capital is defined as purchased capital (PPENT) divided by the sum of leased capital and total assets (AT). Book leverage is the sum of long-term liability (DLTT) and current liability (DLC) divided by total assets (AT). SA index refers to Hadlock and Pierce (2010). O index refers to Ohlson (1980). Distance to default (DD) refers to Bharath and Shumway (2008). Redeployability refers to Kim and Kung (2016). Data on redeployability measures is from Kung's Website. Inflexibility (INFLEX) and operating leverage (QFC) refer to Gu, Hackbarth, and Johnson (2017). The detailed definition of the variables is listed in Appendix B.

Vairables	**L**	**2**	**3**	**4**	**H**
Leased Capital Ratio	0.30	0.54	0.68	0.77	0.83
B/M	0.47	0.42	0.41	0.44	0.47
q	2.09	2.18	2.16	2.12	2.00
I/K	0.31	0.37	0.41	0.42	0.52
I/K adj.	0.21	0.16	0.12	0.09	0.06
OI/AT	0.1	0.06	0.04	0.02	-0.02
OC/AT	1.18	1.48	1.62	1.97	2.24
R&D Intensity	0.32	0.42	0.51	0.56	0.69
Tangibility	0.29	0.19	0.15	0.12	0.10
Tangibility adj.	0.36	0.32	0.32	0.34	0.36
Book Leverage	0.16	0.12	0.11	0.10	0.11
SA	-0.69	-0.61	-0.53	-0.42	-0.21
O	0.50	0.89	1.14	1.40	2.08
DD	7.82	8.35	7.77	7.6	7.21
Redeployability	0.39	0.40	0.41	0.42	0.42
Log INFLEX	1.97	2.21	2.89	2.59	2.97
QFC	0.3	0.46	0.53	0.67	0.71
Number of Firms	281	266	264	264	262

Table B.4: **SIC 4 Digit Code Combination for Leasing Industries**

This table presents SIC 4 digit code combination for leasing industries and the description of business across these industries, where the sample period is from 1987 to 2014.

SIC Code	**Industry Description**
1389	Oil and Gas Field Services, Not Elsewhere Classified
4119	Local Passenger Transportation, Not Elsewhere Classified
4212	Local Trucking without Storage
4213	Trucking, except Local
4222	Refrigerated Warehousing and Storage
4499	Water Transportation Services, Not Elsewhere Classified
4581	Airports, Flying Fields, and Airport Terminal Services
4724	Travel Agencies
4812	Radiotelephone Communications
4813	Telephone Communications, except Radiotelephone
6211	Security Brokers, Dealers, and Flotation Companies
6512	Operators of Nonresidential Buildings
6513	Operators of Apartment Buildings
6517	Lessors of Railroad Property
6519	Lessors of Real Property, Not Elsewhere Classified
6531	Real Estate Agents and Managers
6792	Oil Royalty Traders
6794	Patent Owners and Lessors
7021	Rooming and Boarding Houses
7213	Linen Supply
7218	Industrial Launderers
7299	Miscellaneous Personal Services, Not Elsewhere Classified
7352	Medical Equipment Rental and Leasing
7353	Heavy Construction Equipment Rental and Leasing
7359	Equipment Rental and Leasing, Not Elsewhere Classified
7363	Help Supply Services
7374	Computer Processing and Data Preparation and Processing Services
7377	Computer Rental and Leasing
7381	Detective, Guard, and Armored Car Services
7513	Truck Rental and Leasing without Drivers
7514	Passenger Car Leasing
7515	Passenger Car Leasing
7519	Utility Trailer and Recreational Vehicle Rental
7819	Services Allied to Motion Picture Production
7822	Motion Picture and Video Tape Distribution
7841	Video Tape Rental
7922	Theatrical Producers and Miscellaneous Theatrical Services
7999	Amusement and Recreation Services, Not Elsewhere Classified
8231	Libraries

Definition of Variables

Variables	Definition	Sources
Leased Capital Ratio	Leased capital, which is defined as 10 times rental expense (XRENT), to purchased capital (PPENT) at the end of fiscal year t-1.	Compustat (Annual)
ME (real)	Market capitalization deflated by CPI at the end of June in year t.	CRSP
AT (real)	Total assets (AT) deflated by CPI of fiscal year ending in year t-1.	Compustat (Annual)
K (real)	Purchased capital (PPENT) deflated by CPI of fiscal year ending in year t-1.	Compustat (Annual)
B/M	The ratio of book equity of fiscal year ending in year t-1 to market equity at the end of year t-1.	CRSP;Compustat (Annual)
Tobin' q	The sum of market capitalization at the end of year and book value of preferred shares deducting inventories over total assets (AT).	CRSP; Compustat
I/K	The ratio of investment (CAPX) to purchased capital (PPENT).	Compustat (Annual)
Lease adjusted I/K	The ratio of investment (CAPX) to the sum of leased capital (10 times XRENT) and purchased capital (PPENT).	Compustat (Annual)
OI/AT	The ratio of operating income before depreciation (OIBDP) over total assets (AT).	Compustat (Annual)
OC/AT	The ratio of organization capital to total assets (AT). Following Eisfeldt and Papanikolaou (2013), we construct the organization capital from SG&A expenditures using the perpetual inventory method.	Compustat (Annual)
R&D Intensity	The ratio of R&D capital to total assets (AT), where we construct R&D capital from R&D expenditures using the perpetual inventory method.	Compustat (Annual)
Tangibility	The ratio of purchased capital (PPENT) to total assets (AT).	Compustat (Annual)
Lease adjusted Tangibility	Purchased capital divided by the sum of leased capital (10 times XRENT) and total assets (AT).	Compustat (Annual)
Book Leverage	The sum of long-term liability (DLTT) and current liability (DLCT) divided by total assets (AT).	Compustat (Annual)
Debt Leverage	The ratio of Long-term debt (DLTT) to the sum of leased capital and total assets (AT).	Compustat
Rental Leverage	The ratio of leased capital (10 times XRENT) to the sum of leased capital and total assets (AT).	Compustat (Annual)
Lease adjusted Leverage	The sum of debt and rental leverage.	Compustat (Annual)
SA Index	We follow Hadlock and Pierce (2010) to construct SA index.	Compustat (Annual)
WW Index	We follow Whited and Wu (2006) to construct WW index.	CRSP; Compustat (Annual)
Dividend Payment Dummy	An indicator for the firm with a nonzero dividend on common stock (DVC).	Compustat (Annual)
Credit Rating	The entire list of credit ratings is as follows: AA+, AA, and AA- = 6, A+, A, and A- = 5, BBB+, BBB, BBB- = 4, BB+, BB, BB- = 3, B+, B, and B- = 2, rating below B- or missing is 0.	Compustat (Annual)
O Index	We follow Ohlson (1980) to construct the O index.	Compustat (Annual)
Distance to Default (DD)	We follow Bharath and Shumway (2008) to construct the distance to default.	Compustat (Annual)
Redeployability	Following Kim and Kung (2017).	Kung's Website
Inflexibility (INFLEX)	Following Gu, Hackbarth, and Johnson (2017), inflexibility is measured by firms historical range of operating costs over sales (SALEQ) scaled by the volatility of the difference between the logarithm of sales over total assets and its lagged value. Operating cost is defined as the sum of SG&A expenditures (XSGAQ) and cost of goods sold (COGSQ).	Compustat (Quarterly)
Quasi-Fixed Costs over Sales (QFC)	Following Gu, Hackbarth, and Johnson (2017), QFC is obtained by running 5-year (20-quarter) rolling-window regressions of operating costs on its first lag, contemporaneous sales, and lagged sales. QFC in the year following the 5-year estimation period equals the sum of regression intercept and predicted operating costs, scaled by sales.	Compustat (Quarterly)