# Leasing as a Risk-Sharing Mechanism

Kai Li and Chi-Yang Tsou*

December 22, 2020

**Abstract**

This paper argues leasing is a risk-sharing mechanism: risk-tolerant lessors (capital owners) provide insurance to financially constrained risk-averse lessees (capital borrowers) against systematic capital price fluctuations. We provide strong empirical evidence to support this novel risk premium channel. Among financially constrained stocks, firms with a high leased capital ratio earn average returns 7.35% lower than firms with a low leased capital ratio, which we call it the negative leased capital premium. We develop a general equilibrium model with heterogeneous firms and financial frictions to quantify this channel. Our study also provides a caveat to the recent leasing accounting change of IFRS 16: lease induced liability and financial debt should not be treated equally on firms' balance sheet, as their implications for firms' equity risks and cost of equity are opposite.

**JEL Codes:** E2, E3, G12

**Keywords:** leased capital, operating lease, secured debt, collateral, financial constraint,

*Kai Li (kaili@ust.hk) is an assistant professor of finance at Hong Kong University of Science and Technology; and Chi-Yang Tsou (bentsou@ust.hk) is a research fellow of finance at Hong Kong University of Science and Technology. This paper was previously circulated under the title "The Leased Capital Premium". We thank Hengjie Ai, Doron Avramov, Utpal Bhattacharya, Hui Chen, Max Croce, Neal Galpin, Vidhan Goyal, Po-Hsuan Hsu, Espen Henriksen, Shiyang Huang, Yan Ji, Jun Li, Tse-Chun Lin, Hanno Lustig, Andrey Malenko, Abhiroop Mukherjee, Stavros Panageas, Adriano Rampini, Steven Riddiough, Juliana Salomao, Roberto Steri, Dragon Yongjun Tang, John Wei, Amir Yaron, Haifeng You, Jialin Yu, Chu Zhang, Harold Zhang, Jake Zhao, and Hongda Zhong as well as the seminar participants at WFA, SFS Cavalcade North America, SHoF Conference on Financial Markets and Corporate Decisions, CAPR workshop at BI, Finance Down Under, the 2nd COAP conference, Wellington Finance Summit 2018, China International Conference in Macroeconomics 2018, First World Symposium on Investment Research, Hong Kong University of Science and Technology, University of Hong Kong, Chinese University of Hong Kong, Nankai University, National University of Singapore, Shanghai Jiao Tong University (SAIF), and Shanghai University of Economics and Finance for their helpful comments. Kai Li gratefully acknowledges the General Research Fund of the Research Grants Council of Hong Kong (Project Number: 16502617) for financial support. The usual disclaimer applies.

cross-section of returns

# 1 Introduction

Lease contracts are extensively used in capital markets, and a number of studies suggest that leasing is a critical element of capital structure, notably Eisfeldt and Rampini (2009), Rauh and Sufi (2011) and Rampini and Viswanathan (2013), among others[1]. Consistent with this view, recent lease accounting changes in IFRS 16 require lessees to recognize most leases from the off-balance-sheet activities back onto their balance sheets. In this paper, we argue leasing is a risk-sharing mechanism: risk-tolerant lessors (capital owners) effectively provide insurance to financially constrained risk-averse lessees (capital borrowers) against systematic capital price fluctuations. We provide strong empirical evidence to support this novel risk premium channel. Among financially constrained stocks, firms with a high leased capital ratio earn average returns 7.35% lower than firms with a low leased capital ratio, which we call it the negative leased capital premium. Both our theory and empirical evidence provide an important caveat to the new leases standard from the asset pricing perspective: lease induced liability and financial debt should not be treated equally on firms' balance sheet, as their implications for firms' equity risks and cost of equity are opposite.

In a typical operating lease contract, the owner of the asset (lessor) grants to capital borrower (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 therefore the owner who bears the risk of capital price fluctuations during the contract term. Hence our key intuition is that the lessor, i.e. a capital owner, effectively provides an insurance mechanism to the lessee, who rents the capital, against the risks of capital price fluctuations. From a hedging perspective, the lessee effectively pays a premium and obtains a futures contract (short position) from the lessor to sell back the capital at current price on the maturity date, and thus she is fully hedged against capital price risks. As a result, from the capital borrowers' perspective, the leased capital is less risky than the purchased capital[3],

[1] A longer list includes Ang and Peterson (1984), Smith and Wakeman (1985), Sharpe and Nguyen (1995), Graham et al. (1998).

[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.

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

is expected to earn a lower average return. Furthermore, our model implies the insurance premium charged by a competitive lessor is cheaper than the amount a constrained firm would be willing to pay. That is because, when entrepreneurs are financially constrained, they effectively become more risk averse than unconstrained lessors and therefore would give a higher valuation of such an insurance protection. This cheap insurance channel provides constrained firms an additional incentive to rent capital.

A large literature of macroeconomic models with financial frictions[4], typically do not consider the possibility that firms rent capital. To formalize the above intuition and quantify the effect of leasing on the cross-section of expected returns, we explicitly consider firms' dynamic lease versus buy decision in a general equilibrium model with heterogenous firms, financial frictions and aggregate risks. We demonstrate that lease contract embeds an insurance mechanism through a futures contract with a "cheap" premium from the perspective of financially constrained capital borrowers. Such a novel risk premium channel has several important implications. First, for optimal allocations of lease versus buy, the "cheap" insurance mechanism provides constrained firms additional incentive to rent capital, besides the motive of saving the constraint-induced premium on internal funds. Second, although both leasing and secured loan account for a firm's total liability, they have starkly different implications for equity risks. In particular, a firm's financial leverage increases its equity risks, while the leased capital reduces equity risks and the cost of capital through such an insurance mechanism. We further quantitatively evaluate the implication of this insurance mechanism through the lens of the cross-section of equity returns.

In our model, lease is modelled as highly collateralized albeit costly financing. On one hand, due to the repossession advantage, leasing is highly collateralized and helps to relax firms' financial constraints and provide a "cheap" insurance mechanism, the latter of which is a novel risk premium channel highlighted by our paper; on the other hand, leasing is costly since the lessor incurs a monitoring cost to avoid agency problems due to the separation of ownership and control. Financially constrained firms, whose shadow cost of obtaining secured loans has increased and who think the cheap insurance channel embedded in the lease contract becomes more attractive, find it optimal to lease capital despite of its expensive rents. 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

[4] Quadrini (2011) and Brunnermeier et al. (2012) provide comprehensive reviews of this literature.

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, and we call it a negative leased capital premium. In the cross-section, we derive that a firm's equity return as a weighted average of returns on leased capital and purchased capital. Consequently, the cross-sectional return spread depends on firm's asset compositions. In particular, firms with a higher leased capital ratio earn lower risk premia, despite the fact that their leased adjusted leverage ratios are higher.

To examine the empirical relationship between the leased capital and risk premia, we first construct an empirical measure of firm's leased capital ratio. Guided by the standard accounting practice and follow Rauh and Sufi (2011) and Rampini and Viswanathan (2013), 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 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 within industry and document an economically large and statistically significant return spread of 7.35% 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 B, 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 earn a risk compensation by providing the lessee firms the insurance against the capital price fluctuations.

We also empirically 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. In particular, we verify that the negative leased capital ratio-return relation is not driven by other known predictors which are seemingly correlated with lease capital ratio, for instance, financial distress, asset redeployability, and profitability.

In the quantitative analysis, 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 firms' capital structure decisions. 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 firms' asset collateralizability. Schmid (2008) considers the quantitative implications of dynamic financing with collateral constraints. Nikolov et al. (2018) studies the quantitative implications of various sources of financial frictions on firms' financing decisions, including the collateral constraint. 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 three important dimensions: First, this literature mainly study the financing role of collateral on firms' liability, while we study the implications on the asset side, in particular, through the lens of cross-section of stock returns. Second, most of these previous studies, with the exceptions of Eisfeldt and Rampini (2009); Rampini and Viswanathan (2010, 2013), do not explicitly consider the possibility for firms to rent capital, while we explicitly model firms' dynamic lease versus buy decision and focus on asset pricing implications. Third, we followed Eisfeldt and Rampini (2009); Rampini and Viswanathan (2010, 2013) to set up the dynamic leasing versus buy decision. The key difference is that we build it into a general equilibrium framework with aggregate shocks, which allows us to emphasize a risk premium channel of leased capital.

Our study is closely related to theories of corporate decisions to lease.The papers most related to our's are Eisfeldt and Rampini (2009) and Rampini and Viswanathan (2010, 2013).[5] 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. Chu (2016) uses the anti-recharacterization laws as an exogenous variation to find the supporting empirical evidence on the dynamic lease versus buy trade-off argued in the above-mentioned papers.

Our study builds on the large macroeconomics literature studying the role of credit market 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 **?**, which use a similar model framework (without lease decision) and the aggregation technique to study the asset collateralizability and stock returns. Our paper differs from **?** by further introducing the firm's option to leased capital and focus on the risk profile and therefore expected return of the leased capital. The key difference

[5]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.

between collateralizable capital and leased capital is the difference in asset ownerships and the resulting different entities responsible the systematic risks of capital price fluctuations. The collateralizable capital is owned by borrower with a levered position, while the leased capital is still owned by the lessor (i.e. creditor) who bears the risks and provides an insurance mechanism to the lessee (i.e. borrower).

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 B, we further provide some additional empirical evidence to establish the robustness. Section 7 concludes. Details on data construction are delegated to the Appendix C.

# 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.[6] 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

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

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 C. The sample is from 1977 to 2016 and excludes financial, utility, public administrative, and lessor industries from the analysis.

| | **Panel A: Pooled Statistics** | | **Panel B: Firm Characteristics** | | | | |
|---|---|---|---|---|---|---|---|
| | **Const.** | **Unconst.** | **Portfolios** | | | | |
| **Variables** | **Mean** | **Mean** | **L** | **2** | **3** | **4** | **H** |
| Lease Cap. Ratio | 0.55 | 0.31 | 0.19 | 0.43 | 0.59 | 0.71 | 0.72 |
| Debt Lev. | 0.09 | 0.16 | 0.12 | 0.11 | 0.08 | 0.08 | 0.08 |
| Rental Lev. | 0.18 | 0.10 | 0.06 | 0.14 | 0.20 | 0.25 | 0.27 |
| Lease adj. Lev. | 0.25 | 0.26 | 0.19 | 0.26 | 0.28 | 0.33 | 0.34 |

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 (2006), Hennessy and Whited (2007), WW index hereafter).[7] Panel A presents two salient observations. First, the average leased capital ratio of financially constrained firms (0.55) 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 (0.09) is lower than that of unconstrained group (0.16), 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 (0.25 versus 0.26). 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

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

industry classifications, and report firm characteristics across five quintiles. First, we observe a large dispersion in the average leased capital ratio, ranging from 0.19 in the lowest quintile (Quintile L) to a ratio as much as 0.72 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 [8] and construct portfolios sorted on these firms' leased capital ratios. Following the literature, we use three proxies for financial constraint: WW index, non-dividend payer, and SA index. Financially constrained firms are firms with their implied WW indexes larger than the cross-sectional median, non-dividend payments, or SA indexes larger than the cross-sectional median. Detailed criteria of credit rating refers to Appendix C. 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 1978 to 2016, 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

[8] 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.

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, we report average portfolio returns sorted by leased capital ratio or rental to capital expenditure ratio, respectively, where the measure of financial constraint is WW index. Our benchmark is on the low-minus-high return spread based on financially constrained firms classified by WW index. The spread is economically large (7.35% per annum) and statistically significant at 1% level with t-statistics above 4. The annualized Sharpe ratio is economically sizable, amounting to 0.67, 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.

On the other hand, we consider the portfolio sorting based on other alternative financial constraint measures as the robustness check. The premium we document is robust to different measures of financial constraints as in remaining panels for alternative financial constraint measures. In Panel B, we report average portfolio return sorted by leased capital ratio with the financial constraint measure respect to dividend payment dummy and SA index. The upper panel in Panel B shows that, among the constrained subsample as classified by dividend payment dummy, the lowest leased capital ratio portfolio (Quintile L) and the highest leased capital ratio portfolio (Quintile H) present a comparable magnitude of return spread amounting to 5.44% with a t-statistic 2.07 significant at 5% level. When we refer to the bottom panel in Panel B, the low-minus-high portfolio, among the constrained subsample classified by dividend payment, consistently shows a positively significant but slightly smaller return spread amounting to 4.60% 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

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

This table shows asset pricing tests for five portfolios sorted on leased capital ratio relative to a firm's industry peers, for which we use the Fama-French 49 industry classifications and rebalance portfolios at the end of every June. The results use monthly data, for which the sample is from July 1978 to June 2017 and excludes utility, financial, public administrative, and lessor industries from the analysis. We first split the whole sample into financially constrained and unconstrained firms at the end of every June, as classified by WW index in Panel A and other constrained measures, including dividend payment dummy (DIV) and SA index, in Panel B, and then report average excess returns over the risk-free rate E[R]-$R_f$, standard deviations Std, and Sharpe ratios SR across portfolios. Standard errors are estimated by Newey-West correction with ***, **, and * indicating significance at the 1, 5, and 10% levels. We include t-statistics in parentheses and annualize the portfolio returns by multiplying 12. All portfolio returns correspond to value-weighted returns by firm market capitalization.

| | **Constrained Subsample** | | | | | |
|---|---|---|---|---|---|---|
| **Variables** | **L** | **2** | **3** | **4** | **H** | **L-H** |
| | **Panel A: WW** | | | | | |
| | Leased Capital Ratio | | | | | |
| E[R]-$R_f$ (%) | 10.9 | 10.87 | 9.40 | 7.27 | 3.55 | 7.35 |
| [t] | 2.50 | 2.48 | 2.09 | 1.61 | 0.80 | 4.17 |
| Std (%) | 26.58 | 27.32 | 27.13 | 27.27 | 27.07 | 11.01 |
| SR | 0.41 | 0.40 | 0.35 | 0.27 | 0.13 | 0.67 |
| | Rental to Capital Exp. Ratio | | | | | |
| E[R]-$R_f$ (%) | 8.99 | 11.60 | 8.22 | 8.38 | 3.33 | 5.66 |
| [t] | 2.04 | 2.46 | 1.90 | 1.90 | 0.77 | 2.67 |
| Std (%) | 27.96 | 28.01 | 25.98 | 27.47 | 25.95 | 13.24 |
| SR | 0.32 | 0.41 | 0.32 | 0.31 | 0.13 | 0.43 |
| | **Panel B: Other Constrained Measures** | | | | | |
| | DIV | | | | | |
| E[R]-$R_f$ (%) | 12.21 | 10.79 | 9.21 | 8.62 | 6.77 | 5.44 |
| [t] | 3.00 | 2.60 | 2.02 | 2.00 | 1.74 | 2.07 |
| Std (%) | 25.28 | 25.38 | 25.69 | 26.15 | 24.80 | 16.13 |
| SR | 0.48 | 0.43 | 0.36 | 0.33 | 0.27 | 0.34 |
| | SA | | | | | |
| E[R]-$R_f$ (%) | 10.00 | 9.55 | 7.53 | 8.82 | 5.39 | 4.60 |
| [t] | 2.01 | 1.94 | 1.56 | 1.79 | 1.22 | 2.10 |
| Std (%) | 28.49 | 28.35 | 28.25 | 29.04 | 26.84 | 14.53 |
| SR | 0.35 | 0.34 | 0.27 | 0.30 | 0.20 | 0.32 |

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 in order to study 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.[9]

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 $\beta$ is the time discount rate, $\psi$ is the intertemporal elasticity of substitution, and $\gamma$ is 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 $B_{i,t}$ of risk-free bonds from entrepreneur $i$, from which she will receive $B_{i,t}R_{f,t+1}$ 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 $\Pi_{i,t}$ from entrepreneur $i$ and labor income $W_t L_{j,t}$ 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 $L_{j,t}$ on $j$. The household budget constraint at time $t$ can therefore be written as

$$C_t + \int B_{i,t} di = W_t \int L_{j,t} dj + R_{f,t} \int B_{i,t-1} di + \int \Pi_{i,t} di.$$

Let $M_{t+1}$ denote the the stochastic discount factor implied by household consumption.

[9]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.

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

There is a continuum of entrepreneurs in our economy indexed by $i \in [0, 1]$. 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

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

### 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 assumed to be 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 per unit capital. Moreover, there exists a competitive lessor to charge the leasing fee. 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 $\theta$ 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 $\theta$ 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 the leased capital $K^l_{i,t+1}$, as the argument in Eisfeldt and Rampini (2009) and Rampini and Viswanathan (2013). 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 $\theta$ 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 due to the separation of ownership and control rights 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 $\lambda$, upon which he loses his idea and needs to liquidate his net worth to return it back to the household.[10] 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 $\chi N_t$ in period $t+1$, where $N_t$ is the total (average) net worth of the economy in period $t$, and $\chi$ 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

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

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

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 $\delta$, 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 $V^i_t$ denote the value function of entrepreneur $i$. It must satisfy the following Bellman equation

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

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.

## 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

$$y_{i,t} = \bar{A}_t\left[z^{1-\nu}_{i,t}\left(K^o_{i,t} + K^l_{i,t}\right)^{\nu}\right]^{\alpha} L^{1-\alpha}_{i,t}. \tag{7}$$

In our formulation, $\alpha$ is capital share, and $\nu$ is the span of control parameter as in Atkeson and Kehoe (2005). Note that purchased capital and leased capital are perfect substitutes in production. This assumption is made for tractability.

Firm $i$'s profit at time $t$, $\Pi\left(\bar{A}_t, z_{i,t}, K^o_{i,t}, K^l_{i,t}\right)$ is given as

$$\begin{aligned}\Pi\left(\bar{A}_t, z_{i,t}, K^o_{i,t}, K^l_{i,t}\right) &= \max_{L_{i,t}} y_{i,t} - W_t L_{i,t}, \\ &= \max_{L_{i,t}} \bar{A}_t\left[z^{1-\nu}_{i,t}\left(K^o_{i,t} + K^l_{i,t}\right)^{\nu}\right]^{\alpha} L^{1-\alpha}_{i,t} - W_t L_{i,t}, \end{aligned} \tag{8}$$

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 $\tau_l$ 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 a 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 $K^l_{t+1}$ 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 his entire life time, the lessor's optimization problem is characterized as follows:

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

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 $h\left(\frac{K^l}{K}\right) = \frac{d}{2}\left(\frac{K^l}{K}\right)^2$[11]. 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, $\frac{K^l}{K}$.

The first order conditions implies:

$$\tau_{l,t} = q_{K,t} + q_{K,t} H'\left(K^l_{t+1}, K_{t+1}\right) - \{1-\delta\} E_t \left[M_{t,t+1} q_{K,t+1}\right],$$

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 $q_{K,t} h'\left(\frac{K^l_{t+1}}{K_{t+1}}\right)$, minus the discounted resale value after discount, $\{1-\delta\} E_t \left[M_{t,t+1} q_{K,t+1}\right]$.

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

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

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 $H(K^l_{t+1}, K_{t+1})$ on the leasing market.

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

# 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.[12] 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 $\lambda$ 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.

[12] 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.

**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 $K_{i,t+t}^{o}+K_{i,t+1}^{l}$ to be proportional to $z_{i,t+1}$. Because $\int z_{i,t+1}di=1$, we must have

$$K_{i,t+t}^{o}+K_{i,t+1}^{l}=z_{i,t+1}\left(K_{t+1}^{o}+K_{t+1}^{l}\right), \tag{14}$$

where $K_{t+1}^{o}$ and $K_{t+1}^{l}$ 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 $Y_t=\bar{A}_t\left(K_{t+1}^{o}+K_{t+1}^{l}\right)^{\alpha}\int z_{i,t}di=\bar{A}_t\left(K_{t+1}^{o}+K_{t+1}^{l}\right)^{\alpha}$. In addition, the profit at the firm level is proportional to productivity, i.e.,

$$\pi\left(\bar{A}_t,z_{i,t},K_{i,t}^{o},K_{i,t}^{l}\right)=\alpha\bar{A}_t z_{i,t}\left(K_t^{o}+K_t^{l}\right)^{\alpha},$$

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 $V_t^i\left(N_{i,t},z_{i,t+1}\right)=\mu_t^i N_{i,t}+\Xi_t^i z_{i,t+1}$, where $\mu_t^i$ can be interpreted as the marginal value of net worth for entrepreneur $i$. Furthermore, let $\eta_t^i$ 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 $\eta_t^i$.

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

$$\mu^i_t = E_t\left[\widetilde{M}^i_{t+1}\frac{\Pi_{K^o}\left(\bar{A}_{t+1}, z_{i,t+1}, K^o_{i,t+1}, K^l_{i,t+1}\right) + (1-\delta)\, q_{K,t+1}}{q_{K,t}}\right] + \theta\eta^i_t. \tag{18}$$

An additional unit of purchased capital allows the entrepreneur to purchase $\frac{1}{q_{K,t}}$ units of capital, which generates a profit of $\frac{\partial\pi}{\partial K^p}\left(\bar{A}_{t+1}, z_{i,t+1}, K^o_{i,t+1}, K^l_{i,t+1}\right)$ over the next period before it depreciates at rate $\delta_K$. In addition, a fraction $\theta$ 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

$$\mu^i_t\tau_{l,t} = E_t\left[\widetilde{M}^i_{t+1}\Pi_{K^l}\left(\bar{A}_{t+1}, z_{i,t+1}, K^o_{i,t+1}, K^l_{i,t+1}\right)\right]. \tag{19}$$

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 $\frac{\partial\pi}{\partial K^o}\left(\bar{A}_{t+1}, z_{i,t+1}, K^o_{i,t+1}, K^l_{i,t+1}\right)$ 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, $\mu^i_t$, and the tightness of the collateral constraint, $\eta^i_t$, 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 $\mu^i_t$ and $\eta^i_t$ 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 $K^o_{i,t+1}$ and $K^l_{i,t+1}$ 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 $\mu^i_t$ and $\eta^i_t$ are not firm-specific. Intuitively, because the marginal product of capital depends only on the sum of $K^o_{i,t+1}$ and $K^l_{i,t+1}$, 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 $K^o_{i,t+1}$ to satisfy the collateral constraint. Because capital can be purchased on a competitive market, entrepreneurs will choose $K^o_{i,t+1}$ to equalize its price to its marginal benefit, which includes the marginal product of capital and the Lagrangian multiplier $\eta^i_t$. 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:

$$M' = \beta\left[\frac{c(A',n')\,\Gamma(A,n)}{c(A,n)}\right]^{-\frac{1}{\psi}}\left[\frac{u(A',n')}{E\left[u(A',n')^{1-\gamma}\right]^{\frac{1}{1-\gamma}}}\right]^{\frac{1}{\psi}-\gamma}, \tag{21}$$

$$\widetilde{M}' = M'[(1-\lambda)\,\mu(A',n') + \lambda]. \tag{22}$$

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:*

$$E\left[M' \middle| s\right] R_f(s,n) = 1, \tag{23}$$

$$\mu(s,n) = E\left[\widetilde{M}' \middle| s\right] R_f(s,n) + \eta(s,n), \tag{24}$$

$$\mu(s,n) = E\left[\widetilde{M}' \frac{\alpha A' + (1-\delta)\, q_K(s',n')}{q_K(s,n)}\right| s\right] + \theta\eta(s,n), \tag{25}$$

$$\tau_l(s,n)\,\mu(s,n) = E\left[\widetilde{M}'\alpha A'\right| s\right], \tag{26}$$

$$\frac{n}{\Gamma(s,n)} = (1-\theta)\, q_K(s,n)\left[1-k^l(s,n)\right] + \tau_l(s,n)\, k^l(s,n), \tag{27}$$

$$G'(i(s,n)) = q_K(s,n), \tag{28}$$

$$c(s,n) + g(i(s,n)) + h\left(k^l(s,n)\right)\Gamma(s,n) = A, \tag{29}$$

$$\tau_l(s,n) = q_K(s,n)\left[1 + h'\left(k^l(s,n)\right)\right] - E\left[M' q_K(s',n')(1-\delta)\right| s\right], \tag{30}$$

$$k^o(s,n) + k^l(s,n) = 1. \tag{31}$$

*where the law of motion of $n$ is given by (20), and the stochastic discount factors $M'$ and $\widetilde{M}'$ are defined in (A5) and (A6). 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). Firm's value function is of the form $V_t^i(N_{i,t}, z_{i,t+1}) = \mu(s_t,n_t)\, N_{i,t} + \xi(s_t,n_t)\left(K_t^o + K_t^l\right) z_{i,t+1}$. And the normalized policy functions are constructed as:*

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

   *The normalized value function $\zeta(s_t,n_t)$ is given in Equation (A16) in Section Appendix A in the Appendix.*

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

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

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

3. *Given the aggregate quantities, the individual entrepreneurs' net worth follows from (4). Given the sequences $\{N_{i,t}\}$, the quantities $B_{i,t}, K_{i,t}^o$ and $K_{i,t}^l$ 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.

**Proof**. See Section Appendix A in the Appendix.

The above proposition implies that we can solve for aggregate quantities first, and then use the firm-level budget constraint and the law of motion of idiosyncratic productivity to construct the cross-section of net worth and capital holdings. Note that our construction of the equilibrium allows for $\eta(s,n) = 0$ for some values of $(s,n)$. That is, our general setup allows for occasionally binding constraints. Numerically, we use a local approximation method to solve the model by assuming the constraint is always binding.

In our model, the value function $V_t^i(N_{i,t}, z_{i,t+1}) = \mu(s_t, n_t) N_{i,t} + \xi(s_t, n_t)\left(K_t^o + K_t^l\right) z_{i,t+1}$ has two components: $\mu(s_t, n_t) N_{i,t}$ is the present value of net worth and $\xi(s_t, n_t)\left(K_t^o + K_t^l\right) z_{i,t+1}$ is the present value of profit. In the special case of constant return to scale, $\xi(s_t, n_t) = 0$ because firms do not make any profit. The general expression for $\xi(s,n)$ is provided as Equation (A16) in Appendix Appendix A. By the above proposition, other equilibirum quantities are jointly determined by conditions (23) to (31) independent of the functional form of $\xi(s,n)$. This is because $z_{i,t+1}$ is exogenously given and does not affect the determination of equilibrium optimality conditions.

The above conditions have intuitive interpretations. Equation (23) is the household's intertemporal Euler equation with respect to the choice of the risk-free asset. Equation (24) is the firm's optimality condition for the choice of debt. Equations (25) and (26) are the firm's first-order conditions with respect to the choice of the owned and leased capital. Equation (27) is the binding budget constraint of firms, Equation (28) is the optimality condition for capital goods production, Equation (29) is the aggregate resource constraint, and Equation (30) gives the determination equation of leasing fee implied by competitive lessor's first order condition. Equation (31) is an accounting identity that the proportion of two types of capital summing up to 1. Proposition **??** implies that conditions (23)-(31) are not only necessary but also sufficient for the construction of the equilibrium quantities.

In our model, because leased capital can perfectly substitute for owned capital in production and both types of capital are freely traded on the market, the marginal product of capital must be equalized within and across firms. The trading of capital therefore equalizes the Lagrangian multiplier of the financial constraints across firms. This is the key feature of our model that allows us to construct a Markov equilibrium without having to include the distribution of capital as a state variable.[13]

[13]Because of these simplifying assumptions, our model is silent on why some firms are constrained and others are not.

## 4.2 Optimal Lease and Buy Decision

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 define the user costs of purchased and leased capital in the presence of collateral constraint and aggregate risks by extending the definition of Jorgenson (1963). The optimal lease versus buy decision is achieved when the user costs of purchased and leased capital are equalized. The definitions in this section clarify a new insurance channel (risk premium channel) of leased capital, which has not been emphasized in prior literature.

The user cost of purchased capital, $\tau_{o,t}$ is determined as:

$$\begin{aligned}\tau_{o,t} &= q_{K,t}\left(1-\theta\right) - E_t\left[\frac{\widetilde{M}_{t+1}}{\mu_t}\left\{\left(1-\delta\right)q_{K,t+1} - R_{f,t+1}\theta q_{K,t}\right\}\right], &(32)\\ &= q_{K,t} - E_t\left[\frac{\widetilde{M}_{t+1}}{\mu_t}\left(1-\delta\right)q_{K,t+1}\right] - \theta q_{K,t}\frac{\eta_t}{\mu_t}. &(33)\end{aligned}$$

The interpretation is that the user cost of purchased 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. Or an alternative interpretation based on the second equality is that the user cost of purchased capital is equal to the current price, $q_{K,t}$, minus the discounted resale value after discount, and also substract the marginal value of relaxing the collateral constraint for owning this capital. A similar interpretation applies to the user cost of leased capital, $\tau_{l,t}$, as we demonstrated in equation (12). One key observation is that, due to the fact that entrepreneurs are financial constrained while the competitive lessor is unconstrained, they use different stochastic discount factors, i.e. $\widetilde{M}_{t+1}$ versus $M_{t+1}$, to evaluate the resale value, and therefore, create a wedge of their valuations. This wedge has two consequences: first, it implies that entrepreneurs have to pay a premium if using internal funds borrowed from other entrepreneurs to purchase capital; second, it also lead to a "cheap" insurance mechanism for entrepreneurs through leasing. To further illustrate this intuition. Let us first define two important wedges to reveal the relationship. First, we denote a shadow interest rate for the borrowing and lending among entrepreneurs $R_{I,t}$, and it is determined by:

$$1 = E_t\left[\frac{\widetilde{M}_{t+1}}{\mu_t}\right]R_{I,t}. \tag{34}$$

Based on equation (16) and the above definition (34), we can derive that there is a wedge,

$\Delta_{f,t}$, between two interest rates,

$$\Delta_{f,t} = R_{I,t} - R_{f,t} = \frac{\eta_t}{\mu_t} R_{I,t}.$$

When the collateral constraint is binding ($\eta_t > 0$), this wedge becomes strictly positive. It reflects a premium that entrepreneurs has to pay for the loans among themselves, when cheaper household loans become unaccessible due to a binding collateral constraint. Second, we denote an risk premium wedge, $\Delta_{rp,t}$, as the difference between the insurance premium evaluated by entrepreneurs' and lessors' respective stochastic discount factors, as below:

$$\Delta_{rp,t} = -Cov_t\left(\frac{\widetilde{M}_{t+1}}{\mu_t}, q_{K,t+1}\right) + Cov_t\left(M_{t+1}, q_{K,t+1}\right).$$

Due to the collateral constraint, entrepreneurs' augmented stochastic discount factor $\frac{\widetilde{M}_{t+1}}{\mu_t}$ is more volatile, or, in another word, entrepreneurs are effectively more risk averse than non-financially constrained competitive lessors. Therefore, they value the embedded insurance mechanism more than the premium actually charged by the lessor. This risk premium wedge implies a benefit of a "cheap" insurance mechanism from perspective of entrepreneurs to rent capital.

With the help of the above two wedges, we can decompose the difference in user costs of leased capital versus purchased capital as below.

$$\begin{aligned}\tau_{l,t} - \tau_{o,t} &= q_{K,t} h'\left(\frac{K^l_{t+1}}{K_{t+1}}\right) + \theta q_{K,t}\frac{\Delta_{f,t}}{R_{f,t}+\Delta_{f,t}} \\ &\quad -\frac{1}{R_{f,t}}\left(1-\delta\right) E_t\left(q_{K,t+1}\right)\frac{\Delta_{f,t}}{R_{f,t}+\Delta_{f,t}} - \left(1-\delta\right)\Delta_{rp,t},\end{aligned}$$

The first two terms on the right hand side of the above equation reflect the cost of leasing: leasing will incur a monitoring cost due to the agency problem, and give up the marginal value of relaxing the collateral constraint by owning the capital. The remaining two terms characterize the benefits of leasing: leasing can save a premium on the borrowing cost $\Delta_{f,t}$ and incur a "cheap" insurance benefit due to the risk premium wedge $\Delta_{rp,t}$. The first benefit of leasing has been emphasized in previous literature, for instance, Eisfeldt and Rampini (2009); Rampini and Viswanathan (2010, 2013), while the second "cheap" insurance channel is the key additional channel we emphasize in our paper.

Consider several special cases. First, if there is neither collateral constraint nor agency cost of leasing, then $\tau_{l,t} - \tau_{o,t} = 0$ always holds. We return to a frictionless neoclassical framework and the asset ownership is indeterminate. Second, if there is no financial friction but leasing incurs an agency cost, $\tau_{l,t} - \tau_{o,t} = q_{K,t} h' \left( \frac{K^l_{t+1}}{K_{t+1}} \right)$ is always positive, then leasing will be strictly dominated by secured loan, and no entrepreneurs chose to rent capital. Third, when both frictions exist and agency cost is assumed to be infinity, we essentially go back to the large literature of macro models with financial frictions which ignore the possibility that firms can rent capital. Lastly, when both frictions exist, but there is no aggregate adjustment cost for the capital good producer, that is, $G(I_t, K_t) = I_t$, then capital price is then fixed, $q_{K,t} = 1$. We can further derive the user cost difference as:

$$\tau_{l,t} - \tau_{o,t} = q_{K,t} h' \left( \frac{K^l_{t+1}}{K_{t+1}} \right) - \frac{\Delta_{f,t}}{(R_{f,t} + \Delta_{f,t})} \left[ \frac{1}{R_{f,t}} (1 - \delta) - \theta \right].$$

Importantly, since capital price does not fluctuate, the risk premium channel $\Delta_{rp,t}$ disappears. The standard trade-off that leasing is a highly collateralizable but costly way borrowing as emphasized in Eisfeldt and Rampini (2009); Rampini and Viswanathan (2010, 2013) still applies. The key contribution of our paper is to point out an additional risk premium channel by building a dynamic lease versus buy decision in to a general equilibrium model with financial frictions and aggregate risks.

## 4.3 Asset Pricing Implications

In this section we study the asset pricing implications of the model both at the aggregate and firm level.

**Leased Capital Spread at the Aggregate Level** 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

$$\begin{aligned} R^{Lev}_{t+1} &= \frac{\alpha A_{t+1} + (1-\delta) q_{K,t+1} - R_{f,t+1} \theta q_{K,t}}{q_{K,t} (1-\theta)}, \\ &= \frac{1}{1-\theta} (R_{t+1} - R_{f,t+1}) + R_{f,t+1}. \end{aligned} \tag{35}$$

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, $R^{Lev}_{t+1}$ 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

$$R^l_{t+1} = \frac{\alpha A_{t+1}}{\tau_{l,t}}, \tag{36}$$

in which $\tau_{l,t}$ is the per-period leasing fee that needs to pay upfront, and $\alpha A_{t+1}$ 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 $R^{Lev}_{t+1}$ 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. 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 $R^l_{t+1}$ 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 $R^{Lev}_{t+1}$.

Combine the two Euler equations, (16) and (18), and eliminate $\eta_t$, we have

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

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

$$E_t\left(R^{Lev}_{t+1} - R^l_{t+1}\right) = -\frac{1}{E_t\left(\widetilde{M}_{t+1}\right)}\left(Cov_t\left[\widetilde{M}_{t+1}, R^{Lev}_{t+1}\right] - Cov_t\left[\widetilde{M}_{t+1}, R^l_{t+1}\right]\right). \tag{37}$$

Undoubtedly, risk premiums are determined by the covariances of the payoffs with respect to the stochastic discount factor, as shown in equation (37). 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 (35). Overall, the right hand side of equation (37) 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.

**Leased Capital Spread at the Firm Level** In our model, equity claims to firms can be freely traded among entrepreneurs. In the calibration, $\nu$ is close toone, and the profit component (the second component) in entrepreneur's value function $V^i_t\left(N_{i,t}, z_{i,t+1}\right) = \mu\left(s_t, n_t\right) N_{i,t} + \xi\left(s_t, n_t\right)\left(K^o_t + K^l_t\right) z_{i,t+1}$ is thus quantitatively much smaller than the net worth component (the first component). Recall that $\xi\left(s, n\right) = 0$ when $\nu = 1$ in Equation (A16) of Appendix Appendix A. The equity return of an entrepreneur is therefore approximately equal to the growth of its net worth, defined as $\frac{N_{i,t+1}}{N_{i,t}}$. Using (1) and (4), we can write this return as

$$
\begin{aligned}
R_{i,t+1} &= \frac{\alpha A_{t+1}\left(K^o_{i,t+1} + K^l_{i,t+1}\right) + (1-\delta)\, q_{K,t+1} K^o_{i,t+1} - R_{f,t+1} B_{i,t}}{N_{i,t}} \\
&= R^{Lev}_{t+1} \frac{(1-\theta) q_{K,t} K^o_{i,t+1}}{N_{i,t}} + R^l_{t+1} \frac{\tau_{l.t} K^l_{i,t+1}}{N_{i,t}}.
\end{aligned}
$$

The above expression has an intuitive interpretation: the firm's equity return is a weighted average of the levered return on purchased asset, $R^{Lev}_{t+1}$, and the return on lease, $R^l_{t+1}$. The weights $\frac{(1-\theta) q_{K,t} K^o_{i,t+1}}{N_{i,t}}$ and $\frac{\tau_{l.t} K^l_{i,t+1}}{N_{i,t}}$ are the proportions the down payment of purchased capital and the total lease fee paid upfront with respect to its net worth, respectively. The weights are sum up to one, as restricted by the budget constraint and the binding collateral constraint.

In our model, $R^{Lev}_{t+1}$ and $R^l_{t+1}$ are common across all firms. As a result, expected returns differ only because of the composition of expenditure on the purchased capital versus the leased capital. The composition of expenditure is equivalently summarized by the leased capital ratio. As shown the next section, this parallel between our model and our empirical results allows our model to match well the quantitative features of the leased capital spread in the data.

# 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 C.

## 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

$$a_t = a_{ss}\left(1-\rho_A\right) + \rho_A a_{t-1} + \sigma_A \varepsilon_{A,t}, \tag{38}$$

where $a_{ss}$ denotes the steady-state value of $a$. Second, as in Ai, Li, and Yang (2017), we also introduce a aggregate shock to entrepreneurs' liquidation probability $\lambda$. 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 (A6), and thus allows to generate stronger asset pricing implications.[14]

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 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 $\gamma$ to be 10 and the intertemporal elasticity of substitution $\psi$ 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, $\alpha$, is set to be 0.26, close to the number used in the standard RBC literature, e.g., Kydland and Prescott (1982) The span of control parameter $\nu$ is set to be 0.85, consistent

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

with Atkeson and Kehoe (2005).

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** |
|---|---|---|
| Relative risk aversion | $\gamma$ | 10 |
| IES | $\psi$ | 2 |
| Capital share | $\alpha$ | 0.26 |
| Span of control parameter | $\nu$ | 0.85 |
| Mean productivity growth rate | $E(\tilde{A})$ | 0.68 |
| Time discount factor | $\beta$ | 0.98 |
| Purchased capital dep. rate | $\delta$ | 0.10 |
| Leased capital dep. rate | $\bar{\delta}_l$ | 0.13 |
| Death rate of entrepreneurs | $E(\lambda)$ | 0.12 |
| Collateralizability parameter | $\theta$ | 0.42 |
| Transfer to entering entrepreneurs | $\chi$ | 0.38 |
| Persistence of TFP shock | $\rho_A$ | 0.96 |
| Persistence of $\lambda$ shock | $\rho_x$ | 0.96 |
| Vol. of $\lambda$ shock | $\sigma_x$ | 0.13 |
| Vol. of productivity shock | $\sigma_A$ | 0.025 |
| Inv. adj. cost parameter | $\zeta$ | 15 |
| Dep. rate $\delta_l$ parameter | $d$ | 4 |
| Mean idio. productivity growth | $\mu_Z$ | 0.02 |
| Vol. of idio. productivity growth | $\sigma_Z$ | 0.05 |

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 $\beta$ 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 capital depreciation rate, $\delta$, is set to be 0.10, consistent to the standard RBC literature (Kydland and Prescott (1982)). 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, $\theta$, and the transfer to entering entrepreneurs, $\chi$, 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 economy, but they are determined by the second moments in the data. The persistence parameter $\rho_A$ and $\rho_x$ are calibrated to be the same at 0.96, roughly matching the autocorrelation of consumption and output growth. The standard deviation of the $\lambda$ shock, $\sigma_x$, and that of the productivity shock, $\sigma_A$, 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, $\zeta$, 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 |

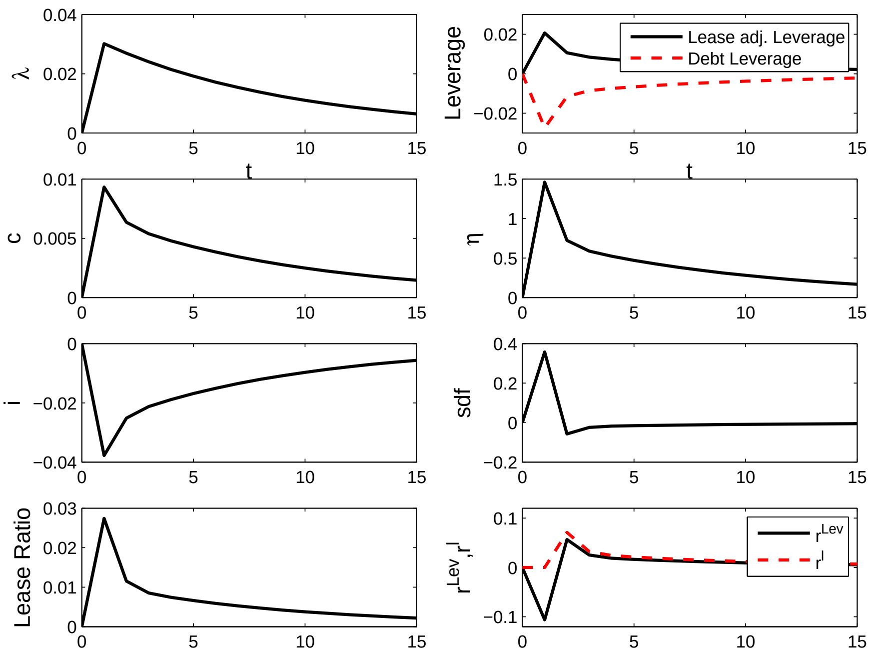
Focusing on the asset pricing moments (bottom panel), we make two observations. First, our model is reasonably successful in generating asset pricing moments at the aggregate level. In particular, it replicates a low and smooth risk free rate, with a mean of 0.82% and a volatility of 1.05%. The equity 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 $\lambda$. 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 $\lambda$. The used parameters are corresponding to Table 3. The only one exception in the above figure is that the financial shock, $\varepsilon_x$, is orthogonal to the productivity shock, $\varepsilon_A$. 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 $\lambda$ (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, $\eta$ (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 (35) and (36), 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 $\lambda$ only affects the resale price $q_{K,t+1}$, but not the dividend, $\alpha A_{t+1}$. 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 Cap. Ratio | 0.19 | 0.43 | 0.59 | 0.71 | 0.72 |
| Purchased Cap. | 1 | 0.95 | 0.74 | 0.62 | 0.47 |
| Debt Lev. | 0.12 | 0.11 | 0.08 | 0.08 | 0.08 |
| Rental Lev. | 0.06 | 0.14 | 0.20 | 0.25 | 0.27 |
| Leased adj. Lev. | 0.19 | 0.26 | 0.28 | 0.33 | 0.34 |
| | | | **Panel B: Model** | | |
| Leased Cap. Ratio | 0.21 | 0.51 | 0.68 | 0.80 | 0.89 |
| Purchased Cap. | 1 | 0.60 | 0.39 | 0.25 | 0.14 |
| Debt Lev. | 0.15 | 0.09 | 0.06 | 0.04 | 0.02 |
| Rental Lev. | 0.08 | 0.20 | 0.27 | 0.32 | 0.36 |
| Leased adj. Lev. | 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]-$R_f$ (%) | 10.90 | 10.87 | 9.40 | 7.27 | 3.55 | 7.35 |
| [t] | 2.50 | 2.48 | 2.09 | 1.61 | 0.80 | 4.17 |
| Std (%) | 26.58 | 27.32 | 27.13 | 27.27 | 27.07 | 11.01 |
| SR | 0.41 | 0.40 | 0.35 | 0.27 | 0.13 | 0.67 |
| | | | **Panel B: Model** | | | |
| E[R]-$R_f$ (%) | 13.64 | 11.45 | 9.56 | 7.73 | 5.80 | 7.84 |
| Std (%) | 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.

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 Cap. Ratio | 0.60 | 0.55 | 0.53 | 0.51 | 0.48 |
| Debt Lev. | 0.06 | 0.07 | 0.07 | 0.08 | 0.12 |
| Rental Lev. | 0.23 | 0.20 | 0.19 | 0.18 | 0.16 |
| | | | **Panel B: Data (K)** | | |
| Leased Cap. Ratio | 0.72 | 0.63 | 0.57 | 0.51 | 0.40 |
| Debt Lev. | 0.05 | 0.06 | 0.07 | 0.09 | 0.13 |
| Rental Lev. | 0.17 | 0.18 | 0.18 | 0.18 | 0.17 |
| Leased adj. Lev. | 0.22 | 0.25 | 0.25 | 0.27 | 0.30 |
| | | | **Panel C: Model** | | |
| Leased Cap. Ratio | 0.89 | 0.79 | 0.67 | 0.50 | 0.23 |
| Debt Lev. | 0.02 | 0.04 | 0.06 | 0.10 | 0.15 |
| Rental Lev. | 0.36 | 0.32 | 0.27 | 0.20 | 0.09 |
| Leased adj. Lev. | 0.38 | 0.36 | 0.33 | 0.30 | 0.24 |

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 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.

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]-$R_f$ (%) | 1.12 | 3.96 | 10.07 | 9.27 | 8.67 | 7.55 |
| [t] | 0.23 | 0.88 | 2.25 | 2.21 | 1.98 | 3.63 |
| Std (%) | 27.71 | 25.9 | 27.09 | 25.49 | 27.5 | 15.23 |
| SR | 0.04 | 0.15 | 0.37 | 0.36 | 0.32 | 0.50 |
| | | | **Panel B: Data (K)** | | | |
| E[R]-$R_f$ (%) | 3.39 | 6.20 | 7.08 | 8.13 | 10.74 | 7.35 |
| [t] | 0.71 | 1.41 | 1.58 | 1.95 | 2.43 | 3.52 |
| Std (%) | 26.99 | 27.28 | 27.38 | 25.96 | 26.68 | 12.64 |
| SR | 0.14 | 0.23 | 0.27 | 0.31 | 0.40 | 0.58 |
| | | | **Panel C: Model** | | | |
| E[R]-$R_f$ (%) | 5.84 | 7.77 | 9.60 | 11.47 | 13.53 | 7.68 |
| Std (%) | 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 |

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 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 Empirical Analysis

In this section, we first present the direct evidence that lessors bear the risk of price fluctuations and earn higher expected returns than lessees. We identify lessor firms and report their average returns and firm characteristics, as the comparison with their counterparts - lessee firms. Second, we provide additional empirical evidence for the negative relation between leased capital ratio and cross-section of stock returns. We perform a battery of asset pricing factor tests to show that such a negative relation is largely unaffected by known return factors for other systematic risks. We then investigate the joint link between leased capital and other firm-level characteristics on one hand and future stock returns in the cross-section on the other using Fama and MacBeth (1973) regressions as a valid cross-check for the positive relation between leased capital ratio and stock returns.

## 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 Standard Industrial Classification (hereafter., SIC 4-digit) level and then study their average returns and firm characteristics. Table B.3 presents the detailed description of business across SIC

4-digit classifications as lessors.[15]

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

This table shows asset pricing test for lessor and lessee firms. We report the pooled portfolio of lessor firms, the lowest and highest quintile portfolios firms (lessee) sorted on leased capital ratios 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 1978 to June 2017. Lessee firms exclude 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. 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** | **EW** | **VW** | **L** | **H** |
| | **Panel A: Portfolio Returns** | | | |
| E[R]-$R_f$ (%) | 14.16 | 8.89 | 10.9 | 3.55 |
| Std (%) | 22.93 | 27.92 | 26.58 | 27.07 |
| SR | 0.62 | 0.32 | 0.41 | 0.13 |
| | **Panel B: Firm Characteristics** | | | |
| Leased Cap. Ratio | 0.32 | 0.35 | 0.19 | 0.72 |
| ROA | 0.13 | 0.17 | 0.12 | 0.04 |
| Tangibility | 0.45 | 0.41 | 0.31 | 0.17 |
| SA | -3.26 | -3.6 | -2.83 | -2.72 |
| WW | -0.28 | -0.37 | -0.20 | -0.18 |
| DIV | 0.57 | 0.68 | 0.13 | 0.14 |
| Rating | 1.69 | 4.26 | 0.17 | 0.20 |
| Number of Firms | 28 | 28 | 227 | 319 |

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 equal-weighted (value-weighted) average excess returns of 14.14 (8.89)% per annum, about 10 (5.5)% 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, the lessor firms feature a higher average profitability (ROA) and tangibility than the lessee firms with high leased capital ratios. This is also coherent to the model implication that the lessee firms pay a expensive leasing fee to

[15]We leave the detailed procedure in Appendix B.5. .

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 payment 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 Operating leverage versus risk insurance channel

Lease payment commitment naturally creates an operating leverage channel and potentially increases the risk of lessee firms. Such an operating channel is opposite to the insurance channel as highlighted in our paper. Given the subtle coexistence of two off-setting channels, the follow-up quantitative question is which channel dominates the other. In Panel A of Table 10, we conduct the double sorting test to investigate and quantify such an off-setting effect. In particular, we present the average returns and rental commitment ratio of our conditional double-sorted (2 by 5) portfolios in Table 10. We use 70th percentile of firm's lease commitment duration in June as the breaking point and sort firms into upper and lower half portfolio.[16] Within each lease commitment duration sorted portfolio, we sorted on leased capital ratio relative to a firm's industry peers. We construct the firm-level lease commitment duration to reflect the timing of lease commitment, which is similar with the equity implied cash flow duration proposed by Dechow, Sloan, and Soliman (2004) as the measure of cash flow duration. The lease commitment duration can be considered as a measure of operating leverage induced by lease activities. A lower lease commitment duration in a firm means that such a lessee firm has committed a fixed flow of lease payment into far future, and, therefore, implies a lower operating leverage effect. In the left panel of Panel A, we report the average excess returns for five portfolios sorted leased capital ratio, as well as for the low-minus-high portfolio. As we zoom in on firms with high lease commitment durations (the lower half of panel A), the average returns of leased capital ratio sorted portfolios display a downward sloping pattern from the lowest to the highest portfolio, but the average return of the long-short portfolio is relatively smaller and statistically insignificant, which suggests that the divergence of the insurance and operating leverage channel offsets against each other. In stark contrast, among firms with low lease commitment durations (the upper half of panel A), we find that the portfolio returns largely decrease across five portfolios and the low-minus-

[16]Details in lease commitment duration refer to Appendix B.2. .

high portfolio return is statistically significant at 1% level. As the result, we provide the directly supporting evidence that the insurance channel relatively dominates the operating leverage channel. In the right panel of Panel A, we report the average rental commitment ratios between low (L) and high (H) portfolios sorted on lease commitment duration. The result consistently shows that rental commitment ratios are lower among firms with shorter lease commitment duration, which further confirms that these firms have a lower operating leverage.

Our interpretation for findings in Table 10 is as follows. First, in contrast to our risk insurance channel, the operating leverage channel has the off-setting effect on the embodied riskiness. As shown in Panel A of Table 10, high lease comment duration firms have higher rental commitment that accounts for a significant proportion in operating expenditure, and therefore the operating leverage is brought into play to increase the riskiness among firms with high leased capital ratios. These two off-setting channels (i.e., the operating leverage and risk insurance) cancel out each other and provide a fairly reasonable explanation for the relatively flat quintile portfolio returns and the insignificant return in the long-short portfolio. However, among the low lease commitment duration firms, the risk insurance channel clearly dominates the operating leverage channel.

In contrast to our risk insurance channel, the operating leverage channel has the off-setting effect on the embodied riskiness. As shown in Panel A of Table 10, high lease comment duration firms have higher rental commitment that accounts for a significant proportion in operating expenditure, and therefore the operating leverage is brought into play to increase the riskiness among firms with high leased capital ratios. These two off-setting channels (i.e., the operating leverage and risk insurance) cancel out each other and provide a fairly reasonable explanation for the relatively flat quintile portfolio returns and the insignificant return in the long-short portfolio. However, among the low lease commitment duration firms, the risk insurance channel clearly dominates the operating leverage channel.

Moreover, to highlight our risk insurance channel, we further present the average returns of our conditional double-sorted (2 by 5) portfolios in Panel B of Table 10. We first use 70th percentile of industry-level price volatility as the breaking point and classify industries into upper and lower half groups.[17] Within each group, we sorted on leased capital ratio relative to a firm's industry peers. Portfolio returns sharply declines across five portfolios, and the low-minus-high portfolio return is statistically significant at 5% level. Both group presents similar pattern, but the return spread is higher among industries with high price volatility.

Our explanation for findings in Panel B of Table 10 is as follows. Firms located in

[17] Details in industry-level price volatility refer to Appendix B.4. .

Table 10: **Conditional Double Sorts**

This table reports average excess returns across two by five portfolios (both Panels) and rental commitment ratios (Panel A). In the left panel of Panel A, we first sort financially constrained firms' stocks into two groups based on their lease commitment duration in June, and then sort firms into five groups based on their leased capital ratios. In the right panel of Panel B, we report the median ratio of rental commitment over capital expenditure (CAPX) and operating income (OIBDP), respectively, between low (L) and high (H) portfolio. In Panel B, we first sort financially constrained firms' stocks into two groups based on their industry-level price fluctuations, and then sort firms into five groups based on their leased capital ratios. The sample is from July 1978 to June 2017 and excludes financial, utility, public administrative, and lessor industries from the analysis. Standard errors are estimated by 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.

| **Panel A: Lease Commitment Duration** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Portfolio Sorts** | | | | | | **Rental Commitment** | |
| | **L** | **2** | **3** | **4** | **H** | **L-H** | **Rental/CAPX** | **Rental/OIBDP** |
| **L** | 10.18 | 8.46 | 7.15 | 7.03 | 2.89 | 7.29 | 0.015 | 0.052 |
| [t] | 2.27 | 2.10 | 1.54 | 1.48 | 0.62 | 3.83 | | |
| **H** | 11.50 | 11.20 | 8.64 | 10.63 | 8.09 | 3.41 | 0.032 | 0.230 |
| [t] | 2.40 | 2.43 | 1.79 | 2.28 | 1.82 | 1.52 | | |

| **Panel B: Price Fluctuations** | | | | | | |
|---|---|---|---|---|---|---|
| | **Portfolio Sorts** | | | | | |
| | **L** | **2** | **3** | **4** | **H** | **L-H** |
| **L** | 10.14 | 10.81 | 10.08 | 8.60 | 5.37 | 4.77 |
| [t] | 2.17 | 2.49 | 2.14 | 1.86 | 1.17 | 2.56 |
| **H** | 10.23 | 9.21 | 7.52 | 4.24 | 2.73 | 7.49 |
| [t] | 2.27 | 2.12 | 1.74 | 0.90 | 0.58 | 2.29 |

high price volatility industries face higher exposures to price fluctuations, and, hence, the advantage of risk insurance becomes prominent through obtaining lease contract to insure price fluctuations. Therefore, we observe a higher return spread among firms in industries with high price volatilities, although we still observed a relative smaller but significant return spread among firms in industries with low price volatilities.

Taken together, both channels co-exist and contribute to the cross-section of stock returns. However, the risk insurance mechanism highlighted in this paper is quantitatively more important. In a nutshell, the insurance channel dominates the lease commitment induced operating leverage channel, and the benefit of insurance channel stands out among firms in industries with high price volatilities.

## 6.3 Asset Pricing Tests

### 6.3.1 Asset Pricing Factor Regressions

In this subsection, we investigate the extent to which the variation in the average returns of the emission-sorted portfolios can be explained by exposure to standard risk factors, including the five factors in Fama and French (2015) (FF5) and the four factors in Hou, Xue, and Zhang (2015) (HXZ).[18] To adjust for risk exposure, we perform time-series regressions of emission-sorted portfolios' excess returns on the Fama and French (2015) five factors (MKT, SMB, HML, the profitability factor-RMW, and the investment factor-CMA) in Panel A, and on the Hou, Xue, and Zhang (2015) q-factors (MKT, SMB, the investment factor-I/A, and the profitability factor-ROE) in Panel B, respectively. 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 %). These betas, together with annualize alphas, are reported in Table 11.

As we show in Table 11, the risk-adjusted returns (intercepts) of the leased capital sorted low-minus-high portfolio remain large and significant, ranging from 8.27% for the Fama and French (2015) five-factor model in Panel A to 7.18% for the Hou, Xue, and Zhang (2015) q-factor model in Panel B, and these intercepts are at least 3 standard errors above zero, in which the t-statistics is far above 1% statistical significance level. Second, the alpha implied by the Fama-French five-factor model is slightly higher than that implied by the HXZ q-factor model, while the risk-adjusted returns implied by both factor models are comparable to the return in the long-short portfolio sorted on leased capital ratio. Third, the return on the low-minus-high portfolio has insignificantly negative betas with respect to both the Fama and French (2015) five-factor model and to the Hou, Xue, and Zhang (2015) q-factor model, including the market, size, value, and investment factor. The only significant loading is the ROE factor with respect to HXZ q-factor model, which implies that firms with low leased capital ratios are more profitable and less constrained to obtain capital through leasing. In summary, results from asset pricing tests in Table 11 suggest that the cross-sectional return spread across portfolios sorted on leased capital ratio cannot be explained by either the Fama and French (2015) five-factor model or the HXZ q-factor model (Hou, Xue, and Zhang (2015)).

[18]The Fama and French factors are downloaded from Kenneth French's data library (http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html). We thank Kewei Hou, Chen Xue, and Lu Zhang for kindly sharing their factors.

Table 11: **Asset Pricing Factor Regressions**

This table shows asset pricing factor regressions for five portfolios sorted on leased capital ratios relative to firm's industry peers, where we use the Fama-French 49 industry classifications and rebalence portfolios at the end of every June. The results use monthly data, where the sample is from July 1978 to June 2017 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. 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 by using Newey-West correction with ***, **, and * indicate significance at the 1, 5, and 10% levels. We include t-statistics in parentheses and annualize the portfolio alphas by multiplying 12. All portfolios returns correspond to value-weighted returns by firm market capitalization.

| | **Panel A: Fama-French Five-Factor Model** | | | | | |
|---|---|---|---|---|---|---|
| **Vairables** | **L** | **2** | **3** | **4** | **H** | **L-H** |
| $\alpha_{\text{FF5}}$ | 5.40 | 5.21 | 3.38 | 0.44 | -2.87 | 8.27 |
| [t] | 2.99 | 3.12 | 2.17 | 0.37 | -1.66 | 3.99 |
| MKT | 1.01 | 1.05 | 1.05 | 1.12 | 1.05 | -0.04 |
| [t] | 31.51 | 25.03 | 36.95 | 33.79 | 35.21 | -0.90 |
| SMB | 1.00 | 0.99 | 1.07 | 1.02 | 1.11 | -0.11 |
| [t] | 18.12 | 14.45 | 21.77 | 18.71 | 23.88 | -1.54 |
| HML | -0.48 | -0.59 | -0.60 | -0.55 | -0.43 | -0.05 |
| [t] | -6.92 | -8.38 | -10.10 | -9.04 | -6.33 | -0.57 |
| RMW | -0.55 | -0.62 | -0.49 | -0.44 | -0.55 | -0.01 |
| [t] | -4.85 | -5.98 | -7.10 | -6.81 | -6.42 | -0.05 |
| CMA | -0.12 | 0.05 | -0.06 | -0.07 | -0.04 | -0.08 |
| [t] | -1.23 | 0.38 | -0.67 | -0.78 | -0.30 | -0.60 |
| | **Panel B: HXZ q-Factor Model** | | | | | |
| $\alpha_{\text{HXZ}}$ | 4.76 | 4.62 | 4.13 | 0.22 | -2.42 | 7.18 |
| [t] | 2.32 | 1.87 | 1.87 | 0.12 | -1.13 | 3.48 |
| MKT | 1.03 | 1.07 | 1.06 | 1.14 | 1.06 | -0.03 |
| [t] | 20.42 | 14.82 | 21.02 | 21.31 | 22.61 | -0.63 |
| SMB | 1.09 | 1.10 | 1.09 | 1.06 | 1.14 | -0.05 |
| [t] | 8.76 | 7.95 | 13.13 | 16.24 | 11.06 | -0.70 |
| I/A | -0.79 | -0.76 | -0.86 | -0.74 | -0.66 | -0.12 |
| [t] | -6.31 | -5.66 | -8.10 | -6.49 | -5.59 | -1.21 |
| ROE | -0.21 | -0.25 | -0.32 | -0.21 | -0.35 | 0.14 |
| [t] | -2.19 | -2.20 | -3.41 | -1.95 | -3.58 | 1.98 |

Overall, results from asset pricing tests in Table 11 show that the cross-sectional return spread across portfolios sorted on leased capital ratio cannot be completely captured by either the Fama and French (2015) five-factor or the HXZ q-factor model (Hou, Xue, and Zhang (2015)). In the following subsection, we reassure the leased capital-return relation by running Fama-Macbeth regressions to control a bundle of firm characteristics.

### 6.3.2 Firm-level Return Predictability Regressions

We further investigate the predictive ability of emissions for the cross-sectional stock returns using Fama-MacBeth cross-sectional regressions (Fama and MacBeth (1973)). This analysis allows us to control for an extensive list of firm characteristics that predict stock returns and to further examine whether the negative leased-capital-ratio-return relation is driven by other known predictors at the firm level.[19]

We conduct cross-sectional regressions for each month from July of year $t$ to June of year $t+1$ as follows:

$$R_{i,t+1} - R_{f,t+1} \quad = \quad a + b \times \textit{Leased Capital Ratio}_{i,t} + c \times \text{Controls}_{i,t} + \varepsilon_{it}. \tag{39}$$

In each month, monthly returns of individual stock returns (annualized by multiplying 12) are regressed on the leased capital ratio of year $t-1$ (which is reported by the end of December of year $t-1$), different sets of control variables that are known by the end of December of year $t-1$, and industry fixed effects. Control variables include the natural logarithm of market capitalization at the end of each June (Size) deflated by the CPI index, the natural logarithm of book-to-market ratio (B/M), investment rate (I/K), profitability (ROA), R&D intensity (R&D/AT), organization capital ratio (OC/AT), and industry dummies based on Fama and French (1997) 49 industry classifications. All independent variables are normalized to a zero mean and a one standard deviation after winsorization at the 1st and 99th percentiles to reduce the impact of outliers.

Table 12 reports the results from cross-sectional predictability regressions performed at a monthly frequency. The reported coefficient is the average slope from monthly regressions 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 $-1.13$, which is 2.79 standard errors from zero. In Specification 2 and 3, we introduce firm-level default probability and failure probability, respectively, as the measure of a firm's financial distress according to Bharath and Shumway (2008) and Campbell, Hilscher, and Szilagyi (2008). We show that coefficients on leased capital ratio

[19]This approach is preferable to the portfolio tests, as the latter requires the specific breaking points to sort firms into portfolios and also requires us to select the number of portfolios. Also, it is difficult to include multiple sorting variables with unique information about future stock returns by using a portfolio approach. Thus, Fama-MacBeth cross-sectional regressions provide a reasonable cross-check.

Table 12: **Fama-Macbeth Regressions**

This table reports the of Fama-Macbeth regressions of individual stock excess returns on their leased capital ratio and other firm characteristics. The sample is from July 1978 to June 2017 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 WW undex, and then 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)** | **(6)** |
|---|---|---|---|---|---|---|
| Lease Cap. Ratio | -1.13 | -1.35 | -0.88 | -1.09 | -1.02 | -1.09 |
| [t] | -2.79 | -3.08 | -2.13 | -2.21 | -2.76 | -2.01 |
| Default Prob. | | -12.50 | | | | -6.76 |
| [t] | | -4.20 | | | | -1.87 |
| Failure Prob. | | | -33.37 | | | |
| [t] | | | -4.19 | | | |
| Redeployability | | | | -0.50 | | -0.76 |
| [t] | | | | -1.21 | | -1.50 |
| Log ME | | | | | 2.20 | 2.15 |
| [t] | | | | | 2.12 | 1.78 |
| B/M | | | | | 4.31 | 5.27 |
| [t] | | | | | 8.84 | 7.30 |
| I/K | | | | | -14.09 | -16.57 |
| [t] | | | | | -4.63 | -3.11 |
| ROA | | | | | 7.10 | 8.03 |
| [t] | | | | | 12.00 | 10.26 |
| OC/AT | | | | | -4.20 | -5.07 |
| [t] | | | | | -7.32 | -6.31 |
| R&D/AT | | | | | 2.27 | 2.83 |
| [t] | | | | | 2.34 | 1.85 |
| Constant | 5.46 | 2.44 | -11.43 | 12.16 | 3.98 | 10.88 |
| [t] | 0.69 | 0.27 | -1.44 | 1.41 | 0.53 | 1.08 |
| Observations | 616,413 | 440,404 | 556,166 | 502,596 | 480,159 | 299,346 |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |

remain significant and even slightly larger in magnitude, even after explicitly controlling for firm-level financial distress measure. As presented in Table 1, firms with high leased capital ratios are less profitable and smaller in size. These characteristics suggest that high leased capital ratio firms might include financial distressed firms. The empirical exercises we conduct here offer two implications. First, the negative leased capital premium is distinctive from the the negative distress-expected return relation as documented in prior literature. Specification 2 and 3 confirm that the predictability of leased capital ratio is not driven by financial distress, and leased capital ratio contains information not captured by financial distress. Second, in fact, our theory might shed some lights on the financial distress puzzle: financial distressed firms are less risky and earn lower average returns, because they tend to rent more capital and receive the insurance from the lease contract. In specification 4, we explicitly control for asset redeployability, where the measure of redeployability refers to Kim and Kung (2016). According to Eisfeldt and Rampini (2009), assets that are easier to redeploy tend to be more leasable. In order to differentiate the key insurance channel in our paper from the asset redepolyability, we introduce an additional variable to control for firm-level redeployability. The estimated coefficient on leased capital ratio is statistically significant at 5% level. Moreover, after controlling variables known to predict stock returns, including size, book-to-market, investment, profitability, organizational capital ratio, and R&D intensity, in Specification 5, we find that the slope of coefficient on the leased capital ratio is still significantly negative and comparable to the benchmark case in Specification 1. On top of that, Specification 6 highlights that the predictability of leased capital ratio is not subsumed by known predictors for stock returns in the literature, when we put all control variables together to run a horse racing test.

# 7 Conclusion

In this paper, we argue leasing is a risk-sharing mechanism: risk-tolerant lessors (capital owners) effectively provide insurance to financially constrained risk-averse lessees (capital borrowers) against systematic capital price fluctuations. Through the lens of cross-section of stock returns, we focus on 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 7.35% 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. Both our theory and empirical evidence provide an important caveat to the new leases standard from the asset pricing perspective: lease induced liability and financial debt should not be treated equally on firms' balance sheet, as their implications for firms' equity risks and cost of equity are opposite.

# References


Ai, Hengjie, and Dana Kiku, 2013, Growth to value: Option exercise and the cross section of equity returns, *Journal of Financial Economics* 107, 325–349.

Ai, Hengjie, Kai Li, and Fang Yang, 2017, Financial intermediation and capital reallocation, Technical report, Working Paper.

Albuquerque, Rui, and Hugo Hopenhayn, 2004, Optimal lending contracts and firm dynamics, *Review of Economic Studies* 71, 285–315.

Alchian, Armen A, and Harold Demsetz, 1972, Production, information costs, and economic organization, *The American economic review* 62, 777–795.

Altman, Edward I, 1968, Financial ratios, discriminant analysis and the prediction of corporate bankruptcy, *The journal of finance* 23, 589–609.

Ang, J., and P. P. Peterson, 1984, The leasing puzzle, *Journal of Finance* 39, 1055–1065.

Atkeson, Andrew, and Patrick J. Kehoe, 2005, Modeling and measuring organization capital, *Journal of Political Economy* 113, 1026–53.

Bansal, Ravi, and Amir Yaron, 2004, Risks for the Long Run: A Potential Resolution, *Journal of Finance* 59, 1481–1509.

Belo, Frederico, Xiaoji Lin, and Fan Yang, 2017, External equity financing shocks, financial flows, and asset prices .

Bharath, Sreedhar T, and Tyler Shumway, 2008, Forecasting default with the merton distance to default model, *The Review of Financial Studies* 21, 1339–1369.

Brunnermeier, Markus K., Thomas Eisenbach, and Yuliy Sannikov, 2012, Macroeconomics with financial frictions: A survey, Working paper.

Brunnermeier, Markus K, and Yuliy Sannikov, 2014, A macroeconomic model with a financial sector, *American Economic Review* 104, 379–421.

Campbell, J.Y., J. Hilscher, and J. Szilagyi, 2008, Determinants of corporate leasing policy, *Journal of Finance* 63, 2899–2939.

Chu, Yongqiang, 2016, Collateral, ease of repossession, and leases: Evidence from anti-recharacterization laws, *Working paper* .

Dechow, Patricia M, Richard G Sloan, and Mark T Soliman, 2004, Implied equity duration: A new measure of equity risk, *Review of Accounting Studies* 9, 197–228.

Eisfeldt, Andrea L., and Dimitris Papanikolaou, 2013, Organization capital and the cross-section of expected returns, *Journal of Finance* 68, 1365–1406.

Eisfeldt, Andrea L., and Adriano A. Rampini, 2009, Leasing, ability to repossess, and debt capacity, *Review of Financial Studies* 22, 1621–1657.

Elenev, Vadim, Tim Landvoigt, and Stijn Van Nieuwerburgh, 2017, A macroeconomic model with financially constrained producers and intermediaries, Technical report, Working Paper.

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

Falato, Antonio, Dalida Kadyrzhanova, Jae W Sim, Antonio Falato, and Jae 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, Eugene F, and Kenneth R French, 1993, Common risk factors in the returns on stocks and bonds, *Journal of Financial Economics* 33, 3–56.

Fama, Eugene F., and Kenneth R. French, 1997, Industry costs of equity, *Journal of Financial Economics* 43, 153 – 193.

Fama, Eugene F., and Kenneth R. French, 2015, A five-factor asset pricing model, *Journal of Financial Economics* 116, 1–22.

Fama, Eugene F, and James D MacBeth, 1973, Risk, return, and equilibrium: Empirical tests, *Journal of political economy* 81, 607–636.

Farre-Mensa, Joan, and Alexander Ljungqvist, 2016, Do measures of financial constraints measure financial constraints?, *The Review of Financial Studies* 29, 271–308.

Frankel, Marvin, 1962, The production function in allocation and growth: A synthesis, *The American Economic Review* 52.

Gârleanu, Nicolae, Leonid Kogan, and Stavros Panageas, 2012, Displacement risk and asset returns, *Journal of Financial Economics* 105, 491–510.

Gertler, Mark, and Nobuhiro Kiyotaki, 2010, Financial intermediation and credit policy in business cycle analysis, *Handbook of monetary economics* 3, 547–599.

Gomes, Joao, Leonid Kogan, and Lu Zhang, 2003, Equilibrium Cross Section of Returns, *Journal of Political Economy* 111, 693–732.

Gomes, Joao, Ram Yamarthy, and Amir Yaron, 2015, Carlstrom and fuerst meets epstein and zin: The asset pricing implications of contracting frictions, *Working paper* .

Graham, John R, Michael L Lemmon, and James S Schallheim, 1998, Debt, leases, taxes, and the endogeneity of corporate tax status, *The Journal of Finance* 53, 131–162.

Hadlock, Charles J, and Joshua R Pierce, 2010, New evidence on measuring financial constraints: Moving beyond the kz index, *Review of Financial Studies* 23, 1909–1940.

He, Zhiguo, and Arvind Krishnamurthy, 2013, Intermediary asset pricing, *American Economic Review* 103, 732–70.

Hennessy, Christopher a., and Toni M. Whited, 2007, How costly is external financing? Evidence from a structural estimation, *Journal of Finance* 62, 1705–1745.

Hou, Kewei, Chen Xue, and Lu Zhang, 2015, Digesting Anomalies: An Investment Approach, *Review of Financial Studies2* 28, 650–705.

Jermann, Urban, and Vincenzo Quadrini, 2012, Macroeconomic Effects of Financial Shocks, *American Economic Review* 102, 238–271.

Jorgenson, Dale W, 1963, Capital theory and investment behavior, *The American Economic Review* 53, 247–259.

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

Kiyotaki, Nobuhiro, and John Moore, 1997, Credit cycles, *Journal of Political Economy* 105, 211–248.

Kiyotaki, Nobuhiro, and John Moore, 2012, Liquidity, business cycles, and monetary policy, NBER Working Paper.

Kogan, Leonid, and Dimitris Papanikolaou, 2012, Economic activity of firms and asset prices, *Annual Review of Financial Economics* 4, 1–24.

Kogan, Leonid, Dimitris Papanikolaou, and Noah Stoffman, 2017, Winners and losers: Creative destruction and the stock market, Working paper.

Kung, Howard, and Lukas Schmid, 2015, Innovation, growth, and asset prices, *Journal of Finance* 70, 1001–1037.

Kydland, Finn E, and Edward C Prescott, 1982, Time to build and aggregate fluctuations, *Econometrica: Journal of the Econometric Society* 1345–1370.

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

Lin, Xiaoji, 2012, Endogenous technological progress and the cross-section of stock returns, *Journal of Financial Economics* 103, 411–427.

Nikolov, Boris, Lukas Schmid, and Roberto Steri, 2018, The sources of financing constraints, *Working paper* .

Ohlson, James A, 1980, Financial ratios and the probabilistic prediction of bankruptcy, *Journal of accounting research* 109–131.

Quadrini, Vincenzo, 2011, Financial frictions in macroeconomic fluctuations, *Economic Quarterly* 209–254.

Rampini, Adriano, and S. Viswanathan, 2010, Collateral, risk management, and the distribution of debt capacity, *Journal of Finance* 65, 2293–2322.

Rampini, Adriano, and S. Viswanathan, 2013, Collateral and capital structure, *Journal of Financial Economics* 109, 466–492.

Rauh, Joshua D, and Amir Sufi, 2011, Explaining corporate capital structure: Product markets, leases, and asset similarity, *Review of Finance* 16, 115–155.

Romer, Paul M., 1986, Increasing returns and long-run growth, *Journal of Political Economy* 94, 1002 – 1037.

Schmid, Lukas, 2008, A quantitative dynamic agency model of financing constraints, Working paper.

Sharpe, S.A., and H.H. Nguyen, 1995, Capital market imperfections and the incentive to lease, *Journal of Financial Economics* 39, 271–294.

Smith, C., and L.M. Wakeman, 1985, Determinants of corporate leasing policy, *Journal of Finance* 40, 895–908.

Whited, Toni M., and Guojun Wu, 2006, Financial constraints risk, *Review of Financial Studies* 19, 531–559.

Zhang, Lu, 2005, The value premium, *Journal of Finance* 60, 67–103.

# Appendix A: Proof of Proposition 1

We prove Proposition 1 in two steps: first, given prices, the quantities satisfy the household's and the entrepreneurs' optimality conditions; second, the quantities satisfy the market clearing conditions.

To verify the optimality conditions, note that the optimization problems of households and firms are all standard convex programming problems; therefore, we only need to verify first order conditions. Equation (23) is the household's first-order condition. Equation (29) is a normalized version of resource constraint (13). Both of them are satisfied as listed in Proposition 1.

To verify that the entrepreneur $i$'s allocations $\{N_{i,t}, B_{i,t}, K^o_{i,t}, K^l_{i,t}, L_{i,t}\}$ as constructed in Proposition 1 satisfy the first order conditions for the optimization problem in equation (5), note that the first order condition with respect to $B_{i,t}$ implies

$$\mu^i_t = E_t\left[\widetilde{M}_{t+1}\right] R^f_t + \eta^i_t. \tag{A1}$$

Similarly, the first order condition for own capital $K^o_{i,t+1}$ is

$$\mu^i_t = E_t\left[\widetilde{M}^i_{t+1} \frac{\Pi_{K^o}\left(\bar{A}_{t+1}, z_{i,t+1}, K^o_{i,t+1}, K^l_{i,t+1}\right) + (1-\delta)\, q_{K,t+1}}{q_{K,t}}\right] + \theta\eta^i_t. \tag{A2}$$

Finally, optimality with respect to the choice of leased capital $K^l_{i,t+1}$ implies

$$\mu^i_t \tau_{l,t} = E_t\left[\widetilde{M}^i_{t+1} \Pi_{K^l}\left(\bar{A}_{t+1}, z_{i,t+1}, K^o_{i,t+1}, K^l_{i,t+1}\right)\right]. \tag{A3}$$

Next, the law of motion of the endogenous state variable $n$ can be constructed from equation (6):

$$n' = (1-\lambda)\left[\begin{array}{c} \alpha A' + (1-\delta)\, q_K\left(s', n'\right)\left[1 - k^l\left(s, n\right)\right] \\ -\theta q_K\left(s, n\right)\left[1 - k^l\left(s, n\right)\right] R_f\left(s, n\right) \end{array}\right] + \lambda\chi \frac{n}{\Gamma\left(s, n\right)}. \tag{A4}$$

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

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

The stochastic discount factors must be consistent with household utility maximization:

$$M' = \beta \left[\frac{c(s',n')\,\Gamma(s,n)}{c(s,n)}\right]^{-\frac{1}{\psi}} \left[\frac{u(s',n')}{E\left[u(s',n')^{1-\gamma}\right]^{\frac{1}{1-\gamma}}}\right]^{\frac{1}{\psi}-\gamma} \tag{A5}$$

$$\widetilde{M}' = M'[(1-\lambda)\,\mu(s',n') + \lambda]. \tag{A6}$$

In our setup, thanks to the assumptions that the idiosyncratic shock $z_{i,t+1}$ is observed before the decisions on $K^o_{i,t+1}$ and $K^l_{i,t+1}$ are made, we can construct an equilibrium in which $\mu^i_t$ and $\eta^i_t$ are equalized across all the firms because $\frac{\partial}{\partial K^o_{i,t+1}}\Pi\left(\bar{A}_{t+1}, z_{i,t+1}, K^o_{i,t+1}, K^l_{i,t+1}\right) = \frac{\partial}{\partial K^l_{i,t+1}}\Pi\left(\bar{A}_{t+1}, z_{i,t+1}, K^o_{i,t+1}, K^l_{i,t+1}\right)$ are the same for all $i$.

Our next step is to verify the market clearing conditions. Given the initial conditions (initial net worth $N_0$, $N_{i,0} = z_{i,1}N_0$) and the net worth injection rule for the new entrant firms ($N^{entrant}_{t+1} = \chi N_t$ for all $t$), we establish the market clearing conditions through the following lemma. For simplicity, we assume the collateral constraint to be binding. The case in which this constraint is not binding can be dealt with in a similar way.

**Lemma 1.** *The optimal allocations* $\{N_{i,t}, B_{i,t}, K^o_{i,t+1}, K^l_{i,t+1}\}$ *constructed as in Proposition 1 satisfy the market clearing conditions, i.e.,*

$$K^o_{t+1} = \int K^o_{i,t+1}\,di, \quad K^l_{t+1} = \int K^l_{i,t+1}\,di, \quad N_t = \int N_{i,t}\,di \tag{A7}$$

*for all* $t \geq 0$.

First, in each period $t$, given prices and $N_{i,t}$, the individual entrepreneur $i$'s capital decisions $\{K^o_{i,t+1}, K^l_{i,t+1}\}$ must satisfy the condition

$$N_{i,t} = (1-\theta)\,q_{K,t}K^o_{i,t+1} + \tau_{l,t}K^l_{i,t+1} \tag{A8}$$

and the optimal decision rule (14). Equation (A8) is obtained by combining the entrepreneur's budget constraint (1) with a binding collateral constraint (2).

Next, we show by induction, that, given the initial conditions, market clearing conditions (A7) hold for all $t \geq 0$. In period 0, we start from the initial conditions. First, $N_{i,0} = z_{i,1}N_0$, where $z_{i,1}$ is chosen from the stationary distribution of $z$. Then, given $z_{i,1}$ for each firm $i$, we use equations (A8) and (14) to solve for $K^o_{i,1}$ and $K^l_{i,1}$. Clearly, $K^o_{i,1} = z_{i,1}K^o_1$ and $K^l_{i,1} = z_{i,1}K^l_1$. Therefore, the market clearing conditions (A7) hold for $t = 0$, i.e.,

$$\int K^o_{i,1}\,di = K^o_1, \quad \int K^l_{i,1}\,di = K^l_1, \quad \int N_{i,0}\,di = N_0. \tag{A9}$$

To complete the induction argument, we need to show that if market clearing holds for $t+1$, it must hold for $t+2$ for all $t$, which is the following claim:

**Claim 1.** *Suppose* $\int K^o_{i,t+1}\,di = K^o_{t+1}$, $\int K^l_{i,t+1}\,di = K^l_{t+1}$, $\int N_{i,t}\,di = N_t$, *and* $N^{entrant}_{t+1} = \chi N_t$, *then*

$$\int K^o_{i,t+2}\,di = K^o_{t+2} \qquad \int K^l_{i,t+2}\,di = K^l_{t+2} \qquad \int N_{i,t+1}\,di = N_{t+1} \tag{A10}$$

*for all* $t \geq 0$.

1. Using the law of motion for the net worth of existing firms, one can show that the total net worth of all surviving firms can be rewritten as follows:

$$\begin{aligned}&(1-\lambda)\int N_{i,t+1}\,di\\ &= (1-\lambda)\int \left[A_{t+1}\left(K^o_{i,t+1}+K^l_{i,t+1}\right)+(1-\delta)\,q_{K,t+1}K^o_{i,t+1}-R_{f,t}B_{i,t}\right]\,di,\\ &= (1-\lambda)\left[A_{t+1}\left(K^o_{t+1}+K^l_{t+1}\right)+(1-\delta)\,q_{K,t}K^o_{t+1}-R_{f,t}B_t\right],\end{aligned}$$

   since by assumption $\int K^o_{i,t+1}\,di = K^o_{t+1}$, $\int K^l_{i,t+1}\,di = K^l_{t+1}$, and $\int B_{i,t}\,di = B_t = \theta q_{K,t}K^o_{t+1}$. Using the assignment rule for the net worth of new entrants, $N^{entrant}_{t+1} = \chi N_t$, we can show that the total net worth at the end of period $t+1$ across survivors and new entrants together satisfies $\int N_{i,t+1}\,di = N_{t+1}$, where aggregate net worth $N_{t+1}$ is given by equation (6).
2. At the end of period $t+1$, we have a pool of firms consisting of old ones with net worth given by (4) and new entrants. All of them will observe $z_{i,t+2}$ (for the new entrants $z_{i,t+2} = \bar{z}$) and produce at the beginning of the period $t+1$.
   We compute the capital holdings for period $t+2$ for each firm $i$ using (A8) and (14). At this point, the capital holdings and the net worth of all existing firms will not be proportional to $z_{i,t+2}$ due to heterogeneity in the shocks. However, we know that $\int N_{i,t+1}\,di = N_{t+1}$, and $\int z_{i,t+2}\,di = 1$. Integrating (A8) and (14) across all $i$ yields the two equations

$$(1-\theta)\,q_{K,t+1}\int K^o_{i,t+2}\,di \;=\; N_{t+1} \tag{A11}$$

$$\int K^o_{i,t+2}\,di + \int K^l_{i,t+2}\,di \;=\; K^o_{t+2} + K^l_{t+2}, \tag{A12}$$

   where we have used $\int N_{i,t+1}\,di = N_{t+1}$ and $\int z_{i,t+2}\,di = 1$. Given that the constraints of all entrepreneurs are binding, the budget constraint (A8) also holds at the aggregate level, i.e.,

$$N_{t+1} = (1-\theta)\, q_{K,t+1} K^o_{t+2} + \tau_{l,t+1} K^l_{i,t+2}.$$

Together with the above system, this implies $\int K^o_{i,t+2}\, di = K^o_{t+2}$ and $\int K^l_{i,t+2}\, di = K^l_{t+2}$. Therefore, the claim is proved.

In summary, we have proved that the equilibrium prices and quantities constructed in Proposition 1 satisfy the household's and entrepreneur's optimality conditions, and that the quantities satisfy market clearing conditions.

Finally, we provide a recursive relationship that can be used to solve for $\xi(s,n)$ given the equilibrium constructed in Proposition 1. The recursion (5) implies

$$\begin{aligned}\mu_t N_{i,t} + \xi_t z_{i,t+1}\left(K^o_t + K^l_t\right) =& E_t M_{t+1}\left[(1-\lambda)\left(\mu_{t+1} N_{i,t+1} + \xi_{t+1}\left(K^o_{t+1} + K^l_{t+1}\right) z_{i,t+2}\right) + \lambda N_{i,t+1}\right] \\ =& E_t M_{t+1}\left[\left\{(1-\lambda)\,\mu_{t+1} + \lambda\right\} N_{i,t+1} + (1-\lambda)\, z_{i,t+1} E_t M_{t+1} \xi_{t+1}\left(K^o_{t+1} + K^l_{t+1}\right)\right].\end{aligned} \tag{A13}$$

Below, we first focus on simplifying the term $E_t M_{t+1}\left[\left\{(1-\lambda)\,\mu_{t+1} + \lambda\right\} N_{i,t+1}\right]$. Note that a binding collateral constraint together with the entrepreneur's budget constraint (1) implies

$$(1-\theta)\, q_{K,t} K^o_{i,t+1} + \tau_{l,t} K^l_{i,t+1} = N_{i,t}. \tag{A14}$$

Equation (A14) together with the optimality condition (14) determine $K^o_{i,t+1}$ and $K^l_{i,t+1}$ as functions of $N_{i,t}$ and $z_{i,t+1}$:

$$K^o_{i,t+1} = \frac{\tau_{l,t} z_{i,t+1}\left(K^o_{t+1} + K^l_{t+1}\right) - N_{i,t}}{\tau_{l,t} - (1-\theta)\, q_{K,t}}; \quad K^l_{i,t+1} = \frac{N_{i,t} - (1-\theta)\, q_{K,t} z_{i,t+1}\left(K^o_{t+1} + K^l_{t+1}\right)}{\tau_{l,t} - (1-\theta)\, q_{K,t}}. \tag{A15}$$

Using Equation (A15) and the law of motion of net worth (6), we can represent $N_{i,t+1}$ as a linear function of $N_{i,t}$ and $z_{i,t+1}$:

$$\begin{aligned}N_{i,t+1} \;=\;& z_{i,t+1}\alpha A_{t+1}\left(K^o_{t+1} + K^l_{t+1}\right) + (1-\delta)\, q_{K,t+1}\frac{\tau_{l,t} z_{i,t+1}\left(K^o_{t+1} + K^l_{t+1}\right) - N_{i,t}}{\tau_{l,t} - (1-\theta)\, q_{K,t}} \\ & - R_{f,t}\theta q_{K,t}\frac{\tau_{l,t} z_{i,t+1}\left(K^o_{t+1} + K^l_{t+1}\right) - N_{i,t}}{\tau_{l,t} - (1-\theta)\, q_{K,t}}.\end{aligned}$$

Because we are only interested in the coefficients on $z_{i,t+1}$, collecting the terms that involves $z_{i,t+1}$ on both sides of (A13), we have:

$$\xi_t z_{i,t+1}\left(K^o_{t+1} + K^l_{t+1}\right) = z_{i,t+1}\left(K^o_{t+1} + K^l_{t+1}\right) \times Term,$$

where

$$Term = E_t \left[ \tilde{M}_{t+1} \left\{ \begin{array}{c} \alpha A_{t+1} + (1-\delta)\, q_{K,t+1} \frac{\tau_{l,t}}{\tau_{l,t}-(1-\theta) q_{K,t}} \\ -R_{f,t} \theta q_{K,t} \frac{\tau_{l,t}}{\tau_{l,t}-(1-\theta) q_{K,t}} \end{array} \right\} \right] + (1-\lambda)\, E_t \left[ M_{t+1} \xi_{t+1} \right].$$

We can simplify the first term using the first order conditions (24)-(26) to get

$$E_t \left[ \tilde{M}_{t+1} \left\{ \alpha (1-\nu)\, A_{t+1} \right\} \right].$$

Therefore, we have the following recursive relationship for $\xi(A, n)$:

$$\xi(s,n) = [1-\delta+i(s,n)] \left\{ \alpha(1-\nu)\, E\left[ M' \left\{ \lambda + (1-\lambda)\, \mu(s',n') \right\} A' \right] + (1-\lambda)\, E\left[ M' \xi(s',n') \right] \right\}. \tag{A16}$$

The term $\alpha(1-\nu) A'$ is the profit for the firm due to decreasing return to scale. Clearly, $\xi(s,n)$ has the interpretation of the present value of profit. In the case of constant returns to scale, $\xi(s,n) = 0$.

# Appendix B: Additional Empirical Evidence

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

## B.1. Summary Statistics across Industries

In Table B.1, we report the summary statistics of leased capital ratio among firms in each industry according to the Fama and French (1997) 49 (FF49) industry classifications. Firms in some industries are intensive to access capital through leasing, such as the Retail industry and the Apparel industry. There are comparatively large cross-industry variations in leased capital ratio, ranging from 0.76 for the Retail industry to 0.09 for the Coal industry. Therefore, to make sure our results are not driven by any particular industry, we control for industry effects as detailed later.

[Insert Table B.1 Here]

## B.2. Leased Capital Premium (Rental Commitment)

For the robustness, we construct the alternative measure of leased capital, defined as the sum of discounted rental commitments following Rauh and Sufi (2011), and present consistent pattern as we document in Table 1 and Table 2. In Panel A of Table B.2, we report summary statistics of leased capital ratio and leverage for the aggregate and the cross-sectional firms in Compustat. To assure the cross-sectional predictability of the alternative leased capital ratio, we report the time-series averages of the cross-sectional median firm characteristics and average returns across portfolios sorted on the alternative leased capital ratio in Panel B of Table B.2.

[Insert Table B.2 Here]

## B.3. Lease Commitment Duration

We construct firm $i$'s lease commitment duration ($Dur_{i,t}$) to reflect the timing of lease commitment, which is similar with the equity implied cash flow duration proposed by Dechow, Sloan, and Soliman (2004) as the measure of cash flow duration. Lease commitment duration resembles the traditional Maculay duration for bonds, which reflects the weighted average time to maturity of cash flows. The ratio of discounted cash flows to price determines the weights:

$$Dur_{i,t} = \text{Rental Expense}_{i,t} + \frac{\sum_{s=1}^{10}(s+1) \times \text{Commitment}_{i,t+s}/(1+r)^s}{\text{Leased Capital}_{i,t}}, \tag{B17}$$

in which we denote $Dur_{i,t}$ as firm $i$'s lease commitment duration at the end of fiscal year $t$, $\text{Commitment}_{i,t+s}$ is the minimum lease commitment at time $t+s$, the definition of $\text{Leased Capital}_{i,t}$ refers to Section B.2. , and $r$ is the Baa corporate bond rate.[20]

## B.4. Price Fluctuations

We construct the measure of volatility by using the price index of fixed asset and Bureau of Economic Analysis (BEA) fixed asset table. The volatility is constructed in two-step procedures as follows. In the first step, we compute the standard deviation of real price changes (log difference) of asset $h$ at the entire window from 1948 to year 2016[21]. In the second step, we value-weight asset-level volatilities across the 71 assets (equipment and structures)

[20] Rental expenditure occurs at current period. Therefore, we make a slight change in the definition of duration by assigning the beginning weight of lease commitment to be 2, but all the results remain robust when the weight starts from 1.

[21] The asset-level price index is deflated by CPI index.

in the BEA table to obtain an industry-level price volatility $Vol_{j,t}$:

$$Vol_{j,t} = \sum_{h=1}^{71} w_{h,j,t} \times Vol_{h,j},$$

where $Vol_{j,t}$ is a measure of price volatility for industry $j$ in year $t$, $w_{h,j,t}$ represents industry $j$'s capital stocks on asset $h$ divided by its total capital stocks in year $t$ from the BEA table, and $Vol_{h,j}$ is the price volatility of asset $h$ employed by industry $j$. The resulting price volatility represents a relative price volatility ranking of each industry's asset composition. Finally, we take a time-series average of the industry $j$ price volatility.[22]

## B.5. Lessor Industries

Our strategy to identify lessor is a two-stage procedure. First, we identify lessor industries according to the description of business for each SIC 4-digit industry. In particular, we searched the U.S. Census Bureau and SICCODE[23], 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.

Second, we zoom in on firms classified into these identified industries in CRSP-Compustat merged universe from July 1977 to June 2017. We identify lessors firms by manually reading each firm's 10K financial statements. In the item 1 in the Part I, a firm's financial statement reviews its business and provide detailed description for its operation and performance. As a result, the second stage enables us to exactly identify a lessor firm. In Table B.3, we report firm-year observations of identified lessors across SIC 4-digit industries.

[Insert Table B.3 Here]

[22] Given that the asset- and industry-level volatility are highly persistent, time-series averages are innocuous for our analysis.

[23] The website of the U.S. Census Bureau is `https://www.census.gov/`, and the website of SICCODE is (`https://siccode.com/en/pages/what-is-a-sic-code`)

Table B.1: **Leased Capital Ratio across Fama-French 49 Industries**

This table reports summary statistics of the firm-year observations of non-missing leased capital ratio across industries, including mean (Mean), standard deviation (Std), and firm-year observations (Obs). Industries are based on Fama-French 49 industry classifications (FF49) and exclude utility, financial, public administrative, and lessor industries. The sample period is 1977 to 2016.

| **FF49** | **Industry Name** | **Mean** | **Std** | **Obs** |
|---|---|---|---|---|
| 43 | Retail | 0.76 | 0.23 | 2,956 |
| 10 | Apparel | 0.74 | 0.27 | 1,009 |
| 36 | Computer Software | 0.73 | 0.20 | 4,787 |
| 11 | Healthcare | 0.67 | 0.28 | 1,689 |
| 33 | Personal Services | 0.67 | 0.28 | 880 |
| 8 | Printing and Publishing | 0.63 | 0.31 | 558 |
| 34 | Business Services | 0.63 | 0.29 | 4,688 |
| 13 | Pharmaceutical Products | 0.58 | 0.29 | 3,407 |
| 42 | Wholesale | 0.58 | 0.28 | 3,266 |
| 5 | Tobacco Products | 0.56 | 0.27 | 25 |
| 35 | Computers | 0.56 | 0.25 | 2,706 |
| 9 | Consumer Goods | 0.53 | 0.29 | 1,343 |
| 24 | Aircraft | 0.53 | 0.26 | 279 |
| 32 | Communication | 0.52 | 0.27 | 783 |
| 6 | Recreation | 0.51 | 0.32 | 905 |
| 22 | Electrical Equipment | 0.51 | 0.29 | 2,550 |
| 38 | Measuring and Control Equipment | 0.51 | 0.30 | 2,258 |
| 44 | Restaurants, Hotels, Motels | 0.51 | 0.25 | 1,562 |
| 12 | Medical Equipment | 0.49 | 0.28 | 2,929 |
| 18 | Construction | 0.49 | 0.32 | 727 |
| 37 | Electronic Equipment | 0.48 | 0.29 | 5,140 |
| 3 | Candy and Soda | 0.46 | 0.25 | 131 |
| 16 | Textiles | 0.44 | 0.26 | 444 |
| 7 | Entertainment | 0.41 | 0.30 | 808 |
| 21 | Machinery | 0.41 | 0.29 | 2,150 |
| 23 | Automobiles and Trucks | 0.34 | 0.27 | 625 |
| 41 | Transportation | 0.34 | 0.37 | 844 |
| 2 | Food Products | 0.33 | 0.26 | 888 |
| 15 | Rubber and Plastic Products | 0.33 | 0.23 | 712 |
| 39 | Business Supplies | 0.33 | 0.25 | 334 |
| 20 | Fabricated Products | 0.29 | 0.23 | 253 |
| 14 | Chemicals | 0.28 | 0.29 | 865 |
| 17 | Construction Materials | 0.28 | 0.26 | 1,624 |
| 40 | Shipping Containers | 0.28 | 0.23 | 194 |
| 25 | Shipbuilding, Railroad Equipment | 0.27 | 0.24 | 56 |
| 26 | Defense | 0.22 | 0.22 | 120 |
| 1 | Agriculture | 0.19 | 0.28 | 206 |
| 19 | Steel Works Etc | 0.19 | 0.21 | 542 |
| 29 | Coal | 0.19 | 0.16 | 52 |
| 4 | Beer and Liquor | 0.18 | 0.21 | 194 |
| 27 | Precious Metals | 0.09 | 0.22 | 185 |
| 28 | Non-Metallic and Industrial Metal Mining | 0.09 | 0.26 | 227 |
| 30 | Petroleum and Natural Gas | 0.09 | 0.17 | 2,507 |

Table B.2: **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 the sum of discounted rental commitments following Rauh and Sufi (2011). 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 medians of these variables at fiscal year end. In Panel B, we report the time-series average of the cross-sectional median firm characteristics and average excess returns over the risk-free rate E[R]-$R_f$, standard deviations Std, and Sharpe ratios SR 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 C. The sample is from July 1978 to June 2017 and excludes financial, utility, public administrative, and lessor industries from our analysis.

| **Panel A: Pooled Statistics** | | |
|---|---|---|
| | **Const.** | **Unconst.** |
| **Variables** | **Median** | |
| Lease Cap. Ratio | 0.32 | 0.15 |
| Debt Lev. | 0.06 | 0.17 |
| Rental Lev. | 0.06 | 0.04 |
| Lease adj. Lev. | 0.17 | 0.25 |

| **Panel B: Univariate Portfolio Sort** | | | | | | |
|---|---|---|---|---|---|---|
| **Variables** | **L** | **2** | **3** | **4** | **H** | **L-H** |
| | **Portfolio Returns** | | | | | |
| E[R]-$R_f$ (%) | 9.80 | 9.95 | 8.71 | 8.22 | 4.72 | 5.09 |
| [t] | 2.38 | 2.47 | 1.82 | 1.83 | 1.07 | 3.11 |
| Std (%) | 24.93 | 25.42 | 27.63 | 28.3 | 27.04 | 10.51 |
| SR | 0.39 | 0.39 | 0.32 | 0.29 | 0.17 | 0.48 |
| | **Firm Characteristics** | | | | | |
| Lease Cap. Ratio | 0.11 | 0.37 | 0.60 | 0.73 | 0.83 | |
| Debt Lev. | 0.09 | 0.08 | 0.05 | 0.03 | 0.02 | |
| Rental Lev. | 0.03 | 0.11 | 0.18 | 0.23 | 0.26 | |
| Lease adj. Lev. | 0.16 | 0.23 | 0.28 | 0.31 | 0.34 | |

Table B.3: **SIC 4-Digit Code Combination for Leasing Industries**

This table presents SIC 4-digit code combination for leasing industries with corresponding description of business across these industries and firm-year observations across these industries. The sample period is from 1977 to 2016.

| SIC | Industry Name | Obs |
|---|---|---|
| 1389 | Oil and Gas Field Services, Not Elsewhere Classified | 8 |
| 4119 | Local Passenger Transportation, Not Elsewhere Classified | 2 |
| 4213 | Trucking, except Local | 36 |
| 4222 | Refrigerated Warehousing and Storage | 22 |
| 4499 | Water Transportation Services, Not Elsewhere Classified | 14 |
| 4581 | Airports, Flying Fields, and Airport Terminal Services | 6 |
| 4724 | Travel Agencies | 8 |
| 4812 | Radiotelephone Communications | 23 |
| 4813 | Telephone Communications, except Radiotelephone | 70 |
| 6211 | Security Brokers, Dealers, and Flotation Companies | 84 |
| 6512 | Operators of Nonresidential Buildings | 112 |
| 6513 | Operators of Apartment Buildings | 14 |
| 6519 | Lessors of Real Property, Not Elsewhere Classified | 55 |
| 6531 | Real Estate Agents and Managers | 79 |
| 6792 | Oil Royalty Traders | 14 |
| 7213 | Linen Supply | 35 |
| 7353 | Heavy Construction Equipment Rental and Leasing | 7 |
| 7359 | Equipment Rental and Leasing, Not Elsewhere Classified | 184 |
| 7363 | Help Supply Services | 7 |
| 7374 | Computer Processing and Data Preparation and Processing Services | 76 |
| 7377 | Computer Rental and Leasing | 33 |
| 7381 | Detective, Guard, and Armored Car Services | 17 |
| 7513 | Truck Rental and Leasing without Drivers | 71 |
| 7514 | Passenger Car Leasing | 33 |
| 7819 | Services Allied to Motion Picture Production | 15 |
| 7922 | Theatrical Producers and Miscellaneous Theatrical Services | 12 |
| 7999 | Amusement and Recreation Services, Not Elsewhere Classified | 122 |
| 8231 | Libraries | 4 |

# Appendix C: 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 4999, finance firms that have SIC codes between 6000 and 6999 (finance, insurance, trusts, and real estate sectors), public administrative firms that have SIC codes between 9000 and 9999, and lessor industries as we summarized in Appendix B.5. . 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.

## C.1. More Detailed Firm Characteristics

Table C.4 documents how differences in firms' leased capital ratios are related to their characteristics. We report average leased capital ratios and other characteristics across five portfolios sorted on leased capital ratio for financially constrained firms.

[Insert Table C.4 Here]

Averaging speaking, our sample contains $1,348$ 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 227 to 319. The cross-sectional variations in leased capital ratios are large, ranging from 0.09 to 0.84 across five portfolios sorted on leased capital ratio. 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 ratios 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 for a firm's 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 (ROA) 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 quintile. 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, our financial distress measures point out to the same direction that firms with higher leased capital tend to be distressed firms. This finding implies a positive relation between financial distress and leasing. Finally, as documented in the literature, high redeployable assets are easily to use for leasing. However, we observe a flat pattern of redeployability across five portfolios.

In summary, firms with a high leased capital ratio tend to have higher intangible capital, as measured of 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 C.4: **Firm Characteristics**

This table reports time-series averages of the cross-sectional median 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 1978 to June 2017 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 (Leased adj. I/K) is investment (CAPX) over the sum of leased and purchased capital (PPENT). Profitability (ROA) 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 (R&D/AT) 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). Z index refers to Altman (1968). Default probability (Default Prob.) refers to Bharath and Shumway (2008). Failure probability (Failure Prob.) refers to Campbell, Hilscher, and Szilagyi (2008). Redeployability refers to Kim and Kung (2016). Data on redeployability measures is from Kung's Website. The detailed definition of the variables is listed in Appendix C.

| **Variables** | **L** | **2** | **3** | **4** | **H** |
|---|---|---|---|---|---|
| Leased Cap. Ratio | 0.09 | 0.41 | 0.59 | 0.74 | 0.84 |
| B/M | 0.67 | 0.61 | 0.61 | 0.61 | 0.62 |
| q | 1.33 | 1.41 | 1.42 | 1.44 | 1.40 |
| I/K | 0.18 | 0.24 | 0.27 | 0.30 | 0.30 |
| Lease adj. I/K | 0.15 | 0.13 | 0.10 | 0.07 | 0.05 |
| ROA | 0.10 | 0.10 | 0.09 | 0.08 | 0.05 |
| OC/AT | 0.18 | 0.24 | 0.27 | 0.30 | 0.30 |
| R&D/AT | 0.15 | 0.13 | 0.10 | 0.07 | 0.05 |
| Tangibility | 0.28 | 0.24 | 0.18 | 0.12 | 0.09 |
| Lease adj.Tangibility | 0.32 | 0.35 | 0.35 | 0.35 | 0.37 |
| Book Lev. | 0.21 | 0.22 | 0.19 | 0.16 | 0.14 |
| SA | -2.65 | -2.71 | -2.67 | -2.58 | -2.46 |
| O | 1.81 | 2.05 | 2.19 | 2.37 | 2.71 |
| Z | 3.93 | 3.79 | 3.84 | 3.86 | 3.63 |
| Default Prob. | 0.43 | 0.43 | 0.32 | 0.57 | 0.88 |
| Failure Prob. | 0.08 | 0.09 | 0.10 | 0.12 | 0.15 |
| Redeployability | 0.41 | 0.41 | 0.41 | 0.41 | 0.42 |
| Number of Firms | 227 | 241 | 281 | 280 | 319 |

Table C.5: **Definition of Variables**

| **Variables** | **Definition** | **Sources** |
|---|---|---|
| Leased Cap. 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. | Compustat (Annual) |
| Tobin's 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) |
| ROA | The ratio of operating income before depreciation (OIBDP) over total assets (AT). | Compustat (Annual) |
| OC/AT | Following Eisfeldt and Papanikolaou (2013). | 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 adj. Tangibility | Purchased capital divided by the sum of leased capital (10 times XRENT) and total assets (AT). | Compustat (Annual) |
| Book Lev. | The sum of long-term liability (DLTT) and current liability (DLCT) divided by total assets (AT). | Compustat (Annual) |
| Debt Lev. | The ratio of Long-term debt (DLTT) to the sum of leased capital and total assets (AT). | Compustat |
| Rental Lev. | The ratio of leased capital (10 times XRENT) to the sum of leased capital and total assets (AT). | Compustat (Annual) |
| Lease adj. Lev. | The sum of debt and rental leverage. | Compustat (Annual) |
| SA Index | Following Hadlock and Pierce (2010). | Compustat (Annual) |
| WW Index | Following Whited and Wu (2006). | Compustat (Annual) |
| DIV | Following Farre-Mensa and Ljungqvist (2016). | Compustat (Annual) |
| O Index | Following Ohlson (1980). | Compustat (Annual) |
| Z Index | Following Altman (1968). | Compustat (Annual) |
| Default Probability | Following Bharath and Shumway (2008). | Compustat (Annual) |
| Failure Probability | Following Campbell, Hilscher, and Szilagyi (2008). | CRSP; Compustat (Annual) |
| Redeployability | Following Kim and Kung (2016). | Howard Kung's Website |