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# NANYANG TECHNOLOGICAL UNIVERSITY

## SCHOOL OF SOCIAL SCIENCES


# Do Intangible Assets Support Financial Leverage? A Study on the US Public Firms

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**ABSTRACT**

This paper analyzes how intangible assets affect a firm's financial leverage by studying the pool of the US publicly listed companies from 2009 to 2021. The article emphasizes the significance of intangible assets in modern businesses, including patents, copyrights, and computer software. By setting the effect of tangible assets on financial leverage as a benchmark, the study seeks to determine relative strength of the intangible assets on supporting debt as collaterals. The Peters & Taylor (2017) technique of estimating intangible assets is used in this study, which draws the sample from 3,416 unbalanced panel data of non-financial US companies listed on stock exchanges between 1975 and 2021. To ensure the reliability of the results, the regression analysis accounts for other determinants of leverage as control variables and provides industry-controlled results using Two-Way Fixed Effects Model (TWFEM). The primary findings of the study show a small, positive and mildly significant effect for intangible assets on financial leverage, as compared to the strongly significant and positive effect of tangible assets. The paper also reveals that such effects of intangible assets have improved significantly for firms with high tangibility in the recent period of 2016-2021 from 2009-2015. To ensure robustness of the regression results, the sensitivity analyses are conducted on the coefficients of the TWFEM to test for potential attenuation bias from measurement errors in intangible asset estimates and survivorship bias from the sample selection. The robustness analysis results suggest that the impact of intangible assets on financial leverage is reasonably robust against the survivorship bias. Despite the measurement errors in intangible asset estimates, financial leverage is still found as significantly supported by the book value of intangible assets, holding other factors constant. Hence, the analysis indicates that the identifiable features of the intangible assets play an important role in supporting the financial leverage. The study concludes that the US listed firms with intangible assets could make more informed financing decisions by understanding the link between intangible assets and financial leverage better, which could also help valuations of businesses with high intangible asset holdings. Therefore, this paper contributes to the growing literature on intangible assets and its significance in financing decisions.

**Keywords:** Intangible Assets, Tangible Assets, Financial Leverage, Asset Collateralization, Determinants of Financial Leverage

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# 1. INTRODUCTION

Intangible assets are known to be valuable to firms, from the patents of pharmaceutical firms to key technologies of technology firms. Intangible assets play an important role to the success of the firms but there is yet to have enough research to study the effects intangible assets have on the firms' leverage. As we see in the digital age where we are shifting from the traditional industry to an economy based on information and communication technologies, we see a boom in the technology field, and it is becoming a prominent sector in the United States (US) (Increditools, 2022). Knowing how important intangible assets are to many firms, we ought to study how they would affect the financial decisions the firms make.

The paper's main objective is to document the relationship between intangible assets and financial leverage of the public firms in the US. Based on theory, we know that tangible assets serve as a collateral, allowing firms with a greater proportion of tangible assets on the balance sheet to have a higher leverage as lenders are more willing to loan them (Rajan & Zingales, 1995). With intangible assets gaining importance for firms, it is crucial to document how it affects their leverage. The firms will be able to make more informed financing decisions by accounting for their intangible asset holdings. Studying this relationship could provide a stronger theoretical background for corporate financing decisions and valuation of firms that are intangible asset heavy. Additionally, we are able to analyze the relative emphasis placed on intangible assets across the US industries. Our findings will serve to contribute to the limited literature that is available on this topic. This paper will provide more current findings based on the latest data and pursue accuracy of results by utilizing a large sample size of readily available financial statement data.

The aim of this paper is to explore the effect of intangible assets on the financial leverage of listed firms in the US. This leads us to our research question – do intangible assets support the financial leverage of the public firms in the US.

### 1.1. Hypothesis

This paper tests the following hypotheses to examine the relationship between intangible assets and financial leverage. Holding other factors constant:

Null Hypothesis ($H_0$): Intangible assets have no effect on the financial leverage

Alternative Hypothesis ($H_\alpha$): Intangible assets have positive effect, or support financial leverage

Our alternative hypothesis is that the more a firm holds intangible assets, it will help increase the firm's financial leverage, as more valuable assets can be collateralized. As intangible assets take up a greater proportion in many firms, they may become important assets for leverage by valuing them differently from tangible assets (Ellis and Jarboe, 2010). We set the effects of tangible assets on financial leverage as the benchmark for comparison, as intangible assets incur greater difficulties in asset valuation and collateralization. Hence, we expect a positive sign for the coefficient of intangible assets but not as large in magnitude as compared to tangible assets' coefficients. We also expect marginally significant coefficients of intangible assets relative to the significant tangible asset effects.

## 2. LITERATURE REVIEW

### 2.1. Tangible and Intangible Assets Do Not Support Leverage

Pecking-order theory indicates that firms have a hierarchy of financing preference which they will prefer using internal financing over debt, followed by equity (Murray & Vidhan, 2013). Firms prefer internal financing to raise funds to avoid adverse selection problems from external financing where asymmetric information is exploited (Zhu & Zhang, 2021). Assets are one of the internal resources used for internal financing by improving firms' profitability and cash flow. Thus, Pecking-order theory predicts a negative relationship between assets and leverage.

Psillaki and Daskalakis (2008) find that large holdings of tangible assets will provide more internal financing and thus discourage firms from external financing. This aligns with Pecking-order theory as firms with more tangible assets will utilize internal funds from assets over debt financing. Ahmad and

Ali (2017) found both tangible assets and intangible assets have a negative relationship with leverage. However, the negative effect of intangible assets is more significant than that of tangible assets. This reflects the difficulty of intangible assets to be evaluated as collateral for debt financing, resulting in a higher cost of debt and reduced external financing. Unlike tangible assets, intangible assets have higher risk than tangible assets and financial assets (Lev, 2001). Therefore, intangible assets are predicted to increase the preference of firms for internal financing and further discourage firms from debt financing.

### 2.2. Tangible and Intangible Assets Support Leverage

Contrary to Pecking-order theory, Trade-off theory suggests a positive effect of tangible and intangible assets on leverage. Trade-off theory states that there is an optimal level of debt for firms to maximize the advantages of debt tax-shield and minimize the cost of financial distress (Kraus & Lintzenberger, 1973; Myers, 1984). Debt interest expense provides tax-deductible benefits to firms. However, a higher debt level increases the risk of default and financial distress. The theory suggests that firms with more valuable assets can borrow debt at lower costs, therefore borrowing more debt to maximize their value with lower perceived risk.

Prior studies proved that tangible assets positively affect the financial leverage of firms as collateralizable tangible assets can reduce the cost of borrowing, resulting in more loans. Irungu et al. (2018) mentioned tangible assets can reduce the cost of financial distress and enhance the liquidation value of firms. Similarly, Parsons and Titman (2008) found that firms with more tangible assets will use more debt financing in the US market. Firms with a higher proportion of tangible assets can easily obtain loan approval since creditors can efficiently assess the value of these assets as reliable collaterals (Laurie et al., 2012; Lev, 2001; Rajan & Zingales, 1995; Rampini & Viswanathan, 2010).

Collateralizing intangible assets with their higher risk and uncertainty may result in smaller impact on leverage compared to tangible assets (Lev, 2001). Tariq, (n.d.) found that tangible assets have a stronger effect on long-term debt while intangible assets affect short-term debt more. The results indicate that creditors are more willing to give long-term financing to firms with more tangible assets due to stronger collaterals while firms with more intangible assets will rely on short-term loans as it is more expensive and harder for them to secure long-term debt.

Recent studies have challenged the notion that intangible assets have a lesser impact on firms' financial leverage compared to tangible assets. Lim et al. (2020) show that identifiable intangible assets constitute collateral and support debt. The result aligns with other studies which reveal that intangible assets have similar investment value as tangible assets in developed countries (Corrado et al, 2009) and are able to be used as collateral assets for loans and debt repayment to financial institutions (Duan et al, 2019). Peng et al (2020) realized that the effect of intangible assets on capital structure has increased over time, while the impact of tangible assets remains unchanged in publicly listed electronic companies in Taiwan. This suggests that creditors increasingly recognize the profitability generated by intangible assets and release more financing funds to companies (Peng et al., 2021).

### 2.3. Research Gap

With more attention paid to intangible assets in an era that is full of the advancements of intangible assets, it is worth studying the degree of the impact of intangible assets on the leverage of the firm in the US and the changes of its effects on financing over the years.

This paper attempts to contribute to existing literature on this topic by analyzing recent developments from the post Global Financial Crisis in 2009 to 2021. Due to the challenge of estimating intangible assets, our paper pursues accuracy of results by using a large sample size and the intangible asset estimation method by Peters and Taylor (2017) (P&T). The study aims to unravel the detailed relationship between the intangible assets and the financial leverage. The paper contributes to efforts of estimating intangible assets by evaluating one of many possible measurement methods.

# 3. METHODOLOGY

## 3.1. Data Cleaning and Sample Selection

The data is extracted from the Compustat universe of 13,469 firms from 1975 to 2021 in the North American financials database. We selected the annual fundamentals of non-financial[1] companies, publicly listed in the US stock exchanges[2]. The firms with missing or non-positive total assets or sales were excluded. We extracted the relevant dataset of 6,383 firms (126,514 firm-year observations) starting from 1975. This data is used to estimate the intangible assets that the firm has accumulated-to-date, using P&T's perpetual inventory method (Peters & Taylor, 2017). The method accumulates the past R&D (Research and Development) and SG&A (Selling, General and Administrative) expenses reported on the income statements since 1975, which is the year when the FASB (Financial Accounting Standards Board) started requiring firms to report R&D as expenses when incurred (FASB, 1974).

For the regression analysis, we sampled the panel data of 3,416 firms (32,908 firm-year observations) for our specified regression period from 2009 to 2021. This allows to capture the relatively recent, post-financial crisis correlations between the intangible assets and the financial leverage. The sizable reduction in the sample size from restricting the regression period exposes our sample to potential survivorship bias. To mitigate such selection bias, we maximized the sample size by including the delisted and newly listed firms during the regressions period, allowing the panel data to be unbalanced[3].

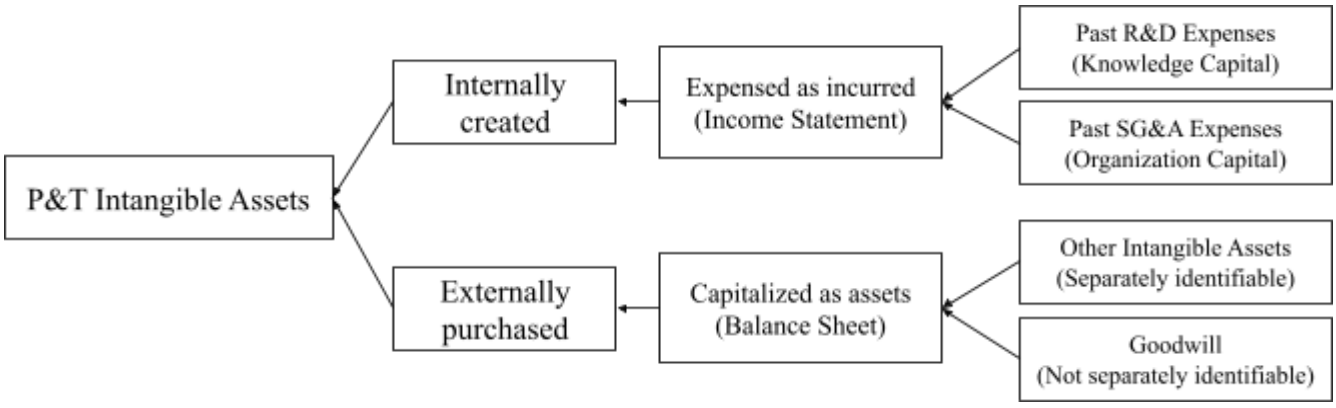
[1] Financial firms were removed based on the Fama-French 12-Industry classification (Kenneth R. French, 2023), Standard Industrial Classification (SIC code) from 6000 to 6999 were removed. Financial industry is excluded to avoid the distortion of the financial leverage in the sample, following the common practice in the literature.
[2] The firms listed on the three major US stock exchanges were extracted: New York Stock Exchange (NYSE), American Stock Exchange (AMEX), and NASDAQ (Compustat exchange code: 11, 12, 14).
[3] The balanced version of the data would result in further loss of the sample, resulting in 1,641 firms (21,333 observations).

### 3.2. Key Variables

3.2.1. Intangible Assets and Tangible Assets Estimations

The P&T method defines a firm's total intangible assets as the sum of externally purchased and internally created intangible assets (Figure 1). The US accounting rules require internally created intangible assets to be expensed as incurred in the income statement, except for some minor exceptions that are capitalized and reflected in the book values of intangible assets[4]. The externally purchased intangible assets are directly capitalized on the balance sheet. This includes Other Intangible Assets which are separately identifiable, such as softwares and client lists. Another is goodwill, which consists of the premiums paid in excess of the fair value of acquired assets, and is not separately identifiable.

**Figure 1: Process of P&T Intangible Assets Estimation**




By using the P&T perpetual inventory method, we can estimate the internally created intangible assets by accumulating back the past R&D and SG&A expenses. Hence, the proxy for the total intangible assets is obtained by summing up the book value of intangible assets with the knowledge and organization capital accumulated since 1975.

The details of the perpetual inventory method to compute knowledge and organization capital is found in Appendix A. For knowledge capital calculation, BEA's (US Bureau of Economic Analysis)

[4] This is captured as part of the Other Intangible Assets in the balance sheet. The capitalized expenditures include externally sold software products at technological feasibility and internally used software at coding phase.

industry-specific estimates of R&D depreciation rates were used to discount the stocks of the past R&D accumulations (Appendix B) (Li & Hall, 2016). For organization capital calculation, 20% depreciation rates were used across all firms with only 30% of SG&A expenses assumed to have contributed to the organization capital formation; whereas the rest of 70% were viewed as expenses supporting the current period profit (Peters & Taylor, 2017).

For tangible assets, the firm's book value of Net PP&E (Plant, Property and Equipment) is used. Tangible assets are directly capitalized on the balance sheet and can be more easily assessed, separated, and collateralized. For comparability across firms, P&T intangible assets and tangible assets are normalized by dividing with total assets of the firms as shown in equation [1] and [2]. In our paper, we refer to these variables scaled by the total assets as P&T intangibility and tangibility for convenience.

$$P\&T\ Intangibility_{i,t} = \frac{P\&T\ Intangible\ Assets_{i,t}}{Total\ Assets_{i,t}} \quad [1]$$

$$Tangibility_{i,t} = \frac{Net\ PP\&E_{i,t}}{Total\ Assets_{i,t}} \quad [2]$$

3.2.2. Financial Leverage

Two commonly used measurements of financial leverage are used as dependent variables in this study: book leverage and market leverage (Appendix A). This enables the examination of intangibles' relationships with both historical value and forward-looking measure of financial leverage, reflecting the market perceptions of the firm's credit risks (Frank & Goyal, 2009). The inclusion of alternative measures of financial leverage strengthens the reliability of regression results by comparing coefficients across different models.

### 3.3. Control Variables

The selection of control variables are based on the determinants of financial leverage commonly used in the literature and those used by Lim et al. (2020), backed by the financial theories. The calculation methods of each control variable are found in Appendix A.

### 3.3.1. Firm Size and Age

We included the natural logarithm of total assets and firm age to control for the firm size and age. Larger firms typically have lower default risk, greater market power, better technology, and are more diversified, which results in a lower cost of debt (Pandey, 2004). Firm age serves as a proxy of a firm's reputation, agency cost, default risk and information asymmetries (Akhtar & Oliver, 2009). Older firms with better reputation in debt markets face lower cost of debt (Frank & Goyal, 2009). Hence, firm size and age are expected to be positively correlated with financial leverage.

### 3.3.2. Market-to-Book Ratio

Market-to-Book ratio captures the effects of the firm's growth opportunities and attractiveness of equity financing. High growth firms tend to face debt overhang concerns, whereas low growth firms face agency conflict between managers and shareholders (Graham & Leary, 2011). Thus, firms with growth opportunities use less debt whereas low growth firms take on debt to manage agency problems. Market timing theory states that firms exploit overvalued stocks by issuing equity rather than debt. Hence Market-to-Book ratio is expected to be negatively correlated with financial leverage. Also, the mechanical negative relationship exists from the definitions of market leverage and Market-to-Book ratio due to opposite effects of changes in market values of equity on both variables (Frank & Goyal, 2009).

### 3.3.3. Operating Profitability and Cash Liquidity

Operating profitability and cash liquidity variables have mixed correlations with leverage; higher profitability and cash holdings support larger debt financing, whereas according to the Pecking-order theory, internal-financing is preferred over debt-financing (Myers, 2001). Profitability has a mechanical negative relationship with book leverage as the increase in profitability directly increases the firm’s book value of equity, by giving rise to retained earnings (Öztekin, 2015).

3.3.4. Marginal Tax Rate

According to the Trade-off theory, marginal tax rates are expected to have a positive relationship with leverage, as higher marginal tax rates imply greater tax shield for firms on taking on more debt. Studies have shown this relationship to be true (Graham, 1996a). Graham (1996b) provides simulated firm-specific marginal tax rates that consider net operating losses, investment tax credits, and alternative minimum tax consistent with the federal tax code.

3.3.5. Industries

Controlling for industry differences is crucial since firms differ more across industries than within an industry. The Fixed Effect Model (FEM) can control for time-invariant differences between firms[5], including differences due to industry. Moreover, we ran the same regression on industry subsamples to present the industry-controlled effects of intangibility and tangibility on financial leverage. We used the robust standard errors clustered by Fama-French industries to correct standard errors and account for any residual correlation among firms within the same industry.

**3.4. Summary Statistics, Correlation Matrix, Industry Decompositions**

Outliers are handled by winsorizing variables at 10th and 90th percentile for those with high proportion of outliers, 5th and 95th percentile for those with mild proportion, and not winsorizing for those without outliers. This helped to ensure that the summary statistics are within an economically reasonable range and also limit distortions in regression results due to outliers. The book value-to-total assets ratios, for instance, must be between 0 and 1.

[5] The inclusion of the time-invariant industry dummy variables results in perfect collinearity, automatically removed by the FEM. Hence, we conducted individual regressions by the industry subsamples in Table 2.

**Table 1: Summary of Descriptive Statistics**

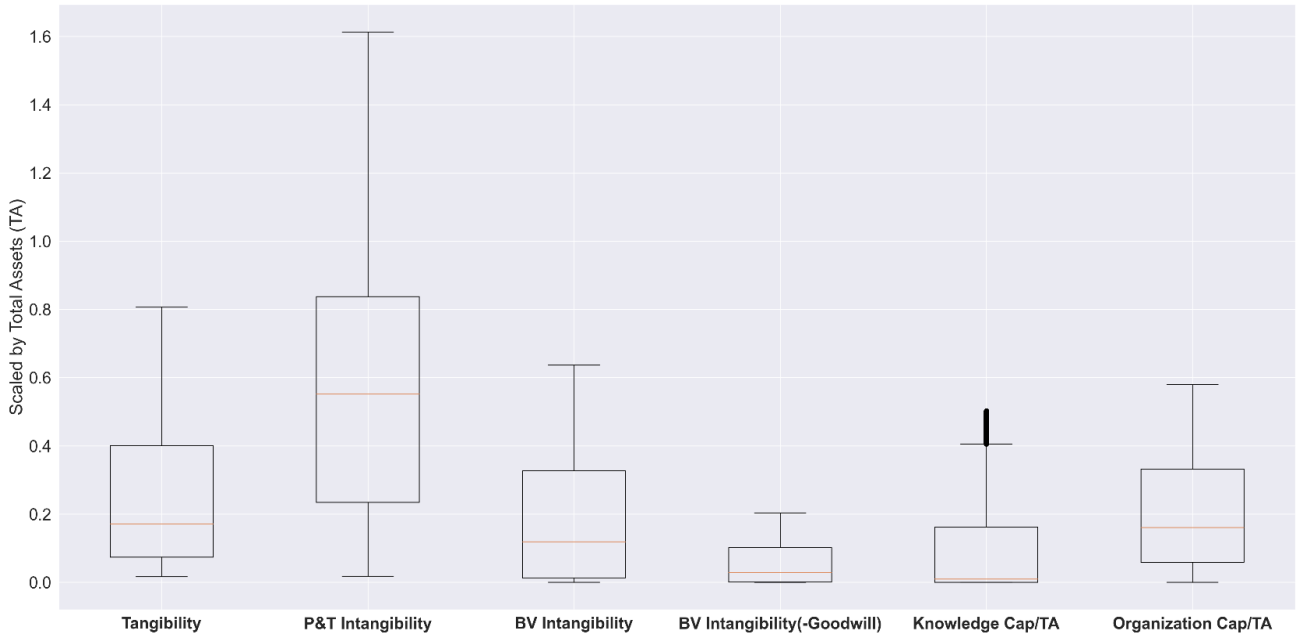
| | Winsorization (Top and Bottom) | mean | sd | min | 25% | median | 75% | max |
|---|---|---|---|---|---|---|---|---|
| Book Leverage | 5% | 0.243 | 0.203 | 0.000 | 0.049 | 0.222 | 0.381 | 0.672 |
| Market Leverage | 5% | 0.159 | 0.150 | 0.000 | 0.021 | 0.123 | 0.253 | 0.498 |
| Tangibility | 5% | 0.265 | 0.243 | 0.017 | 0.074 | 0.171 | 0.401 | 0.806 |
| P&T Intangibility | 5% | 0.590 | 0.426 | 0.018 | 0.234 | 0.552 | 0.838 | 1.614 |
| Knowledge Capital / TA | 10% | 0.113 | 0.169 | 0.000 | 0.000 | 0.010 | 0.162 | 0.502 |
| Organization Capital / TA | 10% | 0.213 | 0.187 | 0.000 | 0.059 | 0.161 | 0.332 | 0.580 |
| BV Intangibility | 5% | 0.192 | 0.202 | 0.000 | 0.014 | 0.119 | 0.327 | 0.637 |
| BV Intangibility less Goodwill | 10% | 0.0600 | 0.0700 | 0.000 | 0.001 | 0.029 | 0.102 | 0.203 |
| Firm age | 0% | 30.600 | 19.100 | 1.000 | 15.000 | 26.000 | 47.000 | 76.000 |
| Log Total Assets | 5% | 6.871 | 2.101 | 3.101 | 5.312 | 6.926 | 8.433 | 10.609 |
| Market to Book | 10% | 2.876 | 2.223 | 0.538 | 1.201 | 2.120 | 3.868 | 7.695 |
| Operating Profitability | 10% | 0.086 | 0.097 | -0.119 | 0.047 | 0.102 | 0.153 | 0.216 |
| Cash Liquidity | 10% | 0.317 | 0.283 | 0.022 | 0.077 | 0.223 | 0.494 | 0.880 |
| Marginal Tax Rate | 0% | 0.143 | 0.112 | 0.000 | 0.028 | 0.143 | 0.210 | 0.392 |

Note: TA is abbreviation for Total Assets, BV is abbreviation for Book Value

Table 1 shows wider dispersion of P&T intangibility estimates than tangibility with higher range and standard deviation. Figure 2 compares the boxplot of each intangibility and tangibility estimates, all scaled by the total assets. This reveals that there may be measurement errors in P&T intangibility that cause less precision compared to other variables directly from the balance sheet[6].

[6] The measurements that do not involve separate estimation and use values directly from the balance sheet in Figure 2 includes: Tangibility, BV intangibility, BV less goodwill. These variables exhibit smaller dispersions.

**Figure 2: Boxplot of Tangible and Intangible Assets Scaled by Total Assets**




Furthermore, Table 1 shows that the tangibility variable has an upper bound of 1 as tangible assets cannot exceed the total assets, unlike P&T intangibility. This is because P&T intangibility is estimated independently using the P&T method, not taken directly from the balance sheet. This makes the sum of P&T intangibility and tangibility does not necessarily equal 1, satisfying no perfect collinearity. This is also supported by the correlation matrix of the regression variables in Appendix C. The correlation between P&T intangibility and tangibility are -0.58, which is well above -1 if there is a perfect collinearity problem. Moreover, the correlation matrix reveals no independent variables that are significantly correlated with each other. The variables correlated above absolute value of 0.7 are only between book and market leverages, and between the BV intangibility and BV intangibility less goodwill. These correlations do not raise concerns on multicollinearity as they are regressed in separate regression models. Hence, it is safe to include both P&T intangibility and tangibility variables into our regression model as the model is less likely to suffer a significant problem of multicollinearity.

The industry constitution of our regression sample in Appendix D reveals that almost half of sample firms come from Business Equipment, Healthcare and Shops industries, whereas half of observations come from Business Equipment and Consumer Goods industries. Appendix E visualizes that Business Equipment and Healthcare industries accumulated the most intangible assets relative to their total

assets, while holding the least tangibility on average. In contrast, the Energy and Utilities industries hold the highest tangibility and lowest intangibility on average. This tells that our sample contains a higher proportion of industries with relatively high intangibility. This is consistent with the sample statistics in Table 1, where P&T intangibility exhibits higher central tendency than tangibility in the overall sample. The average of book and market leverage reveals that the industries with higher tangibility are associated with higher leverage on average than industries with high intangibility.

### 3.5. Regression Analysis

This paper focuses on two regression models based on the use of book leverage (LEV) or market leverage (MktLEV) as the dependent variable as shown in equation 3 and 4. Our model specifications resemble the structure of Pooled OLS model used by Lim et al. (2020), where the variables of interest for our hypothesis testing: intangibility (INT) and tangibility (TAN) are regressed with a vector of control variables. In this paper, the control variables are log Total Assets (lnAsset), firm age (Age), Market-to-Book (MtB), Operating Profitability (Opprofit), Cash Liquidity (Cashliq), and Marginal Tax Rates (MTR). These variables control for the factors that determine financial leverage by channels other than via the collateralization of intangible and tangible assets of the firms.

#### 3.5.1. Two-Way Fixed Effects Model (TWFEM)

[3] $$LEV_{i,t} = \beta_0 + \beta_1 INT_{i,t} + \beta_2 TAN_{i,t} + \beta_3 lnAsset_{i,t} + \beta_4 Age_{i,t} + \beta_5 MtB_{i,t} + \beta_6 Opprofit_{i,t} + \beta_7 Cashliq_{i,t} + \beta_8 MTR_{i,t} + \alpha_i + \sum_{t=2010}^{2021} \lambda_t D_t + \varepsilon_{i,t}$$

[4] $$MktLEV_{i,t} = \beta_0 + \beta_1 INT_{i,t} + \beta_2 TAN_{i,t} + \beta_3 lnAsset_{i,t} + \beta_4 Age_{i,t} + \beta_5 MtB_{i,t} + \beta_6 Opprofit_{i,t} + \beta_7 Cashliq_{i,t} + \beta_8 MTR_{i,t} + \alpha_i + \sum_{t=2010}^{2021} \lambda_t D_t + \varepsilon_{i,t}$$

$\alpha_i$: firm-specific effects, constant across time

$\lambda_t$: year-specific effects, constant across firms

$D_t$: Year dummy variables from 2010 to 2021 (base year = 2009)

Gormley and Matsa (2014) recommends using Fixed Effects Model (FEM) as the fixed effects could provide consistent estimates in the presence of the unobserved heterogeneity. To assure that FEM is the statistically appropriate model, we conducted the Hausman test to select between FEM and Random Effect Model (REM), Breusch-Pagan LM test to select between REM and Pooled Ordinary Least Squares (Pooled OLS), and F-test for individual effects to select between FEM and Pooled OLS (Appendix F). The test results preferred FEM over the other models[7], confirming our choice. In addition to firm fixed effects, we also included year fixed effects using the Two-Way Fixed Effects Model (TWFEM), commonly used in the literature. TWFEM controls for the effect of the firm-specific characteristics on leverage that are unobserved but constant over time and controls for some industry-wide, macroeconomic conditions that affect all firms the same over time. This helps to mitigate the potential unobservable heterogeneity, enhancing the robustness of our regression results.

3.5.2. Heterogeneity Analysis across Tangibility and Time

To add layers to our fixed effects results, we analyzed how the relationship between P&T intangibility and the financial leverage changes across firms with different levels of tangibility and over time. This is done by adding two dummy variable interaction terms with P&T intangibility: High Tangibility (HiTan) and After year 2015 (After2015) using FEM[8] in equation 5. High Tangibility equally splits the firms into high and low tangibility based on the industry median tangibility as a threshold. After 2015 is a time dummy variable splitting the regression into two periods, taking value of 1 for 2016-2021 period and 0 for 2009-2015 period.

$$
\begin{aligned}
[5] \quad LEV_{i,t} \text{ or } MktLEV_{i,t} = {} & \beta_1 INT_{i,t} + \beta_2 HiTan + \beta_3 (HiTan * INT_{i,t}) \\
& + \beta_3 After2015 + \beta_4 (After2015 * INT_{i,t}) \\
& + \beta_5 (HiTan * After2015 * INT_{i,t}) \\
& + \beta_6 lnAsset_{i,t} + \beta_7 Age_{i,t} + \beta_8 MtB_{i,t} + \beta_9 Opprofit_{i,t} \\
& + \beta_{10} Cashliq_{i,t} + \beta_{11} MTR_{i,t} + \alpha_i + \varepsilon_{i,t}
\end{aligned}
$$

[7] Test results rejected the null hypothesis of Hausman test, Breusch-Pagan LM test and F-test at 1% significance level. As a result, FEM was the most preferred model, followed by REM and Pooled OLS was the least preferred (Appendix F).

[8] Due to perfect collinearity between time period dummy variable (After 2015) and year dummy variables for year fixed effects in TWFEM, the FEM with entity fixed effects is used instead.

$\alpha_i$: firm-specific effects, constant across time

The rationale behind the period split of 2015 was due to the significance of its economic turning point and balanced split of the observations. The period 2009-2015 was marked with post-financial crisis low and static federal funds rate as the Federal Reserve (Fed) constantly targeted 0%-0.25% (*FRED*, n.d.). Year 2016 onwards was marked with more dynamic movements in the benchmark interest rate, where the Fed started its rate hike from end 2015 and lowered with COVID-19 crisis. The split-off point at year 2015 divides the period of relatively stable monetary environment with the more volatile monetary environment which may have implications on the cost of debt.

### 3.6. Robustness Tests

It is important to acknowledge that the coefficients from our regression model may be subject to different biases. In order to assess and enhance the reliability of our regression, we conducted robustness tests using sensitivity analysis of the coefficients, using the same control variables.

#### 3.6.1. Measurement Errors in P&T Intangible Asset Estimates

We decomposed the P&T intangible assets using its subcomponents (Figure 1) to assess its measurement errors in estimating the true intangible assets of the firms. Gormley and Matsa (2014) points out that FEM estimates are subject to attenuation bias when the independent variable is measured with error, as the fixed effects amplify the share of noise in the estimates. The noise weakens the true relationship between independent and dependent variables, which leads to the biased coefficient towards zero. The P&T method is subject to measurement errors as it assumes that the past R&D and SG&A expenses always contribute fully or partially to accumulation in intangible assets, regardless of whether the particular intangible investment is successful or not. This poses measurement errors for knowledge and organization capital which are calculated using the perpetual inventory method. The perpetual inventory method may result in measurement errors that systematically overestimates the true intangible assets over time. Hence, we ran TWFEM regressions with different versions of intangibility regressors to re-evaluate the relationship between different types of intangible assets and financial leverage.

Beside our main TWFEM regression model, we ran additional regressions using two versions of P&T intangibility subcomponents as the key regressors. First version uses the three-parts subcomponents as the key regressor, which includes: BV intangible assets, knowledge capital and organization capital (all scaled by total assets). Segregating book value of intangible assets from the other estimates that are subject to greater measurement error from the perpetual inventory method allows us to evaluate the effect of measurement error on the intangibility coefficients. Second version removes the goodwill from the first version, using the BV intangible assets less goodwill[9] with knowledge and organization capital (scaled by total assets). The rationale for removing goodwill is that goodwill is not separately identifiable and could be contaminated by the premiums paid on physical assets (Peters & Taylor, 2017). Removing goodwill could further mitigate the measurement errors from the potential noise caused by the non-intangible assets that are not separately identifiable.

3.6.2. Survivorship Bias in Sample Selection

We conducted sensitivity analysis on the coefficients of our main regression by using different sizes of samples to test for survivorship bias. Our main regression is likely subject to the survivorship bias, as our unbalanced regression sample implicitly assumes that the firms have survived up to 2010 at minimum to end up in the sample, excluding those newly listed in the regression period. By restricting the regression period 2009-2021,the sample firms from 1975-2021 were reduced from 6,383 firms to 3,416 firms (46% of firms lost) and firm-year observations dropped from 126,514 to 32,908 (74% of observations lost). If we sampled only those that fully lived through the regression period to ensure a balanced panel data, the sample size is further reduced down to 1,641 firms. Hence, it is possible that some characteristics that the firms in our regression sample have in common could have driven the survival of the firms into our sample and the significance in our coefficients. To evaluate our regression against the survivorship bias, we ran our main TWFEM regression on two samples in addition to our original sample of unbalanced data of 3,416 firms (32,908 observations) from 2009 to 2021:

[9] Book Value of intangible assets less goodwill is equivalent to the Other Intangible Assets on the balance sheet (Figure 1). It consists of the separately identifiable intangible assets unlike goodwill. They may arise from contractual or other legal rights.

1. Balanced version of the original sample: 1,641 firms (21,333 observations) from 2009 to 2021. This sample holds the time period constant, only differing in the number of firms compared to the original sample.
2. Unbalanced and longer time series sample of 6,383 firms (126,514 observations) from 1975 to 2021. This sample differs in both time periods and number of firms compared to the original sample.

The summary statistics of firm age on the three different samples including our original sample revealed that the larger sample size is associated with lower mean and median firm age[10], evidencing the losses of short-lived firms' data from restricting regression period and ensuring balanced data. The 2009-2021 balanced sample is likely to be exposed to the most survivorship bias, and the 1975-2021 unbalanced sample is to be the least biased sample with the largest data. By analyzing the sensitivity of regression coefficients across samples, we can evaluate if survivorship bias affects our regression.

## 4. RESULTS AND DISCUSSION

### 4.1. Regression Results for Two-Way Fixed Effect Model

The TWFEM results of the book and market leverage models revealed small, positive coefficients (0.0258 for book leverage and 0.0173 for market leverage) at 5% significance level for P&T Intangibility and relatively large, positive magnitude of coefficients (0.2250 for book leverage and 0.1650 for market leverage) highly significant at 1% level for Tangibility (Appendix G Table 4). It supports our alternative hypothesis as the positive relationship reveals that more intangible assets support financial leverage, holding others factors constant. Our results are consistent with the previous research which showed the positive effect of intangible assets on financial leverage (Lim et al., 2020; Corrado et al, 2009; Duan et al, 2019). Furthermore, the relatively smaller size and lower significance of intangibility coefficients compared to the tangibility coefficients as a benchmark is also aligned with our prediction. The coefficient differences between intangibility and tangibility are found to be significantly different from 0 at 1% level using F-test, which may be due to difficulties in

[10] Comparing the firm age of the three samples shows following: 2009-2021 unbalanced data (original sample) has a mean age of 30.6 years (median: 26), 2009-2021 balanced data (smaller sample) has a mean age of 34.7 years (median: 31), and 1975-2021 unbalanced data (larger sample) has a mean age of 23.4 years (median: 21).

collateralizing intangible assets (Appendix G Table 4). Lim et al. (2020) found that tangible assets and separately identifiable intangible assets exhibit significantly positive effects on financial leverage. Lenders prefer to lend more to firms with high tangibility than with high intangibility due to the higher risk involved in collateralizing intangible assets.

**Table 2: Two-Way Fixed Effect Coefficients by Industry Subsamples**

| | Book Leverage | | Market Leverage | |
|---|---|---|---|---|
| Industry Subsamples | (1) P&T Intangibility | (2) Tangibility | (3) P&T Intangibility | (4) Tangibility |
| Business Equipment (N = 7670) | 0.0236* (0.0137) | 0.1510*** (0.0564) | 0.0199*** (0.0066) | 0.0766** (0.0337) |
| Healthcare (N = 4460) | 0.0423*** (0.0155) | 0.3475*** (0.0717) | 0.0283*** (0.0065) | 0.1746*** (0.0403) |
| Manufacturing (N = 3886) | 0.0382 (0.0383) | 0.1834** (0.0911) | 0.0260 (0.0250) | 0.1691*** (0.0650) |
| Energy (N = 1720) | -0.1819** (0.0711) | 0.0532 (0.0780) | -0.2257*** (0.0582) | 0.1052* (0.0582) |
| Utilities (N = 1391) | -0.0536 (0.1383) | 0.0087 (0.0885) | -0.0013 (0.0941) | -0.0176 (0.0627) |
| Telecommunication (N = 1147) | 0.1404** (0.0578) | -0.0366 (0.1688) | 0.0757* (0.0396) | -0.0599 (0.1060) |
| Consumer Non-durables (N = 1765) | 0.0746 (0.0656) | 0.2256** (0.0984) | 0.0197 (0.0444) | 0.1223 (0.0780) |
| Consumer Durables (N = 1137) | 0.0066 (0.0384) | 0.2540* (0.1396) | 0.0138 (0.0324) | 0.1118 (0.0911) |
| Shops (N = 3574) | -0.0862*** (0.0319) | 0.2979*** (0.0573) | -0.0322 (0.0257) | 0.2441*** (0.0469) |
| Chemicals (N = 1075) | 0.1019* (0.0590) | 0.1375 (0.0948) | 0.0505 (0.0325) | 0.0449 (0.0655) |
| Other (N = 5083) | 0.0281 (0.0348) | 0.1760** (0.0691) | 0.0155 (0.0197) | 0.1534*** (0.0415) |

| | | | | |
|---|---|---|---|---|
| Entire Sample (N = 32908) | 0.0258** (0.0115) | 0.2250*** (0.0543) | 0.0173** (0.0071) | 0.1650*** (0.0374) |

Note: *: 10% significance level, **: 5% significance level, ***: 1% significance level
Heteroskedasticity-robust standard errors clustered by Fama-French 12 industry classification in parentheses.

Table 2 displays TWFEM coefficients of intangibility and tangibility for each industry group subsamples. 8 out of 11 industries revealed positive coefficients for intangibility, with 4 significant at 10% level for book leverage and 3 for market leverage model (Columns 1 and 3). Tangibility coefficients were positive in 10 out of 11 industries for book leverage (9 for market leverage), and 7 of which was significant at 10% level for book leverage (6 for market leverage) (Columns 2 and 4). This suggests that the coefficient for intangibility is driven by a few industries, which aligns with our expectations about the difficulty of intangible assets to serve as collateral.

Table 2 also reveals that the industries with highest intangibility, such as Healthcare and Business Equipment, show positive and significant coefficients for intangibility while industries with the lowest intangibility, like Energy and Utilities, have negative coefficients with some significance. Tangibility coefficients exhibit significantly positive coefficients, even for industries with high intangibility. This could be because tangible assets are more easily collateralized and have identifiable features that play a crucial role in serving as collateral.

In Appendix G Table 4, the main regression shows the appropriateness of control variables for other leverage factors. Many control variable coefficients align with corporate finance theories. Log Total Assets shows significant positive coefficients, indicating the ability of larger firms to finance more debt than smaller firms. Negative Market-to-Book coefficients for market leverage relate to lower financial leverage with higher growth opportunities or equity overvaluation backed by Market timing theory. The high significance of Market-to-Book in the market leverage model is probably due to the mechanical negative relationship built by the market leverage definitions (Column 2). Operating Profitability and Cash Liquidity are significantly negative coefficients at 1% level; this is consistent with the Pecking-order theory, which states that the firms with higher profitability and cash holdings would prefer the internal financing, thus associated with lower leverage.

The coefficient results reveal some unexpected findings. Firm age reveals significantly negative relationships with leverage, consistent with Nguyen et al. (2020) on the determinants of financial leverage for Vietnam listed firms using FEM. Also, Zulfiqar Ali Memon et al. (2019) found that leverage decreases as firms age, due to the preference to use equity over debt when they age. The coefficients for Marginal Tax Rate show mixed signs with little significance. Trade-off theory states that there exists an optimal level of debt. The summary statistic of age[11] and firm size[12] reveals that our regression sample firms consist of long-survived, larger firms than the larger sample from 1975-2021. Since these long-lived large firms are likely to be at optimal levels of debt financing, increase in tax benefit may have no significant changes on capital structures as our regression results show.

Nevertheless, testing for the joint significance of control variables using the F-test revealed a strong significance at 1% level for both book and market leverage models (Appendix G Table 4). The unexpected coefficients are explained with alternative rationale, and thus control variables are effective in controlling for some desired variations in financial leverage in the observable level. As these control variables are justified as determinants of financial leverage in corporate finance and commonly used by other literatures, we kept these variables throughout our regression analysis.

### 4.2. Regression Results for Heterogeneity Analysis across Tangibility and Time

The heterogeneity analysis shows varying P&T intangibility coefficients depending on tangibility of the firms and the time period. Firms with high tangibility have significantly higher leverage (0.0286 for book leverage and 0.0234 for market leverage) on average than low tangibility firms over the entire period (Appendix G Table 5). This supports the consistent, positive relationship between tangibility and financial leverage. However, the dummy variable for time period (After 2015) revealed weak coefficients with mixed signs in book and market leverage models, contradicting the expectation that changes in federal funds rate would significantly influence the financial leverage.

[11] The summary statistics of age for the three samples are found in Section 3.6.2 footnotes.
[12] Comparing the Log Assets from the three samples in Section 3.6.2, 2009-2021 unbalanced data (original sample) has Log Assets with mean of 6.86 (median: 6.93), 2009-2021 balanced data (sample 1) has a mean of 7.29 (median: 7.38), and 1975-2021 unbalanced data (sample 2) has a mean of 5.78 (median: 5.68).

**Table 3: P&T Intangibility Coefficient by Tangibility and Time**

| | Book Leverage Model | | Market Leverage Model | |
|---|---|---|---|---|
| Time | High Tangibility | Low Tangibility | High Tangibility | Low Tangibility |
| 2009-2015 | -0.0023 | 0.0151 | 0.0012** | 0.0164 |
| | (2.11) | (0.89) | (5.48) | (3.24) |
| 2016-2021 | 0.0297*** | 0.0197 | 0.0087*** | 0.0118 |
| | (21.01) | (0.62) | (11.66) | (1.90) |
| Entire Period | 0.0259* (4.43) | | 0.0178** (5.27) | |

Note: *: 10% significance level, **: 5% significance level, ***: 1% significance level
Joint significance F-test statistic of intangibility coefficient and its interaction terms in parentheses. Entire Period intangibility coefficients are estimated using FEM without year fixed effects, which is consistent with the model used by the heterogeneity analysis.

The interaction terms with intangibility coefficient in Table 3 are jointly tested for significance using F-test. In Table 3, the first period of 2009-2015 reveals that high tangibility firms generally show weaker coefficients or negative sign for intangibility coefficients compared to that of the low tangibility firm. This is similar to the findings by Lim et al. (2020), where the interaction of High Tangibility and Intangibility coefficients revealed negative coefficients. However, in the second period of 2016-2021, the intangibility coefficient for firms with high intangibility significantly rose to have a positive relationship with the financial leverage, consistent with the findings of Peng et al. (2020); the effect of intangible assets on capital structure increased over the years. This reveals that both high and low tangibility firms contribute to the positive relationship between tangibility and leverage in the period 2016-2021. This may be attributed to the emerging importance of intangible assets such as softwares and patents, which have become a greater portion of the firm's assets that can support debt financing.

### 4.3. Robustness Test Results

#### 4.3.1. Measurement Errors in P&T Intangibility Results

Appendix H Table 6 shows the results of TWFEM on subcomponents of P&T intangible assets, with significantly positive coefficients for book intangibility and book intangibility less goodwill. The book intangibility coefficient is relatively small but significant at 1% level (columns 2 and 5). When the goodwill is removed, the coefficient size resembles the tangibility coefficient at the same 1% level (columns 3 and 6). However, knowledge capital and organization capital exhibit small, weakly significant and some negative coefficients. This implies that the positive relationship between P&T intangibility and financial leverage may be driven by the identifiable feature of book intangible assets.

The Other Intangible Assets, which represents book intangible assets less goodwill, is less susceptible to measurement errors caused by P&T perpetual inventory method and excludes unidentifiable intangible assets. Unlike knowledge and organization capital, which are calculated using the perpetual inventory method and showing insignificant results, Other Intangible Assets is extracted directly from the balance sheet, being exposed to less measurement error. By removing goodwill and segregating the knowledge and organization capital from book intangibles, the coefficient size and significance improved, indicating the importance of identifiable features of intangible assets for debt financing. However, this approach does not account for the internally generated intangible assets but only externally purchased intangible assets, in exchange for highly significant coefficients.

Despite the individually insignificant coefficients of knowledge and organization capital with susceptibility to measurement errors and lack of identifiability, the P&T intangible asset subcomponents are jointly significant 5% and 1% levels (Appendix G Table 6). The P&T intangible asset estimates are still relevant and useful as it allows us to approximate the total intangibility of the firms with both internally generated and externally purchased portions using a relatively simple estimation method. Its weakly significant relationship with the financial leverage acknowledges the nature of high risk of intangible assets to be collateralized.

4.3.2. Survivorship Bias in Sample Selection Results

Appendix G Table 7 shows the results of running the main TWFEM regression on three different samples: original data (Columns 1 and 4), 2009-2021 balanced data (Columns 2 and 5), 1975-2021 unbalanced (Columns 3 and 6). The intangibility coefficients become stronger in the balanced version of the original sample (Columns 2 and 5), while the coefficients' size and significance are lost in the 1975-2021 unbalanced data (Columns 3 and 6). Tangibility's coefficient size is also reduced in 1975-2021 unbalanced data, but still retains the high level of significance across all three samples. Thus, P&T intangibility coefficient is more sensitive to survivorship bias than the tangibility coefficient. However, our heterogeneity analysis revealed that the emergence of intangible assets is a recent phenomenon. Hence, including a longer time horizon may have diluted the recent effects of intangibility over a longer time period, causing significant changes in the coefficient.

To test the impact of survivorship bias on coefficients more precisely, we compare regression results on a balanced and unbalanced sample over the same period 2009-2021. Holding the time period constant, they differ in the number of firms included[13]. The P&T intangibility coefficient slightly declined in the unbalanced dataset, but there were no significant enough changes against our alternative hypothesis (Columns 1 and 4 compared to 2 and 5). The same is observed for tangibility coefficients. Hence, we can conclude that the survivorship bias does not materially impact our coefficient results.

Appendix G Table 8 presents a sensitivity test on survivorship bias using the subcomponents regression. The book intangible assets revealed consistently high significance at 1% level, similar to tangibility coefficients but smaller in magnitude. Knowledge and organization capital exhibit weakly significant coefficients with mixed signs. Nevertheless, the intangibility subcomponents are jointly significant at 5% and 1% levels. This returns to the idea that the identifiable features of the assets have a significantly positive relationship with financial leverage, which still holds even when regressed on the most survivorship bias-robust dataset.

[13] The difference between unbalanced panel data and balanced panel data for the period 2009-2021 is 1,775 firms (11,575 observations). This is a 52% reduction in firms (35% in observations) from the original unbalanced panel data, which is reasonably large to artificially create survivorship bias to test its effect on our coefficients.

Therefore, the robustness test for survivorship bias revealed that the P&T intangibility in the main regression is reasonably robust to the survivorship bias. The subcomponent regression of P&T show that intangible assets have a strongly positive effect on the financial leverage, holding all else constant, through the channel of identifiability. The more identifiable intangible assets the firm holds, the assets will better support the firm's financial leverage.

## 5. LIMITATIONS AND FURTHER STUDIES

This paper attempts to address some of the biases faced by regression results, but there are still limitations to the research. The model used may be subject to endogeneity problems due to unobserved factors that TWFEM fails to control for, varying across both individual firms and time. The omitted factors could also allow for the reverse causality of financial leverage on intangible assets accumulations, which does not support our hypothesis that intangible assets support debt. Therefore, the paper is an observational study, and the findings cannot establish a causal relationship.

In addition, the relationship between intangible assets and financial leverage may not be linear as the Trade-off theory suggests that nonlinear function may be required to better understand the correlational effect of intangible assets on debt financing when the optimal level of debt exists.

Moreover, estimating intangible assets is a general challenge and is prone to high measurement errors due to the difficulty in valuing them fairly. The measurement error also creates high proportions of outliers in the data that could have distorted the true effects even after the winsorization of variables.

For further research, we believe it will be worthwhile to explore the relationship between financial leverage and intangible assets across other countries or make cross-comparisons between countries. This could help adding external validity to our research, as our scope is limited to the US public firms. This may also raise interesting questions about how the different industry emphasis across countries affect the intangible asset and financial leverage relationship. Moreover, using different estimation methods of intangible assets or model specifications could also add to more diverse insights into the intangible assets.

## 6. CONCLUSION

This study uses the TWFEM regression method to analyze data from 3,416 firms over a 12-year period from 2009 to 2021, resulting in 32,908 firm-year observations. The findings reveal a small but significant positive relationship between intangible assets and financial leverage, supporting the alternative hypothesis. In comparison, the effect of tangible assets is found to be more significant, as they are easier to identify and value to support financial leverage. Further analysis is conducted to examine the intangibility coefficient across different levels of tangibility and time, which showed that intangible assets gained significance in supporting financial leverage in the recent periods, driven by all firms regardless of their tangibility holdings. Robustness tests are conducted to assess the accuracy of the intangibility estimates and the sample's susceptibility to survivorship bias which reveals that the regression results are not materially affected by the survivorship bias. However, regression is exposed to measurement errors causing attenuation bias. We suggested the alternative regression of regressing subcomponents of our intangible estimates, and the result found a strong relationship between externally purchased intangible assets and financial leverage in which the significance is driven by the identifiable feature of intangible assets.

This paper aims to contribute to the corporate finance literature by examining the relationship between intangible assets and financing decisions using the P&T's intangible asset estimation method. We aim to unravel the correlational relationships using a large set of panel data with calculation of intangible proxy variables from the easily-obtained financial statement data, to pursue accuracy of the estimates. We also aim to evaluate the accuracy of measures and the estimation method of intangible assets. Discovering the association of intangible assets with financial leverage could provide a stronger theoretical background for corporate investment and financing decisions as well as valuations of firms that are intangible asset heavy. However, further research is needed to better understand the growing effect of intangible assets in the field of corporate finance.

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# 8. APPENDICES

## Appendix A: Variables and Definitions

| Variable Type | Notation | Variable Name | Measurement |
|---|---|---|---|
| Dependent Variables | $LEV_{i,t}$ | Book Leverage | $LEV_{i,t} = \frac{Short-term\ Debt_{i,t} + Long-term\ Debt_{i,t}}{Total\ Assets}$ |
| | $MktLEV_{i,t}$ | Market Leverage | $MktLEV_{i,t} = \frac{Short-term\ Debt_{i,t} + Long-term\ Debt_{i,t}}{Total\ Assets_{i,t} - Book\ Common\ Equity_{i,t} + Market\ Common\ Equity_{i,t}}$ The market value of common equity is evaluated at the closing share price at the end of the firm's fiscal year. |
| Key Independent Variables | $INT_{i,t}$ | Intangibility | $P\&T\ Intangibles_{i,t} = BVINT_{i,t} + (KnowCap_{i,t} + OrganCap_{i,t})$ $Intangibility_{i,t} = \frac{P\&T\ Intangibles_{i,t}}{Total\ Assets_{i,t}}$ |
| | $TAN_{i,t}$ | Tangibility | $Tangibility_{i,t} = \frac{Net\ PP\&E_{i,t}}{Total\ Assets_{i,t}}$ |
| | $KnowCap_{i,t}$ | Knowledge Capital / TA | $KnowCap_{i,t} = \frac{G_{i,t}}{Total\ Assets_{i,t}}$ $G_{i,t} = (1 - \delta_{R\&D})G_{i,t-1} + R\&D_{i,t}$, where $G_{i,t=0} = 0$ $G_{i,t-1}$: Beginning of the period knowledge capital stock $G_{i,t}$: End of the period knowledge capital stock $\delta_{R\&D}$: BEA's industry-specific R&D depreciation rates |
| | $OrganCap_{i,t}$ | Organization Capital / TA | $OrganCap_{i,t} = \frac{O_{i,t}}{Total\ Assets_{i,t}}$ $O_{i,t} = (1 - \delta_{SG\&A})O_{i,t-1} + (0.3 * SG\&A_{i,t})$, where $O_{i,t=0} = 0$ $O_{i,t-1}$: Beginning of the period organization capital stock $O_{it}$: End of the period organization capital stock $\delta_{SG\&A} = 20\%$ across all firms |
| | $BVINT_{i,t}$ | Book Intangibility | Total book value of intangible assets on the balance sheet. This includes a goodwill ($GDWL_{i,t}$). |
| Control Variables | $lnAsset_{i,t}$ | Firm Size | $lnAsset_{i,t} = ln(Total\ Assets_{i,t})$ |
| | $Age_{i,t}$ | Firm Age | Approximated by age by taking the longer of the age since the available IPO date and the starting point of data availability. |
| | $MtB_{i,t}$ | Market to Book | $MtB_{i,t} = \frac{Market\ Capitalization_{i,t}}{Book\ Common\ Equity_{i,t}}$ |

| | | | |
|---|---|---|---|
| | $Opprofit_{i,t}$ | Operating Profitability | $Opprofit_{i,t} = \frac{EBITDA_{i,t}}{Total\ Assets_{i,t}}$<br>EBITDA: Earnings Before Interest, Tax, Depreciation and Amortization |
| | $Cashliq_{i,t}$ | Cash Liquidity | $Cashliq_{i,t} = \frac{Cash_{i,t} + Short{-}term\ Investments_{i,t}}{Total\ Assets_{i,t}}$ |
| | $MTR_{i,t}$ | Marginal Tax Rates | Simulated marginal tax rate based on income after interest expense (Graham, 1996b). |

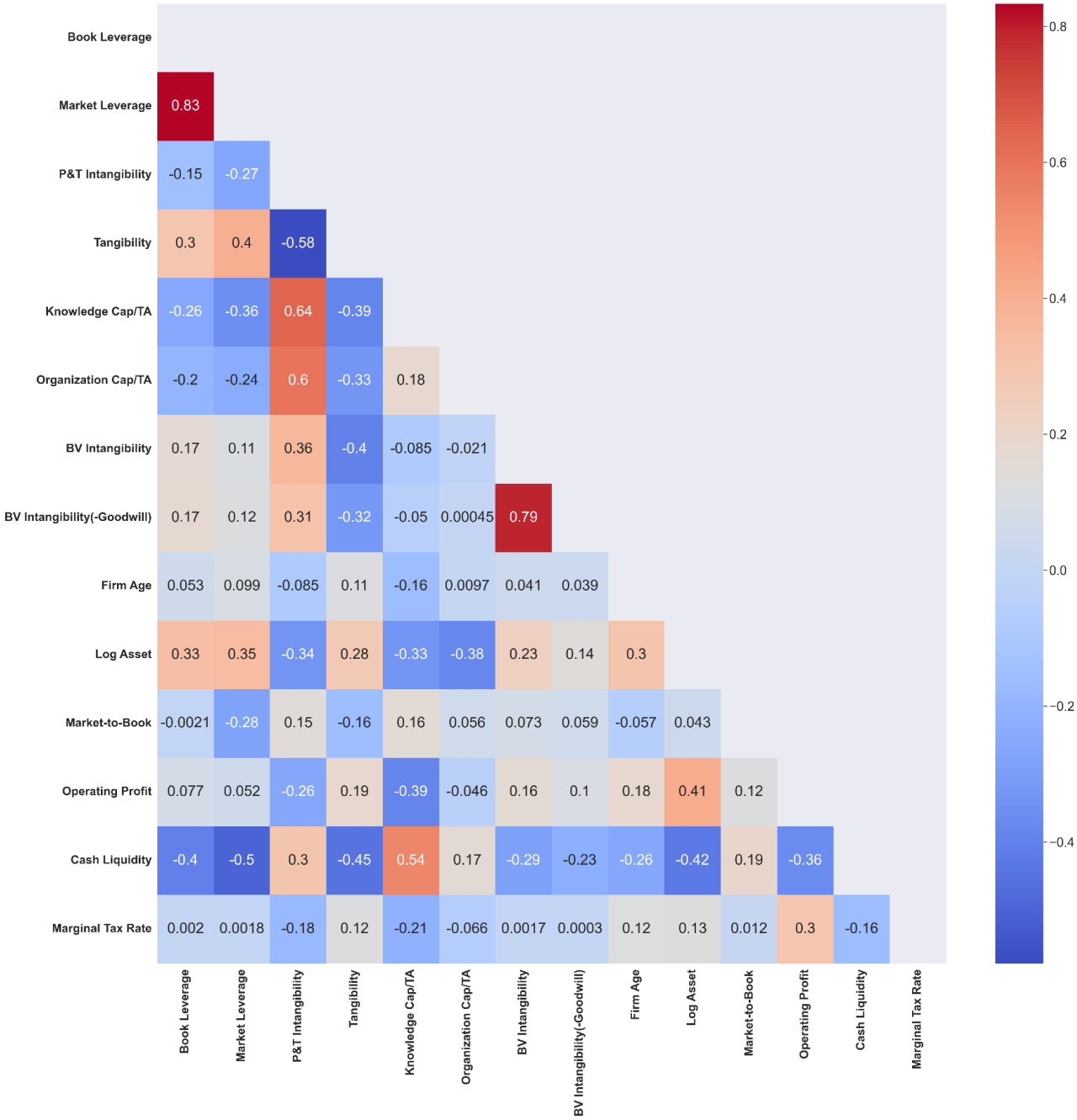
Note: The missing values among the constituent variables in estimating P&T intangible assets were replaced with zero, following the P&T method. For control variables, any missing data for each variable was replaced with the mean of the variable for each firm. If the mean does not exist due to the firm missing the entire data for that variable, then the firm was dropped.

## Appendix B: BEA's Industry-specific R&D Depreciation Rates

| Industry | SIC Codes | R&D Depreciation Rates |
|---|---|---|
| Computer and peripheral equipment | 3570-3579, 3680-3689, 3695 | 36.3% |
| Software | 7372 | 30.8% |
| Pharmaceutical | 2830, 2831, 2833-2836 | 11.2% |
| Semiconductor | 3661-3666, 3669-3679 | 22.6% |
| Aerospace products and parts | 3720, 3721, 3724, 3728, 3760 | 33.9% |
| Communication equipment | 3576, 3661, 3663, 3669, 3679 | 19.2% |
| Computer system design | 7370, 7371, 7373 | 48.9% |
| Motor vehicles, bodies and trailers, and parts | 3585, 3711, 3713-3716 | 73.3% |
| Navigational, measuring, electromedical, and control instruments | 3812, 3822, 3823, 3825, 3826, 3829, 3842, 3844, 3845 | 32.9% |
| Scientific research and development | 8731 | 29.5% |

Note: The industries not specified above use a 15% depreciation rate.

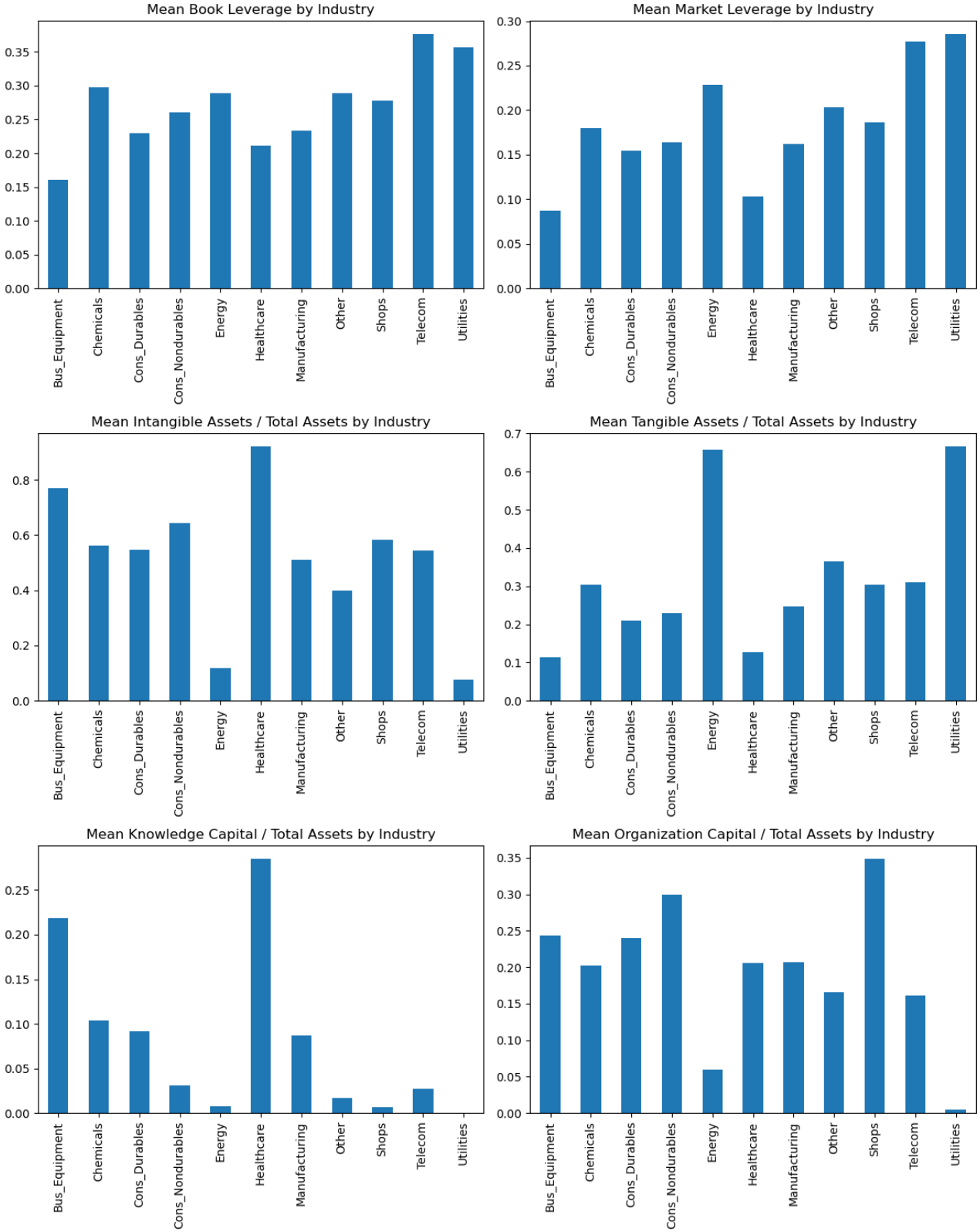
# Appendix C: Correlation Matrix of Regression Variables



**Appendix D: Industry of Regression Sample**

| Industry | Firms | Firms(%) | Observations | Observations(%) |
|---|---|---|---|---|
| Business Equipment | 859 | 25.15 | 7670 | 23.31 |
| Chemicals | 104 | 3.04 | 5083 | 15.45 |
| Consumer Durables | 105 | 3.07 | 4460 | 13.55 |
| Consumer Non-Durables | 177 | 5.18 | 3886 | 11.81 |
| Energy | 178 | 5.21 | 3574 | 10.86 |
| Healthcare | 511 | 14.96 | 1765 | 5.36 |
| Manufacturing | 374 | 10.95 | 1720 | 5.23 |
| Other | 497 | 14.55 | 1391 | 4.23 |
| Shops | 351 | 10.28 | 1147 | 3.49 |
| Telecom | 118 | 3.45 | 1137 | 3.46 |
| Utilities | 142 | 4.16 | 1075 | 3.27 |
| Total | 3416 | 100 | 32908 | 100 |

# Appendix E: Mean of Key Regression Variables Across Industries



**Appendix F: Statistical Tests for Model Specification**

| Regressions: | Book Leverage | Market Leverage |
|---|---|---|
| **F-test for individual effects** | 16.55*** | 16.46*** |
| H0: Pooled OLS | (0.00) | (0.00) |
| Ha: FEM | **FEM over Pooled OLS** | **FEM over Pooled OLS** |
| **Hausman test** | 779.57*** | 348.90*** |
| H0: REM | (0.00) | (0.00) |
| Ha: FEM | **FEM over REM** | **FEM over REM** |
| **Breusch-Pagan LM test** | 52815.43*** | 54443.55*** |
| H0: Pooled OLS | (0.00) | (0.00) |
| Ha: REM | **REM over Pooled OLS** | **REM over Pooled OLS** |

Note: *: 10% significance level, **: 5% significance level, ***: 1% significance level

Heteroskedasticity-robust p-values clustered by Fama-French 12 industry classification in parentheses.

## Appendix G: Regression Results

### Table 4: Two-Way Fixed Effects Model (TWFEM) with Firm and Year Fixed Effects

| | (1) | (2) |
|---|---|---|
| | Book Leverage | Market Leverage |
| P&T Intangibility | 0.0258** | 0.0173** |
| | (0.0115) | (0.0071) |
| Tangibility | 0.2250*** | 0.1650*** |
| | (0.0543) | (0.0374) |
| Firm Age | -0.0931** | -0.0686** |
| | (0.0364) | (0.0296) |
| Log Total Assets | 0.0213** | 0.0312*** |
| | (0.0093) | (0.0053) |
| Market-to-Book | -0.0010 | -0.0108*** |
| | (0.0026) | (0.0014) |
| Operating Profitability | -0.1710*** | -0.2240*** |
| | (0.0435) | (0.0481) |
| Cash Liquidity | -0.1290*** | -0.0725*** |
| | (0.0101) | (0.0058) |
| Marginal Tax Rate | 0.0032 | -0.0236* |
| | (0.0225) | (0.0115) |
| Observations | 32,908 | 32,908 |
| $Adjusted\ R^2$ | 0.146 | 0.212 |
| Control variables joint significance F-test statistic | 144.65*** | 63.15*** |
| Coefficients Difference F-test statistic (P&T Intangibility - Tangibility) | 11.25*** | 12.47*** |

Note: *: 10% significance level, **: 5% significance level, ***: 1% significance level

Table reports Two-Way Fixed Effects Model regressions with firm fixed effects and year fixed effects. Columns 1 is regression with Book Leverage as the dependent variable and Columns 2 uses Market Leverage as the dependent variable. Standard errors are reported in parentheses. All regressions ran with heteroskedasticity-robust standard errors clustered by Fama-French 12 industry classification.

**Table 5: Heterogeneity Analysis of P&T Intangible Assets (FEM with Firm Fixed Effects)**

| | (1) | (2) |
|---|---|---|
| | Book Leverage | Market Leverage |
| P&T Intangibility | 0.0151 | 0.0164 |
| | (0.0161) | (0.0091) |
| High Tangibility | 0.0286** | 0.0234** |
| | (0.0098) | (0.0080) |
| High Tangibility * P&T Intangibility | -0.0174* | -0.0152* |
| | (0.0096) | (0.0074) |
| After 2015 | -0.0054 | 0.0054 |
| | (0.0035) | (0.0036) |
| After 2015 * P&T Intangibility | 0.0046 | -0.0046 |
| | (0.0099) | (0.0069) |
| High Tangibility *After 2015 | 0.0274** | 0.0121 |
| * P&T Intangibility | (0.0102) | (0.0068) |
| Firm Age | 0.0063*** | 0.0022** |
| | (0.0010) | (0.0007) |
| Log Total Assets | 0.0193* | 0.0296*** |
| | (0.0097) | (0.0051) |
| Market-to-Book | -0.0011 | -0.0111*** |
| | (0.0025) | (0.0014) |
| Operating Profitability | -0.2000*** | -0.2420*** |
| | (0.0511) | (0.0560) |
| Cash Liquidity | -0.1520*** | -0.0898*** |
| | (0.0101) | (0.0083) |
| Marginal Tax Rate | 0.0066 | -0.0165 |
| | (0.0200) | (0.0103) |
| Observations | 32,908 | 32,908 |
| $Adjusted\ R^2$ | 0.130 | 0.189 |

Note: *: 10% significance level, **: 5% significance level, ***: 1% significance level
Table reports Fixed Effects Model regressions with firm fixed effects. Columns 1 is regression with Book Leverage as the dependent variable and Columns 2 uses Market Leverage as the dependent variable. Standard errors are reported in parentheses. All regressions ran with heteroskedasticity-robust standard errors clustered by Fama-French 12 industry classification.

**Table 6: P&T Intangible Assets Subcomponent Analysis (TWFEM)**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Book Leverage | Book Leverage | Book Leverage | Market Leverage | Market Leverage | Market Leverage |
| P&T Intangibility | 0.0258** | | | 0.0173** | | |
| | (0.0115) | | | (0.0071) | | |
| BV Intangibility | | 0.1580*** | | | 0.0937*** | |
| | | (0.0396) | | | (0.0243) | |
| BV Intangibility less Goodwill | | | 0.3760*** | | | 0.2530*** |
| | | | (0.0700) | | | (0.0418) |
| Know Cap / TA | | -0.0461* | -0.0429* | | -0.0243 | -0.0217 |
| | | (0.0231) | (0.0234) | | (0.0170) | (0.0155) |
| Organ Cap / TA | | -0.0201 | -0.0252 | | 0.0164 | 0.0142 |
| | | (0.0407) | (0.0394) | | (0.0238) | (0.0226) |
| Tangibility | 0.2250*** | 0.2910*** | 0.2730*** | 0.1650*** | 0.2010*** | 0.1950*** |
| | (0.0543) | (0.0605) | (0.0572) | (0.0374) | (0.0379) | (0.0383) |
| Firm Age | -0.0931** | -0.0934** | -0.0966** | -0.0686** | -0.0683* | -0.0702* |
| | (0.0364) | (0.0391) | (0.0404) | (0.0296) | (0.0307) | (0.0319) |
| Log Total Assets | 0.0213** | 0.0105 | 0.0120 | 0.0312*** | 0.0263*** | 0.0269*** |
| | (0.0093) | (0.0095) | (0.0092) | (0.0053) | (0.0054) | (0.00512) |
| Market-to-Book | -0.0010 | -0.0006 | -0.0005 | -0.0108*** | -0.0106*** | -0.0105*** |
| | (0.0026) | (0.0024) | (0.0024) | (0.0014) | (0.0015) | (0.0015) |
| Operating Profitability | -0.1710*** | -0.1750*** | -0.1750*** | -0.2240*** | -0.2250*** | -0.2240*** |
| | (0.0435) | (0.0396) | (0.0383) | (0.0481) | (0.0464) | (0.0453) |
| Cash Liquidity | -0.1290*** | -0.0862*** | -0.0987*** | -0.0725*** | -0.0480*** | -0.0526*** |
| | (0.0101) | (0.0114) | (0.0109) | (0.0058) | (0.0113) | (0.0084) |
| Marginal Tax Rate | 0.0032 | -0.0030 | -0.0016 | -0.0236* | -0.0259** | -0.0249** |
| | (0.0225) | (0.0199) | (0.0199) | (0.0115) | (0.0109) | (0.0108) |
| Less Goodwill | No | No | Yes | No | No | Yes |
| Observations | 32,908 | 32,908 | 32,908 | 32,908 | 32,908 | 32,908 |
| $Adjusted\ R^2$ | 0.146 | 0.154 | 0.156 | 0.212 | 0.217 | 0.220 |
| Intangibility Joint significance F-test statistic | - | 10.56*** | 12.05*** | - | 6.53** | 14.05*** |

Note: *: 10% significance level, **: 5% significance level, ***: 1% significance level
Table reports Two-Way Fixed Effects Model regressions with firm fixed effects and year fixed effects. Columns 1-3 are regression with Book Leverage as the dependent variable and Columns 4-6 use Market Leverage as the dependent variable. Standard errors are reported in parentheses. All regressions ran with heteroskedasticity-robust standard errors clustered by Fama-French 12 industry classification.

**Table 7: Survivorship Bias Robustness Test with P&T Intangibility (TWFEM)**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Book Leverage | Book Leverage | Book Leverage | Market Leverage | Market Leverage | Market Leverage |
| P&T Intangibility | 0.0258** | 0.0572** | 0.0040 | 0.0173** | 0.0223* | 0.0099 |
| | (0.0115) | (0.0211) | (0.0153) | (0.0071) | (0.0118) | (0.0109) |
| Tangibility | 0.2250*** | 0.2790*** | 0.1130*** | 0.1650*** | 0.2160*** | 0.09160*** |
| | (0.0543) | (0.0440) | (0.0195) | (0.0374) | (0.0360) | (0.0135) |
| Firm Age | -0.0931** | -0.0715 | 0.0073 | -0.0686** | -0.0354 | 0.0152 |
| | (0.0364) | (0.0458) | (0.0124) | (0.0296) | (0.0407) | (0.0101) |
| Log Total Assets | 0.0213** | 0.0371*** | 0.0118*** | 0.0312*** | 0.0296*** | 0.0214*** |
| | (0.0093) | (0.0033) | (0.0035) | (0.0053) | (0.0033) | (0.0030) |
| Market-to-Book | -0.0010 | 0.0045* | 0.0049** | -0.0108*** | -0.0117*** | -0.0152*** |
| | (0.0026) | (0.0021) | (0.0018) | (0.0014) | (0.0016) | (0.0018) |
| Operating Profitability | -0.1710*** | -0.2820*** | -0.2920*** | -0.2240*** | -0.3510*** | -0.2890*** |
| | (0.0435) | (0.0585) | (0.0274) | (0.0481) | (0.0631) | (0.0456) |
| Cash Liquidity | -0.1290*** | -0.1010*** | -0.1960*** | -0.0725*** | -0.0805*** | -0.1280*** |
| | (0.0101) | (0.0091) | (0.0064) | (0.0058) | (0.0048) | (0.0085) |
| Marginal Tax Rate | 0.0032 | -0.0309 | -0.0684*** | -0.0236* | -0.0269* | -0.0739*** |
| | (0.0225) | (0.0189) | (0.0091) | (0.0115) | (0.0125) | (0.0052) |
| Balanced Panel Data | No | Yes | No | No | Yes | No |
| Observations | 32,908 | 21,333 | 126,514 | 32,908 | 21,333 | 126,514 |
| $Adjusted\ R^2$ | 0.146 | 0.208 | 0.123 | 0.212 | 0.246 | 0.219 |

Note: *: 10% significance level, **: 5% significance level, ***: 1% significance level
Table reports Two-Way Fixed Effects Model regressions with firm fixed effects and year fixed effects. Columns 1-3 are regression with Book Leverage as the dependent variable and Columns 4-6 use Market Leverage as the dependent variable. Standard errors are reported in parentheses. All regressions ran with heteroskedasticity-robust standard errors clustered by Fama-French 12 industry classification.

**Table 8: Survivorship Bias Robustness Test with P&T Intangibility Subcomponents (TWFEM)**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Book Leverage | Book Leverage | Book Leverage | Market Leverage | Market Leverage | Market Leverage |
| BV Intangibility | 0.1580*** | 0.2180*** | 0.1660*** | 0.0937*** | 0.1250*** | 0.1070*** |
| | (0.0396) | (0.0342) | (0.0267) | (0.0243) | (0.0265) | (0.0217) |
| Know Cap / TA | -0.0461* | 0.0349 | -0.0999** | -0.0243 | 0.0033 | -0.0610** |
| | (0.0231) | (0.0668) | (0.0321) | (0.0170) | (0.0491) | (0.0242) |
| Organ Cap / TA | -0.0201 | -0.0337 | -0.0449** | 0.0164 | -0.0376 | 0.0022 |
| | (0.0407) | (0.0562) | (0.0161) | (0.0238) | (0.0327) | (0.0125) |
| Tangibility | 0.2910*** | 0.3650*** | 0.1680*** | 0.2010*** | 0.2710*** | 0.1240*** |
| | (0.0605) | (0.0419) | (0.0155) | (0.0379) | (0.0358) | (0.0105) |
| Firm Age | -0.0934** | -0.0855 | 0.0061 | -0.0683* | -0.0436 | 0.0143 |
| | (0.0391) | (0.0523) | (0.0132) | (0.0307) | (0.0453) | (0.0104) |
| Log Total Assets | 0.0105 | 0.0177*** | 0.0051 | 0.0263*** | 0.0177*** | 0.0179*** |
| | (0.0095) | (0.0044) | (0.0029) | (0.0054) | (0.0039) | (0.0025) |
| Market-to-Book | -0.0006 | 0.0045* | 0.0047** | -0.0106*** | -0.0117*** | -0.0152*** |
| | (0.0024) | (0.0020) | (0.0016) | (0.0015) | (0.0016) | (0.0018) |
| Operating Profitability | -0.1750*** | -0.2870*** | -0.2890*** | -0.2250*** | -0.3510*** | -0.2880*** |
| | (0.0396) | (0.0516) | (0.0260) | (0.0464) | (0.0597) | (0.0448) |
| Cash Liquidity | -0.0862*** | -0.0471*** | -0.1640*** | -0.0480*** | -0.0461*** | -0.1090*** |
| | (0.0114) | (0.0102) | (0.0060) | (0.0113) | (0.0094) | (0.0077) |
| Marginal Tax Rate | -0.0030 | -0.0319 | -0.0739*** | -0.0259** | -0.0277** | -0.0766*** |
| | (0.0199) | (0.0181) | (0.0070) | (0.0109) | (0.0119) | (0.0045) |
| Balanced Panel Data | No | Yes | No | No | Yes | No |
| Observations | 32,908 | 21,333 | 126,514 | 32,908 | 21,333 | 126,514 |
| $Adjusted\ R^2$ | 0.154 | 0.222 | 0.138 | 0.217 | 0.256 | 0.226 |
| Intangibility Joint significance F-test statistic | 10.56*** | 32.24*** | 87.28*** | 6.53** | 15.76*** | 16.93*** |

Note: *: 10% significance level, **: 5% significance level, ***: 1% significance level

Table reports Two-Way Fixed Effects Model regressions with firm fixed effects and year fixed effects. Columns 1-3 are regression with Book Leverage as the dependent variable and Columns 4-6 use Market Leverage as the dependent variable. Standard errors are reported in parentheses. All regressions ran with heteroskedasticity-robust standard errors clustered by Fama-French 12 industry classification.