Discounting Complexity:
A Study into the Effect of Complexity on the Excess Values of Diversified Firms

by

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Abstract

This paper studies the effect of diversification on firm values in the U.S. market between 1976 and 2018. It also examines how such effects vary across firms with different levels of complexities between 1996 and 2017. First, using an improved version of the Berger and Ofek (1995) methodology that includes diversified firms with financial services segments, we find that the median diversified firms have consistently traded at discounts compared to their undiversified counterparts since 1976. The diversification discount persists after we control for the firm size, reinvestments, and profitability. Then, using the sizes of their 10-K filings as a proxy for complexities, we obtain that the more complex a diversified firm is, the larger discount (loss in value) it tends to suffer after we control for firm size, reinvestments, cross-subsidization, and time fixed effects; for an undiversified firm, the reverse is true. As a result, complexities could be a factor contributing to the phenomenon of diversification discount.

Table of Contents

1. Introduction

"To diversify or not to diversify" — this decision proves difficult, according to London Business School researcher, Constantinos Markides. While Professor Markides highlights remarkable diversification successes, such as General Electric and 3M, he also warns there is no lack of crippling failures.[1]

Due to the high stakes involved, the topic of diversification premium/discount has been extensively studied. As early as 1975, Professor Oliver Williamson discussed this matter theoretically, arguing that by engaging in "internal competition" and "assign(ing) cash flows to high yield use", diversified firms could create excess values[2]. Similarly, Professor Jeremy Stein argued in 1997 that diversified firms could engage in "winner-picking" and thus create values.[3] On the other hand, in "The Agency Costs of Free Cash Flow, Corporate Finance and Takeovers" (1986), Professor Michael Jensen brought up an alternative viewpoint, suggesting that diversification could be "one way managers spend cash instead of paying it out to shareholders" and could often be low-benefit, if not value-destroying[4].

In one of the most well-cited papers in this area, "Diversification's Effect on Firm Value" (1995), Professor Philip Berger and Professor Eli Ofek researched the diversification premium/discount empirically. They concluded that, compared with the median undiversified firms, the median diversified firms trade at discounts. According to Berger and Ofek, the value-reducing factors associated with the discount include cross-subsidization, and overinvestment, while the value-enhancing factors include tax advantages, debt capacities,

[1] Markides, Constantinos C. "To Diversify or Not To Diversify." *Harvard Business Review*, November–December 1997, hbr.org/1997/11/to-diversify-or-not-to-diversify.
[2] Williamson, Oliver E. "Hierarchies, Markets and Power in the Economy: An Economic Perspective." *Industrial and Corporate Change*, vol. 4, no. 1, 1995, pp. 21-49., doi: https://doi.org/10.1093/icc/4.1.21.
[3] Stein, Jeremy C. "Internal Capital Markets and the Competition for Corporate Resources." *The Journal of Finance*, vol. 52, no. 1, 1997, pp. 111-133., doi: https://doi.org/10.1111/j.1540-6261.1997.tb03810.x.
[4] Jensen, Michael C. "The Agency Costs of Free Cash Flow: Corporate Finance and Takeovers." *The American Economic Review*, vol. 76, no. 2, 1986, pp. 323-329, https://www.jstor.org/stable/1818789?seq=1.

etc.[5]

The previous studies highlighted the many factors behind the diversification premium/discount, including 'winner picking, cross-subsidization, debt capacities, overinvestment, etc., which all directly impact a diversified firm's fundamental value. Nevertheless, there could very well be another type of factor at play. In "The Value of Transparency and the Cost of Complexity" (2006), Professor Aswath Damodaran argues that financial complexities, resulting from business, structural, or disclosure decisions, often have adverse effects on the market valuations of firms.[6] Different from the previously mentioned factors, complexities influence the market valuations of firms but do not necessarily impact their fundamental values. Instead, given that firms often use complexities to conceal unpleasant news, financial complexities cause the information asymmetry to grow and the public perception of the firm to erode, which subsequently affects its market capitalization.

Diversified firms have long been known for their convoluted and often opaque structures. Consequently, it is worthwhile for us to investigate the effect of complexities on the premiums/discounts associated with diversified firms.

In this paper, we start by imputing diversification's effects on firm values with an improved version of the Berger-Ofek method and, after obtaining the diversification premiums/discounts, we examine how they are affected by complexities.

More specifically, section 2 details the data sources, sample selection, and the empirical methods used to obtain the diversification premiums/discounts. Section 3 examines the results regarding the diversification premiums/discounts. Section 4 explains the data and

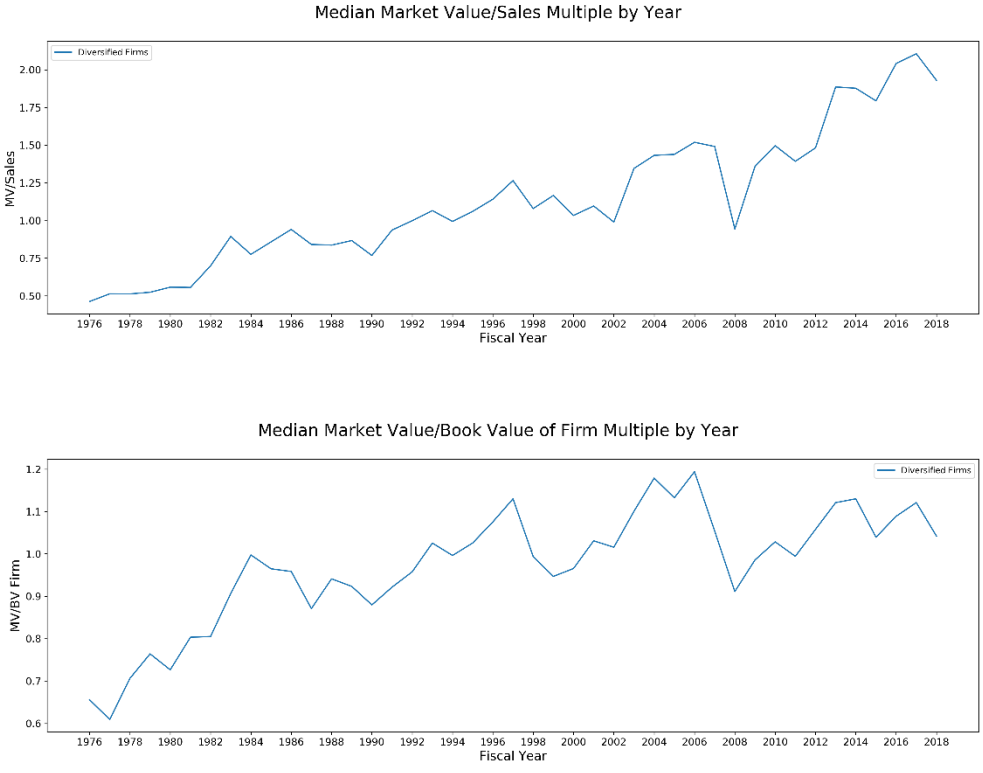
[5] Berger, Philip G., and Ofek, Eli. "Diversification's Effect on Firm Value." *Journal of Financial Economics*, vol. 37, no. 1, 1995, pp. 39–65., doi:10.1016/0304-405x(94)00798-6.
[6] Damodaran, Aswath. "The Value of Transparency and the Cost of Complexity." *SSRN Electronic Journal*, Jan. 2006, doi:10.2139/ssrn.886836.

empirical methods used to investigate the effect of complexity on the diversification premiums/discount. Section 5 makes explicit the potential qualifications that the methodologies of this study are subjected to and section 6 concludes.

2. Data and Methodology

The methodologies used to impute the effect of diversification on firm values are primarily inspired by Professor Berger and Professor Ofek's paper "Diversification's effect on firm value" (1995). Nevertheless, several moderations were made so that more consistent and comprehensive results could be obtained. Most importantly, this paper will cover firms over a much longer period (1976-2019) and will include firms with financial services segments, which account for 8,762 out of the 54,670 observations of diversified firms, and 11,309 out of the 82,198 observations of undiversified firms. Moreover, in this paper, values of diversified firms in a specific year will be imputed using the median pricing multiples corresponding to that year, rather than five-year periods, so that the results would not be affected by the short-term fluctuations and the long-term upward trends associated with the pricing multiples, which are demonstrated in Graph 1 and 2.

Graph 1 and 2: Median Pricing Multiples by Year



2.1. Data:

In this paper, we use data from the Compustat "Fundamental Annual" and "Historical Segments" databases, which provide us with firm-level and segment-level financial data between 1976 and 2018.

2.2. Sample Selection

As the analysis is based on merging the "Fundamental Annual" and "Historical Segments", the sample for both diversified and undiversified firms will be limited to firms that appear in both of the databases. Moreover, following the Berger-Ofek methodology, this paper has excluded diversified firms with sales less than $20 million and diversified firms whose segment-level data do not add up to the firm-level data by $\pm$ 1%, so that the pricing multiples and the later imputation of value would be relatively accurate.[7] As different pricing multiples would be used for non-financial firms and financial services, this paper requires diversified firms without financial services to have sales data that add up, and diversified firms with financial services to have both sales and assets data that add up.

Having filtered out these observations, the "Fundamental Annual" and "Historical Segments" databases are merged and undiversified firms and diversified firms are separated from each other. Whether a firm is diversified or undiversified in a particular year is determined by the number of unique primary Standard Industrial Classification (SIC) codes of its segments. By only counting unique primary SIC codes, we ensure that distinct segments operating in the same area would not be counted redundantly.

Graph 3 shows the number of diversified and undiversified firms in the sample by

[7] Berger, Philip G., and Ofek, Eli. "Diversification's Effect on Firm Value." *Journal of Financial Economics*, vol. 37, no. 1, 1995, pp. 39–65., doi:10.1016/0304-405x(94)00798-6.

year.

Graph 3: Number of Diversified and Undiversified Firms in the Sample

2.3. Analysis

With sample processed and firms separated based on whether they are diversified, the analysis ensues. First, using the data of undiversified non-financial firms (SIC code 0100-5990, 7000-9999), the Market Value / Sales (MV/Sales) multiples for non-financial firms are calculated. MV/Sales is preferred when estimating the value of non-financial firms as it works equally well for money-losing firms, a feature that earnings multiples do not possess. The MV/Sales multiples are calculated using the formula below:

$$MV/Sales = \frac{CSHO \times PRCC_F + DLC + DLTT + PSTKRV}{REVT}$$

(CSHO refers to common share outstanding, PRCC_F refers to annual price close by fiscal year, DLC refers to debt in current liabilities, DLTT refers to total long-term debt, PSTKRV refers to preferred stock redemption value, while REVT refers to total revenue)

Any observation with any variable (excluding preferred share redemption value) being null or negative is excluded.

Second, using the data of undiversified financial services (SIC code 6000-6799), the Market Value / Book Value Firm (MV/BV Firm) multiples for financial services are calculated. MV/BV Firm is preferred when estimating the value of financial services because financial services cannot be properly valued with revenue multiples. The MV/BV Firm multiples are calculated using the formula below:

$$MV/BV\ Firm = \frac{CSHO \times PRCC\_F\ +\ DLC\ +\ DLTT\ +\ PSTKRV}{AT}$$

(AT refers to total assets)

Similar to the calculation of MV/Sales, observations with null or negative variables are excluded.

Third, the observations are grouped up by SIC code and by years. The median pricing multiple for each 2-digit SIC code and each year is calculated. Similar to the Berger-Ofek study, this paper requires each 2-digit SIC 1-year group to have more than or equal to 5 observations. [8] For groups with insufficient numbers of observations, the median multiples of the corresponding 1-digit SIC 1-year group are used instead. And if even the 1-digit SIC 1-year group lack observations, the median multiple of the market during that year were used. In practice, among the 2,810 2-digit SIC 1-year groups, 2,259 of them base their median multiples on 2-digit SIC 1-year groups, 489 of them base their median multiples on 1-digit SIC 1-year groups, and 62 base their median multiples on the market multiple of that year.

Fourth, the aforementioned median multiples were used to impute segment market

[8] Berger, Philip G., and Ofek, Eli. "Diversification's Effect on Firm Value." *Journal of Financial Economics*, vol. 37, no. 1, 1995, pp. 39–65., doi:10.1016/0304-405x(94)00798-6.

values. For the non-financial segments, market values were imputed by multiplying MV/Sales with the segment-level net sales (SALES). For the financial segments, market values were imputed by multiplying MV/BV Firm with the segment-level identifiable total assets (IAS). This process helps us impute segment market values assuming that are ran individually. Then, the imputed segment values are summed up to obtain imputed diversified firm values. The actual market values of diversified firms are calculated using the formula:

$$MV = CSHO \times PRCC\_F + DLC + DLTT + PSTKRV$$

Lastly, following the Berger-Ofek methods, excess values of the diversified firms are calculated from the imputed market value and the actual market values of them, using the following formula:

$$Excess\ Value\ (Premium/Discount) = \ln\left(\frac{MV}{Imputed\ MV}\right)$$ [9]

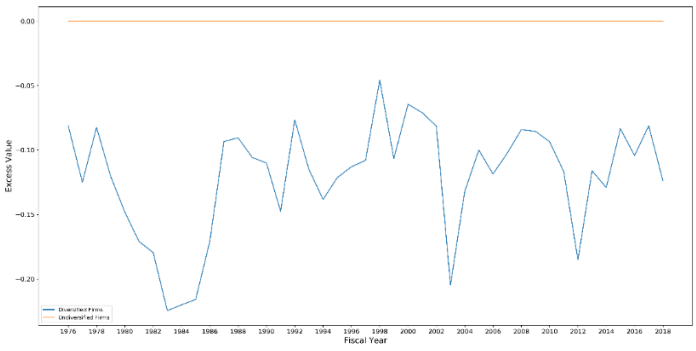
Excess values were also computed for undiversified firms following the same methods for comparison. The median and average excess values are then calculated for undiversified firms and diversified firms by year. Positive excess values indicate premiums, while negative excess values indicate discounts.

[9] Berger, Philip G., and Ofek, Eli. "Diversification's Effect on Firm Value." *Journal of Financial Economics*, vol. 37, no. 1, 1995, pp. 39–65., doi:10.1016/0304-405x(94)00798-6.

3. Diversification Discount

Following the aforesaid methodologies, we obtain the results demonstrated in Table 1, Graph 4, and Graph 5. The results show that consistent with the results of the Berger-Ofek study, diversified firms consistently trade at lower values compared to diversified firms. Table 1 and Graph 4 show that while the median undiversified firms have excess values that are approximately zero, the median diversified firms have consistently had excess values below zero since 1976. Table 1 and Graph 5 show that while the average excess values of undiversified firms oscillate over time, the average excess values of diversified firms have been consistently below that of undiversified firms. In other words, diversified firms have traded at discounts compared to their undiversified counterparts.

Graph 4: Median Excess Values by Fiscal Year



Graph 5: Average Excess Values by Fiscal Year

Table 1: Excess Value (Premium/Discount) Statistics for Diversified and Undiversified Firms

Fiscal Year	Median Excess Value (Premium/Discount)		Mean Excess Value (Premium/Discount)	
	Undiversified Firms	Diversified Firms	Undiversified Firms	Diversified Firms
1976	0	-0.081	0.028	0.017
1977	0	-0.125	-0.043	-0.1
1978	0	-0.082	-0.006	-0.065
1979	0	-0.12	-0.03	-0.113
1980	0	-0.148	-0.028	-0.133
1981	0	-0.171	-0.008	-0.162
1982	0	-0.18	-0.01	-0.174
1983	0	-0.225	-0.007	-0.22
1984	0	-0.22	0.019	-0.2
1985	0	-0.216	0.015	-0.184
1986	0	-0.171	0.023	-0.146
1987	0	-0.093	0.009	-0.107
1988	0	-0.09	0.03	-0.095
1989	0	-0.106	0.012	-0.087
1990	0	-0.11	0.008	-0.13
1991	0	-0.148	0.01	-0.151
1992	0	-0.077	0.021	-0.089
1993	0	-0.115	0.022	-0.128
1994	0	-0.138	0.013	-0.115
1995	0	-0.121	0.027	-0.119
1996	0	-0.113	0.036	-0.077
1997	0	-0.108	0.019	-0.099
1998	0	-0.046	0.04	-0.025
1999	0	-0.107	0.098	-0.062
2000	0	-0.064	0.066	-0.057
2001	0	-0.071	-0.018	-0.107
2002	0	-0.081	-0.038	-0.11
2003	0	-0.205	-0.041	-0.231
2004	0	-0.132	0.005	-0.139
2005	0	-0.1	-0.005	-0.106
2006	0	-0.119	0.008	-0.112
2007	0	-0.103	0.029	-0.102
2008	0	-0.084	-0.04	-0.121
2009	0	-0.085	-0.029	-0.12
2010	0	-0.093	-0.029	-0.133
2011	0	-0.117	-0.021	-0.148
2012	0	-0.185	-0.044	-0.222
2013	0	-0.116	-0.016	-0.168
2014	0	-0.129	-0.032	-0.158
2015	0	-0.083	0.004	-0.121
2016	0	-0.104	-0.009	-0.159
2017	0	-0.081	-0.003	-0.134
2018	0	-0.124	0.002	-0.178

Controlling for firm size and reinvestment, we obtain the same result of diversification discount. Table 2 shows an ordinary least square (OLS) regression in which excess values (premiums/discounts) of diversified and undiversified firms are regressed against the total assets, capital expenditure (CapEx) over sales, and an indicator variable that show whether the firm is diversified. The regression shows that diversified firms on average trade at market values that are 15.21% lower than that of undiversified firms with firm size and reinvestment controlled. With a t-stat of -34.26, the result is statistically significant. Table 3 shows a variation of the OLS regression in which profitability, represented by earnings before interest and taxes (EBIT) over sales is also controlled. The sample was limited to profiting firms. The result is, nonetheless, consistent. The statistically significant result shows that after controlling for firm size, reinvestment, and profitability, profiting diversified firms on average trade at market values that are 7.52% than that of undiversified firms.

Table 2: Excess Returns Controlling for Firm Size and Reinvestment

OLS Regression Results

Dep. Variable:	ExcessValue	R-squared:	0.050
Model:	OLS	Adj. R-squared:	0.050
Method:	Least Squares	F-statistic:	2263.
Date:	Sun, 21 Mar 2021	Prob (F-statistic):	0.00
Time:	22:59:01	Log-Likelihood:	-1.4325e+05
No. Observations:	128947	AIC:	2.865e+05
Df Residuals:	128943	BIC:	2.865e+05
Df Model:	3		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	-0.2760	0.006	-43.885	0.000	-0.288	-0.264
C(Diversified)[T.1]	-0.1521	0.004	-34.260	0.000	-0.161	-0.143
Ln_TotalAssets	0.0412	0.001	42.459	0.000	0.039	0.043
CapEx_Sales	0.4130	0.007	61.300	0.000	0.400	0.426

Omnibus:	8362.092	Durbin-Watson:	0.649
Prob(Omnibus):	0.000	Jarque-Bera (JB):	38242.281
Skew:	0.119	Prob(JB):	0.00
Kurtosis:	5.657	Cond. No.	21.9

Table 3: Excess Returns Controlling for Firm Size, Profitability, and Reinvestment

OLS Regression Results

Dep. Variable:	ExcessValue	R-squared:	0.085
Model:	OLS	Adj. R-squared:	0.085
Method:	Least Squares	F-statistic:	2526.
Date:	Sun, 21 Mar 2021	Prob (F-statistic):	0.00
Time:	22:59:06	Log-Likelihood:	-1.1089e+05
No. Observations:	108808	AIC:	2.218e+05
Df Residuals:	108803	BIC:	2.218e+05
Df Model:	4		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	-0.2033	0.006	-31.568	0.000	-0.216	-0.191
C(Diversified)[T.1]	-0.0752	0.004	-16.789	0.000	-0.084	-0.066
EBIT_Sales	0.9807	0.014	70.635	0.000	0.954	1.008
Ln_TotalAssets	0.0039	0.001	3.782	0.000	0.002	0.006
CapEx_Sales	0.4624	0.010	48.618	0.000	0.444	0.481

Omnibus:	5632.269	Durbin-Watson:	0.616
Prob(Omnibus):	0.000	Jarque-Bera (JB):	21418.343
Skew:	0.088	Prob(JB):	0.00
Kurtosis:	5.166	Cond. No.	46.4

4. The Effect of Complexity on the Diversification Discount

The results in the previous section suggest that diversified firms overall trade at discounts compared with their undiversified counterparts. And that conclusion holds even when we control for firm size, reinvestment, and profitability. That entails that the market values of diversified firms are more often lower than that of the sum of its parts, assuming they were individually run. Professor Berger and Professor Ofek have suggested in their 1995 study that the factors of value gains and losses for diversified firms include tax advantages, debt capacities, cross-subsidization, over-investment, etc.[10] The mechanism through which the aforementioned factors influence a firm's diversification discount/premium is that they directly affect its fundamental attributes (profitability, leverage, etc.) and intrinsic values. However, the gaps between intrinsic values and market values in the equity market can often be considerable, so there could very well be another type of factor at play. This other type of factor could influence the market values without necessarily altering the fundamentals of firms, by increasing the level of information asymmetry or hampering the public perceptions associated with a firm.

Among the most notable attributes of diversified firms are their formidable complexities, so it is only natural that we investigate the effects of complexities on the excess values of diversified firms.

In "The Value of Transparency and the Cost of Complexity" (2006), Professor Damodaran has provided us a "simplistic but surprisingly effective" measure of complexity, which is the length of the firm's 10-K filings. Admittedly, there could be many subtleties surrounding the length of 10-K filings. For example, according to Professor Damodaran,

[10] Berger, Philip G., and Ofek, Eli. "Diversification's Effect on Firm Value." *Journal of Financial Economics*, vol. 37, no. 1, 1995, pp. 39–65., doi:10.1016/0304-405x(94)00798-6.

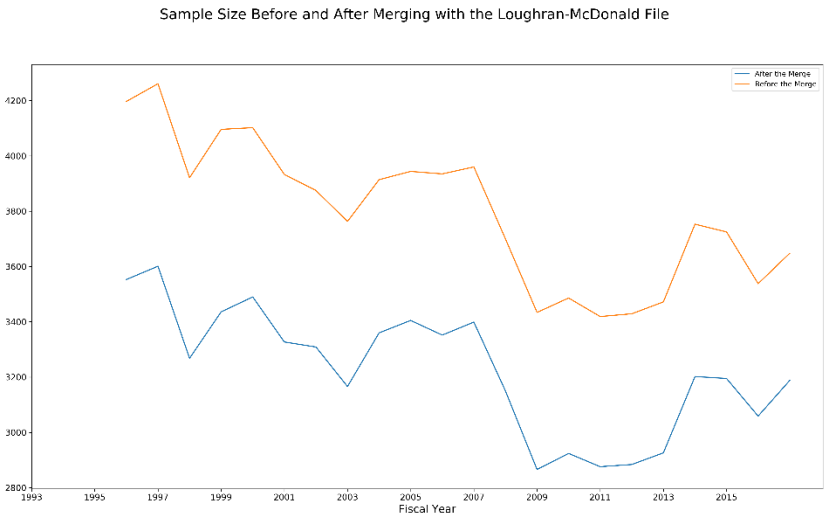
short 10-K filings could indicate that the business and financial structures of the firm are simple, yet it could mean a lack of disclosure. Moreover, he suggests that complexity in 10-Ks could reflect complexities of different dimensions, as it can result from "business decisions", "structuring decisions on how the firm is organized", "disclosure decisions", or simply "accounting decisions".[11] That said, the length of 10-K filings is a relatively accurate measure of complexity, as 10-K filings, unlike annual reports, are governed by a common set of standards set by the SEC. And more importantly, being highly available, it provides us a proxy through which we could analyze a large sample of firms. Therefore, we will use the length of 10-K filings as the indicator of complexities in this paper to analyze the effects of complexities on diversification premiums/discounts.

4.1. Data

For the sizes of 10-K filings, we will use the Loughran-McDonald 10-K file summaries from the Software Repository for Accounting and Finance at the University of Notre Dame. With its methods detailed in Professor Tim Loughran and Professor Bill McDonald's paper "Textual Analysis in Accounting and Finance: A Survey", the file provides us with 10-K lengths in characters after a "stage one parse" which "cleans each filing document of extraneous materials"[12]. In total, it provides us with more than 240,000 observations between 1996 and 2017. We proceed with regression analysis after merging our results on diversification premiums/discounts with the Loughran-McDonald file.

[11] Damodaran, Aswath. "The Value of Transparency and the Cost of Complexity." *SSRN Electronic Journal*, Jan. 2006, doi:10.2139/ssrn.886836.
[12] Loughran, Tim, and McDonald, Bill. "Textual Analysis in Finance and Accounting: A Survey." *SSRN Electronic Journal*, Oct. 2014, doi:10.2139/ssrn.2504147.

Graph 6: Sample Size Before and After Merging with the Loughran-McDonald file (1996-2017)



4.2. Analysis

With the data merged and cleaned, the analysis ensues. Regressions of undiversified firms are conducted as well as regressions of diversified firms for comparison. Under simple linear regression, as shown in Tables 4 and 5, we find that the excess values for both diversified and undiversified firms are directly proportional to the natural log of 10-K filing sizes, though the latter are influenced more significantly: with a 100% increase in its 10-K size, the premium of a diversified firm is expected to increase by approximately 4.55%, while that of an undiversified firm is expected to increase by approximately 7.18%. However, much of the effects could be due to confounding biases. To obtain more accurate results, we must control for firm size, reinvestments, cross-subsidization, and fixed effects. Firm sizes (total assets), according to Professor John E. Hund, Professor Donald Monk, and Professor Sheri Tice, predict growth rate uncertainties to a certain extent, and is among the "key value relevant characteristics."[13] Reinvestments, represented by capital expenditure over sales, are

[13] Hund, John E., Monk, Donald, and Tice, Sheri. "The Berger-Ofek Diversification Discount Is Just Poor Firm

controlled following the Berger-Ofek method. Lastly, a dummy variable indicating whether there is a segment with negative operating profits is controlled as it stands for cross-subsidization, a value-destroying factor associated with diversification according to Professor Berger and Professor Ofek.[14] While firm age is also among the "key value relevant characteristics" according to Professor Hund, Professor Monk, and Professor Tice[15], it would not be controlled in this study due to its low availability. While Compustat includes relatively abundant data on the Initial Public Offering (IPO) dates of firms, the IPO dates are highly different from the founding dates. On the other hand, while Professor Jay Ritter at the University of Florida presents us with very accurate founding dates for IPOs between 1975 and 2020, the data covers less than 14,000 firms, which accounts for but a very small proportion of our sample.[16] Moreover, while operating margins (EBIT/Sales) could be controlled, we would not use it as a control variable extensively. The reason is that to include it in the regression, money-losing firms that account for 12% of the diversified and 35% of the undiversified observations would need to be filtered out, which would not only reduce the sample size but also cause significant selection bias.

After controlling for firm sizes (log of total assets), capital expenditure over sales, and cross-subsidization (a variable that indicates whether the firm has money-losing segments for diversified firms / whether the firm is losing money for undiversified firms), as shown in Tables 6 and 7, we obtain results different from that of the simple linear regressions: the excess values of diversified firms are adversely affected by complexities (10-K sizes) at a

Matching", 2019.

[14] Berger, Philip G., and Ofek, Eli. "Diversification's Effect on Firm Value." *Journal of Financial Economics*, vol. 37, no. 1, 1995, pp. 39–65., doi:10.1016/0304-405x(94)00798-6.

[15] Hund, John E., Monk, Donald, and Tice, Sheri. "The Berger-Ofek Diversification Discount Is Just Poor Firm Matching", 2019.

[16] The Field-Ritter dataset of company founding dates, as used in Laura C. Field and Jonathan Karpoff "Takeover Defenses of IPO Firms" in the October 2002 Journal of Finance Vol. 57. No. 5, pp. 1857-1889, and Tim Loughran and Jay R. Ritter, "Why Has IPO Underpricing Changed Over Time?" in the Autumn 2004 Financial Management Vol. 33, No. 3, pp. 5-37.

statistically significant level. With a 100% increase in its 10-K size, a diversified firm is expected to suffer an approximately larger 4.79% discount. Meanwhile, the excess values of undiversified firms have no significant relationship with 10-K sizes.

After introducing time-fixed effects to our regressions, we obtain very similar results. As demonstrated in Tables 10 and 11, a diversified firm is expected to suffer a 3.34% larger discount if its 10-K size increases by 100%. Different from our previous results though, the excess values of undiversified firms are now directly proportional to their 10-K sizes. A doubling in its 10-K size is expected to bring a 2.2% premium to the undiversified firm. Bringing in profitability (EBIT/Sales) as a control variable and limiting the sample to profiting firms do not change our results significantly either. As shown in Tables 12 and 13, at t-stats of -4.391, with its 10-K size doubled, a diversified firm tends to suffer a value loss of 4.87%, while the effect is insignificant for undiversified firms.

Nevertheless, we obtain rather conflicting results after bringing in firm-level fixed effects. As shown in Tables 14 and 15, while the excess values of diversified firms are still inversely proportional to the 10-K sizes, the excess values of undiversified firms suffer such effects more significantly: a 100% increase in the 10-K sizes predict a 2.36% discount for a diversified firm and a 2.79% discount for an undiversified firm. According to Professor Damodaran, complexity in 10-Ks could reflect complexities of different dimensions, resulting from "business decisions", "structuring decisions on how the firm is organized", "disclosure decisions", or simply "accounting decisions".[17] As firms' business decisions and structuring decisions tend not to change as drastically in shorter periods of time, introducing firm-level fixed effects tends to make 10-K length an indicator of complexities mostly resulting from disclosure decisions. Coupling with the observation that firm-level fixed effects are

[17] Damodaran, Aswath. "The Value of Transparency and the Cost of Complexity." *SSRN Electronic Journal*, Jan. 2006, doi:10.2139/ssrn.886836.

excessively restrictive in equity research, we would focus mostly on the regressions shown in Tables 10 and 11 in our research.

To sum up, it is observed in our research that diversified firms tend to suffer larger losses in their excess values, or, in other words, more significant diversification discount, when their level of complexities, as signified by their 10-K sizes, increases. Meanwhile, undiversified firms seem not to suffer similar losses when they become more complex. Coupling with the fact that diversified firms are known for their convoluted and often opaque structures, it is reasonable for us to argue that complexity is a factor that contributes to the diversification discount.

This research, however, did not distinguish between the different dimensions resulting from "business decisions", "structuring decisions on how the firm is organized", "disclosure decisions", or simply "accounting decisions" [18]. Which dimension of complexity causes diversified firms' excess values to decrease the most is worth further investigation. (Though if our previous line of reasoning[19] is consistent, the regressions with firm fixed effects may have shown that it is not complex due to disclosure decisions, as it has more negative impacts on undiversified firms' excess values).

Moreover, this research may be subjected to a potentially wide range of limitations, which will be made explicit in the next section.

[18] Damodaran, Aswath. "The Value of Transparency and the Cost of Complexity." *SSRN Electronic Journal*, Jan. 2006, doi:10.2139/ssrn.886836.

[19] That as firms' business decisions and structuring decisions tend not to change drastically in shorter periods, in regressions with firm fixed effects, 10-K length could represent complexity resulting from disclosure decisions above all else.

Table 4 and 5: Simple Linear Regression of Excess Values on 10-K File Size

Diversified Firms

OLS Regression Results

Dep. Variable:	ExcessValue	R-squared:	0.001
Model:	OLS	Adj. R-squared:	0.001
Method:	Least Squares	F-statistic:	20.26
Date:	Sun, 18 Apr 2021	Prob (F-statistic):	6.79e-06
Time:	21:43:10	Log-Likelihood:	-18278.
No. Observations:	15730	AIC:	3.656e+04
Df Residuals:	15728	BIC:	3.657e+04
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	-0.7021	0.129	-5.443	0.000	-0.955	-0.449
Ln_NetFileSize	0.0455	0.010	4.502	0.000	0.026	0.065

Omnibus:	1051.936	Durbin-Watson:	0.730
Prob(Omnibus):	0.000	Jarque-Bera (JB):	4730.307
Skew:	0.152	Prob(JB):	0.00
Kurtosis:	5.669	Cond. No.	268.

Undiversified Firms

OLS Regression Results

Dep. Variable:	ExcessValue	R-squared:	0.004
Model:	OLS	Adj. R-squared:	0.004
Method:	Least Squares	F-statistic:	199.3
Date:	Sun, 18 Apr 2021	Prob (F-statistic):	3.61e-45
Time:	21:43:11	Log-Likelihood:	-62681.
No. Observations:	55206	AIC:	1.254e+05
Df Residuals:	55204	BIC:	1.254e+05
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	-0.9006	0.065	-13.872	0.000	-1.028	-0.773
Ln_NetFileSize	0.0718	0.005	14.116	0.000	0.062	0.082

Omnibus:	4127.780	Durbin-Watson:	0.620
Prob(Omnibus):	0.000	Jarque-Bera (JB):	21395.277
Skew:	0.146	Prob(JB):	0.00
Kurtosis:	6.036	Cond. No.	260.

Table 6 and 7: Linear Regression of Excess Values on 10-K File Size Controlling for Firm Size, Capital Expenditure Over Sales, and Cross-Subsidization

Diversified Firms

OLS Regression Results

Dep. Variable:	ExcessValue	R-squared:	0.044
Model:	OLS	Adj. R-squared:	0.044
Method:	Least Squares	F-statistic:	180.8
Date:	Sun, 18 Apr 2021	Prob (F-statistic):	1.15e-151
Time:	21:45:32	Log-Likelihood:	-17816.
No. Observations:	15635	AIC:	3.564e+04
Df Residuals:	15630	BIC:	3.568e+04
Df Model:	4		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	0.1438	0.135	1.066	0.286	-0.121	0.408
C(MoneyLosingSegment)[T.1]	-0.0921	0.016	-5.753	0.000	-0.124	-0.061
Ln_TotalAssets	0.0550	0.003	16.674	0.000	0.049	0.061
CapEx_Sales	0.4225	0.022	19.311	0.000	0.380	0.465
Ln_NetFileSize	-0.0479	0.011	-4.195	0.000	-0.070	-0.026

Omnibus:	1292.692	Durbin-Watson:	0.748
Prob(Omnibus):	0.000	Jarque-Bera (JB):	7321.706
Skew:	0.167	Prob(JB):	0.00
Kurtosis:	6.336	Cond. No.	328.

Undiversified Firms

OLS Regression Results

Dep. Variable:	ExcessValue	R-squared:	0.050
Model:	OLS	Adj. R-squared:	0.050
Method:	Least Squares	F-statistic:	565.9
Date:	Sun, 18 Apr 2021	Prob (F-statistic):	0.00
Time:	21:45:54	Log-Likelihood:	-50988.
No. Observations:	43297	AIC:	1.020e+05
Df Residuals:	43292	BIC:	1.020e+05
Df Model:	4		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	-0.4375	0.081	-5.400	0.000	-0.596	-0.279
C(MoneyLosingFirm)[T.1]	0.0396	0.010	3.801	0.000	0.019	0.060
Ln_TotalAssets	0.0614	0.002	27.085	0.000	0.057	0.066
CapEx_Sales	0.4348	0.013	34.377	0.000	0.410	0.460
Ln_NetFileSize	0.0006	0.007	0.087	0.931	-0.013	0.014

Omnibus:	2895.418	Durbin-Watson:	0.697
Prob(Omnibus):	0.000	Jarque-Bera (JB):	12891.321
Skew:	0.164	Prob(JB):	0.00
Kurtosis:	5.653	Cond. No.	308.

Table 8 and 9: Linear Regression of Excess Values on 10-K File Size Controlling for Operating Margin, Firm Size, and Capital Expenditure Over Sales (Sample limited to profiting firms)

Diversified Firms

OLS Regression Results

Dep. Variable:	ExcessValue	R-squared:	0.149
Model:	OLS	Adj. R-squared:	0.148
Method:	Least Squares	F-statistic:	601.8
Date:	Sun, 18 Apr 2021	Prob (F-statistic):	0.00
Time:	21:46:41	Log-Likelihood:	-14067.
No. Observations:	13802	AIC:	2.814e+04
Df Residuals:	13797	BIC:	2.818e+04
Df Model:	4		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	0.1987	0.127	1.560	0.119	-0.051	0.448
EBIT_Sales	2.5406	0.062	40.746	0.000	2.418	2.663
Ln_TotalAssets	0.0159	0.003	4.739	0.000	0.009	0.023
CapEx_Sales	0.5374	0.046	11.783	0.000	0.448	0.627
Ln_NetFileSize	-0.0591	0.011	-5.475	0.000	-0.080	-0.038

Omnibus:	1398.500	Durbin-Watson:	0.742
Prob(Omnibus):	0.000	Jarque-Bera (JB):	11626.253
Skew:	0.035	Prob(JB):	0.00
Kurtosis:	7.496	Cond. No.	331.

Undiversified Firms

OLS Regression Results

Dep. Variable:	ExcessValue	R-squared:	0.061
Model:	OLS	Adj. R-squared:	0.061
Method:	Least Squares	F-statistic:	572.0
Date:	Sun, 18 Apr 2021	Prob (F-statistic):	0.00
Time:	21:47:04	Log-Likelihood:	-37061.
No. Observations:	35064	AIC:	7.413e+04
Df Residuals:	35059	BIC:	7.418e+04
Df Model:	4		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	-0.1288	0.079	-1.631	0.103	-0.284	0.026
EBIT_Sales	0.5929	0.020	29.809	0.000	0.554	0.632
Ln_TotalAssets	0.0294	0.002	12.595	0.000	0.025	0.034
CapEx_Sales	0.4472	0.017	26.077	0.000	0.414	0.481
Ln_NetFileSize	-0.0162	0.007	-2.416	0.016	-0.029	-0.003

Omnibus:	1700.543	Durbin-Watson:	0.625
Prob(Omnibus):	0.000	Jarque-Bera (JB):	6119.818
Skew:	0.085	Prob(JB):	0.00
Kurtosis:	5.040	Cond. No.	308.

Table 10 and 11: Linear Regression of Excess Values on 10-K File Size Controlling for Firm Size, Capital Expenditure Over Sales, Cross-Subsidization, and Time Fixed Effects

Diversified Firms

OLS Regression Results

Dep. Variable:	ExcessValue	R-squared:	0.050
Model:	OLS	Adj. R-squared:	0.048
Method:	Least Squares	F-statistic:	32.74
Date:	Sun, 18 Apr 2021	Prob (F-statistic):	2.61e-152
Time:	21:47:46	Log-Likelihood:	-17770.
No. Observations:	15635	AIC:	3.559e+04
Df Residuals:	15609	BIC:	3.579e+04
Df Model:	25		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	-0.0552	0.139	-0.396	0.692	-0.329	0.218
C(MoneyLosingSegment)[T.1]	-0.0738	0.018	-4.216	0.000	-0.108	-0.040
C(DataFiscalYr)[T.1997.0]	-0.0191	0.041	-0.463	0.643	-0.100	0.062
C(DataFiscalYr)[T.1998.0]	0.0543	0.040	1.369	0.171	-0.023	0.132
...						
C(DataFiscalYr)[T.2016.0]	-0.0925	0.043	-2.161	0.031	-0.176	-0.009
C(DataFiscalYr)[T.2017.0]	-0.0806	0.043	-1.888	0.059	-0.164	0.003
Ln_TotalAssets	0.0595	0.003	17.729	0.000	0.053	0.066
CapEx_Sales	0.4181	0.022	19.113	0.000	0.375	0.461
Ln_NetFileSize	-0.0334	0.012	-2.872	0.004	-0.056	-0.011

Omnibus:	1275.934	Durbin-Watson:	0.744
Prob(Omnibus):	0.000	Jarque-Bera (JB):	7137.054
Skew:	0.164	Prob(JB):	0.00
Kurtosis:	6.294	Cond. No.	360.

Undiversified Firms

OLS Regression Results

Dep. Variable:	ExcessValue	R-squared:	0.054
Model:	OLS	Adj. R-squared:	0.054
Method:	Least Squares	F-statistic:	99.36
Date:	Sun, 18 Apr 2021	Prob (F-statistic):	0.00
Time:	21:48:48	Log-Likelihood:	-50883.
No. Observations:	43297	AIC:	1.018e+05
Df Residuals:	43271	BIC:	1.020e+05
Df Model:	25		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	-0.6607	0.083	-7.919	0.000	-0.824	-0.497
C(MoneyLosingFirm)[T.1]	0.0455	0.010	4.352	0.000	0.025	0.066
C(DataFiscalYr)[T.1997.0]	-0.0320	0.021	-1.507	0.132	-0.074	0.010
C(DataFiscalYr)[T.1998.0]	-0.0188	0.022	-0.843	0.399	-0.063	0.025
...						
C(DataFiscalYr)[T.2016.0]	-0.1463	0.025	-5.901	0.000	-0.195	-0.098
C(DataFiscalYr)[T.2017.0]	-0.1528	0.025	-6.219	0.000	-0.201	-0.105
Ln_TotalAssets	0.0680	0.002	29.178	0.000	0.063	0.073
CapEx_Sales	0.4241	0.013	33.509	0.000	0.399	0.449
Ln_NetFileSize	0.0220	0.007	3.128	0.002	0.008	0.036

Omnibus:	2736.299	Durbin-Watson:	0.690
Prob(Omnibus):	0.000	Jarque-Bera (JB):	11657.773
Skew:	0.152	Prob(JB):	0.00
Kurtosis:	5.524	Cond. No.	319.

Table 12 and 13: Linear Regression of Excess Values on 10-K File Size Controlling for Operating Margin, Firm Size, Capital Expenditure Over Sales, and Time Fixed Effects (Sample limited to profiting firms)

Diversified Firms

OLS Regression Results

Dep. Variable:	ExcessValue	R-squared:	0.153
Model:	OLS	Adj. R-squared:	0.152
Method:	Least Squares	F-statistic:	99.57
Date:	Mon, 19 Apr 2021	Prob (F-statistic):	0.00
Time:	20:31:39	Log-Likelihood:	-14030.
No. Observations:	13802	AIC:	2.811e+04
Df Residuals:	13776	BIC:	2.831e+04
Df Model:	25		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	0.0661	0.132	0.500	0.617	-0.193	0.325
C(DataFiscalYr)[T.1997.0]	-0.0097	0.039	-0.248	0.804	-0.087	0.067
C(DataFiscalYr)[T.1998.0]	0.0579	0.038	1.539	0.124	-0.016	0.132
...						
C(DataFiscalYr)[T.2016.0]	-0.0735	0.039	-1.865	0.062	-0.151	0.004
C(DataFiscalYr)[T.2017.0]	-0.0398	0.039	-1.016	0.310	-0.117	0.037
EBIT_Sales	2.5382	0.062	40.725	0.000	2.416	2.660
Ln_TotalAssets	0.0194	0.003	5.675	0.000	0.013	0.026
CapEx_Sales	0.5325	0.046	11.672	0.000	0.443	0.622
Ln_NetFileSize	-0.0487	0.011	-4.391	0.000	-0.070	-0.027

Omnibus:	1421.393	Durbin-Watson:	0.738
Prob(Omnibus):	0.000	Jarque-Bera (JB):	12120.162
Skew:	0.030	Prob(JB):	0.00
Kurtosis:	7.590	Cond. No.	358.

Undiversified Firms

OLS Regression Results

Dep. Variable:	ExcessValue	R-squared:	0.065
Model:	OLS	Adj. R-squared:	0.064
Method:	Least Squares	F-statistic:	96.80
Date:	Mon, 19 Apr 2021	Prob (F-statistic):	0.00
Time:	20:31:39	Log-Likelihood:	-36999.
No. Observations:	35064	AIC:	7.405e+04
Df Residuals:	35038	BIC:	7.427e+04
Df Model:	25		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	-0.2476	0.081	-3.041	0.002	-0.407	-0.088
C(DataFiscalYr)[T.1997.0]	-0.0238	0.021	-1.148	0.251	-0.064	0.017
C(DataFiscalYr)[T.1998.0]	-0.0306	0.022	-1.393	0.164	-0.074	0.012
...						
C(DataFiscalYr)[T.2016.0]	-0.1272	0.024	-5.286	0.000	-0.174	-0.080
C(DataFiscalYr)[T.2017.0]	-0.1278	0.024	-5.360	0.000	-0.174	-0.081
EBIT_Sales	0.5963	0.020	29.942	0.000	0.557	0.635
Ln_TotalAssets	0.0347	0.002	14.407	0.000	0.030	0.039
CapEx_Sales	0.4381	0.017	25.529	0.000	0.404	0.472
Ln_NetFileSize	-0.0017	0.007	-0.247	0.805	-0.015	0.012

Omnibus:	1675.555	Durbin-Watson:	0.619
Prob(Omnibus):	0.000	Jarque-Bera (JB):	5932.895
Skew:	0.089	Prob(JB):	0.00
Kurtosis:	5.007	Cond. No.	319.

Table 14 and 15: Linear Regression of Excess Values on 10-K File Size Controlling for Firm Size, Capital Expenditure Over Sales, Cross-Subsidization, and Time and Firm Fixed Effects

Diversified Firms

OLS Regression Results

Dep. Variable:	ExcessValue	R-squared:	0.768
Model:	OLS	Adj. R-squared:	0.714
Method:	Least Squares	F-statistic:	14.02
Date:	Sun, 18 Apr 2021	Prob (F-statistic):	0.00
Time:	21:39:32	Log-Likelihood:	-6732.7
No. Observations:	15635	AIC:	1.945e+04
Df Residuals:	12641	BIC:	4.238e+04
Df Model:	2993		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	-1.0800	0.335	-3.229	0.001	-1.736	-0.424
C(MoneyLosingSegment)[T.1]	-0.0122	0.013	-0.902	0.367	-0.039	0.014
C(DataFiscalYr)[T.1997.0]	-0.0387	0.024	-1.587	0.113	-0.086	0.009
C(DataFiscalYr)[T.1998.0]	-0.0139	0.026	-0.543	0.587	-0.064	0.036
...						
C(Ticker)[T.ZRN]	1.0845	0.509	2.130	0.033	0.087	2.082
C(Ticker)[T.ZRO]	1.1149	0.418	2.669	0.008	0.296	1.934
Ln_TotalAssets	0.1536	0.010	15.776	0.000	0.134	0.173
CapEx_Sales	0.1437	0.019	7.754	0.000	0.107	0.180
Ln_NetFileSize	-0.0236	0.009	-2.545	0.011	-0.042	-0.005

Omnibus:	5400.727	Durbin-Watson:	1.569
Prob(Omnibus):	0.000	Jarque-Bera (JB):	214422.649
Skew:	0.964	Prob(JB):	0.00
Kurtosis:	21.039	Cond. No.	2.31e+19

Undiversified Firms

OLS Regression Results

Dep. Variable:	ExcessValue	R-squared:	0.766
Model:	OLS	Adj. R-squared:	0.721
Method:	Least Squares	F-statistic:	17.25
Date:	Sun, 18 Apr 2021	Prob (F-statistic):	0.00
Time:	22:24:48	Log-Likelihood:	-21627.
No. Observations:	45959	AIC:	5.789e+04
Df Residuals:	38642	BIC:	1.218e+05
Df Model:	7316		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	-0.3098	0.140	-2.215	0.027	-0.584	-0.036
C(MoneyLosingFirm)[T.1]	-0.1392	0.008	-17.432	0.000	-0.155	-0.124
C(DataFiscalYr)[T.1994.0]	0.0201	0.029	0.703	0.482	-0.036	0.076
C(DataFiscalYr)[T.1995.0]	0.0287	0.025	1.138	0.255	-0.021	0.078
...						
C(Ticker)[T.ZYXI]	-0.1405	0.245	-0.573	0.567	-0.621	0.340
C(Ticker)[T.ZZ]	0.6327	0.201	3.146	0.002	0.239	1.027
Ln_TotalAssets	0.0913	0.005	19.039	0.000	0.082	0.101
CapEx_Sales	0.2482	0.010	24.265	0.000	0.228	0.268
Ln_NetFileSize	-0.0279	0.005	-5.730	0.000	-0.037	-0.018

Omnibus:	6743.703	Durbin-Watson:	1.412
Prob(Omnibus):	0.000	Jarque-Bera (JB):	99633.571
Skew:	0.166	Prob(JB):	0.00
Kurtosis:	10.206	Cond. No.	8.82e+19

Table 16 and 17: Linear Regression of Excess Values on 10-K File Size Controlling for Operating Margin, Firm Size, Capital Expenditure Over Sales, and Time and Firm Fixed Effects (Sample limited to profiting firms)

Diversified Firms

OLS Regression Results

Dep. Variable:	ExcessValue	R-squared:	0.798
Model:	OLS	Adj. R-squared:	0.750
Method:	Least Squares	F-statistic:	16.68
Date:	Mon, 19 Apr 2021	Prob (F-statistic):	0.00
Time:	20:38:28	Log-Likelihood:	-4155.1
No. Observations:	13802	AIC:	1.358e+04
Df Residuals:	11165	BIC:	3.345e+04
Df Model:	2636		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	-0.9739	0.301	-3.240	0.001	-1.563	-0.385
C(DataFiscalYr)[T.1997.0]	-0.0421	0.023	-1.830	0.067	-0.087	0.003
C(DataFiscalYr)[T.1998.0]	-0.0113	0.024	-0.466	0.641	-0.059	0.036
...						
C(Ticker)[T.ZRN]	0.9995	0.447	2.234	0.026	0.122	1.877
C(Ticker)[T.ZRO]	0.8352	0.368	2.272	0.023	0.115	1.556
EBIT_Sales	2.5222	0.083	30.442	0.000	2.360	2.685
Ln_TotalAssets	0.0749	0.010	7.712	0.000	0.056	0.094
CapEx_Sales	0.4727	0.047	10.093	0.000	0.381	0.565
Ln_NetFileSize	-0.0040	0.009	-0.460	0.645	-0.021	0.013

Omnibus:	6335.939	Durbin-Watson:	1.614
Prob(Omnibus):	0.000	Jarque-Bera (JB):	441900.900
Skew:	1.360	Prob(JB):	0.00
Kurtosis:	30.586	Cond. No.	6.06e+19

Undiversified Firms

OLS Regression Results

Dep. Variable:	ExcessValue	R-squared:	0.798
Model:	OLS	Adj. R-squared:	0.758
Method:	Least Squares	F-statistic:	19.96
Date:	Mon, 19 Apr 2021	Prob (F-statistic):	0.00
Time:	20:41:11	Log-Likelihood:	-10145.
No. Observations:	35064	AIC:	3.187e+04
Df Residuals:	29276	BIC:	8.086e+04
Df Model:	5787		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	-0.0965	0.135	-0.717	0.473	-0.360	0.167
C(DataFiscalYr)[T.1997.0]	-0.0507	0.012	-4.351	0.000	-0.074	-0.028
C(DataFiscalYr)[T.1998.0]	-0.0712	0.013	-5.492	0.000	-0.097	-0.046
...						
C(Ticker)[T.ZYXI]	-0.4594	0.237	-1.937	0.053	-0.924	0.005
C(Ticker)[T.ZZ]	0.5304	0.178	2.973	0.003	0.181	0.880
EBIT_Sales	0.9250	0.030	31.239	0.000	0.867	0.983
Ln_TotalAssets	0.0308	0.005	6.124	0.000	0.021	0.041
CapEx_Sales	0.2050	0.015	13.842	0.000	0.176	0.234
Ln_NetFileSize	-0.0178	0.005	-3.667	0.000	-0.027	-0.008

Omnibus:	4817.476	Durbin-Watson:	1.300
Prob(Omnibus):	0.000	Jarque-Bera (JB):	56499.030
Skew:	0.234	Prob(JB):	0.00
Kurtosis:	9.201	Cond. No.	4.99e+19

5. Qualifications

Being based on the Berger-Ofek (1995) methodology, this research is susceptible to the limitations of it. In a recent paper, Professor John Hund, Professor Donald Monk, and Professor Sheri Tice point out that the Berger-Ofek methodology "matches larger and old diversified firms with small and young focused firms." Since pricing multiples "decline with sales and age", their paper argues that the methodology itself "manufactures a discount".[20] Though we have included firm size (log of total assets), which according to Professor Hund, Professor Monk, and Professor Tice, predict growth rate uncertainties to a certain extent, and is among the "key value relevant characteristics[21]," it would not be sufficient to eliminate the bias caused by the Eli-Ofek methodology proposed by them. According to them, in their sample, diversified firms are "on the order of 15 times larger with respect to sales and 3.5 times older.[22]" In our sample, diversified firms are also larger and older than undiversified firms, though the differences are less pronounced. By merging our data with the Field-Ritter dataset of company founding dates, we find that in our sample, the average age of undiversified firms is 40.14, while the average age of diversified firms is 29.14, which means diversified firms are on average 11 years older than undiversified firms[23]. Moreover, the average sales of undiversified firms are $2,084 million, while that of diversified firms is $5,753, which means undiversified firms are on average 176% larger than undiversified firms. It seems that there are indeed significant differences of ages and sizes between diversified and undiversified firms in our sample.

[20] Hund, John E., Monk, Donald, and Tice, Sheri. "The Berger-Ofek Diversification Discount Is Just Poor Firm Matching", 2019.
[21] Hund, John E., Monk, Donald, and Tice, Sheri. "The Berger-Ofek Diversification Discount Is Just Poor Firm Matching", 2019.
[22] Hund, John E., Monk, Donald, and Tice, Sheri. "The Berger-Ofek Diversification Discount Is Just Poor Firm Matching", 2019.
[23] The Field-Ritter dataset of company founding dates, as used in Laura C. Field and Jonathan Karpoff "Takeover Defenses of IPO Firms" in the October 2002 Journal of Finance Vol. 57. No. 5, pp. 1857-1889, and Tim Loughran and Jay R. Ritter, "Why Has IPO Underpricing Changed Over Time?" in the Autumn 2004 Financial Management Vol. 33, No. 3, pp. 5-37.

Nevertheless, the differences, especially in sales, are much less prominent than they appear to be. With the Berger-Ofek methodology, we impute the segments of diversified firms assuming that they were individually run. Therefore, it would be more consistent if we were to compare the segment sizes, rather than firm sizes of diversified firms to the firm sizes of undiversified firms. Doing so, we obtain that the average segment sales of diversified firms are $2,234 million, while the average sizes of undiversified firms, while the average sales of undiversified firms are $2,084. The 10-year difference in average ages and the 7% difference in average sales in our sample is material but much less prominent than suggested by Professor Hund, Professor Monk, and Professor Tice. Overall, this study is valid to the extent that the Berger-Ofek method is valid in the sample[24]. While we believe the methodology is consistent given our assumption[25] and given the limited differences of firm sizes and ages between diversified and undiversified firms in the sample, we admit that mismatching of firms exists and could be material in this research.[26]

That brings us to the next limitation that is the oversimplifying nature of pricing multiples. Professor Hund, Professor Monk, and Professor Tice make explicit the potentials for mismatching firms of different ages and sizes when applying pricing multiples to impute diversification discounts. Yet even if we have controlled for firm ages and sizes, we would still suffer significant omitted-variable bias, as pricing multiples neglect innumerable crucial factors behind firm prices/values. Among the most important of them are expected growth and discount rates (which further involves country risk exposures and market exposures)[27]. Therefore, while our research applied mostly consistent methodology and yielded statistically

[24] The sample used in the regression analysis covered observations between 1996 and 2017. Only observations that are in the Compustat "Fundamental Annual" and "Historical Segment" as well as the Loughran-McDonald 10-K file are covered.
[25] That we could impute segment values for diversified firms assuming they were individually run.
[26] It is worth noting that we have attempted to control for firm sizes, reinvestment rates, and profitability using regressions when imputing segment values. However, the attempt failed due to the oversimplifying nature of pricing multiples: many firms were imputed to have negative values.
[27] Damodaran, Aswath. Equity Valuation. New York University. New York. 2020. Lecture.

significant results, its implications could still be rather limited. Very often it is more worthwhile for us to study individual firms with extensive context using Discounted Cash Flow models than drawing generalizations with minimal context using pricing multiples.

That said, the results from this study may have certain implications. As diversified firms that are more complex tend to suffer larger discounts, it may be better for them to reduce unnecessary complexities in their business models, their corporate structure, or their accounting practices. However, as the magnitudes of the coefficient and R-squared of such effect are relatively small, it would be unworthwhile for firms to reduce complexities that they consider beneficial for their fundamentals.

6. Conclusion

Using an improved version of the Berger-Ofek (1995) methodology that calculates median pricing multiples each year and includes diversified firms with financial services segments, we have found that the median diversified firms have consistently traded at discounts compared to undiversified firms between 1976 and 2018. The diversification discounts range from 4.6% in 1998 to 22.5% in 1983. It persists after we control firm sizes, reinvestments, and profitability.

Then, we use the 10-K filings sizes of firms from the Loughran-McDonald 10-K file as a proxy for the level of complexities of firms and investigated the effects of complexities on the excess values of diversified firms. We obtain that diversified firms tend to suffer larger discounts, or losses in their excess values when they are more complex. More specifically, a diversified firm is expected to suffer a 3.34% larger discount if its 10-K size increases by 100% with its total assets, capital expenditure over sales, and cross-subsidization held constant. Such effects do not hold for undiversified firms. As a result, we hold that complexities could be a factor contributing to the phenomenon of diversification discount. And we believe it would be beneficial for diversified firms to reduce unnecessary complexities in their business models, corporate structures, accounting choices, etc. Though, as the magnitudes of the coefficient and R-squared of this effect are rather small, firms should not reduce dimensions of their complexities that they deem beneficial for their fundamentals.

Lastly, we address criticisms of the Berger-Ofek methodology by Professor John Hund, Professor Donald Monk, and Professor Sheri Tice. We acknowledge the existence of mismatching in our methodology but have shown that the mismatching is far less prominent in our sample than in their study. We recognize that pricing multiples often neglect many crucial factors behind firm prices/values, and advise that this study is valid to the extent that the Berger-Ofek method is valid in this sample.

Looking into the future, we could come up with methods to calculate diversification premiums/discounts while taking into account more crucial variables (e.g. expected growth, discount rate). Moreover, we could further investigate what dimensions of complexity contribute the most to the value loss of diversified firms. In Professor Loughran and Professor McDonald's 2014 paper, they discovered textual qualities as a proxy for complexity[28]. In their recent paper, they established audit fees as a novel measure of complexity[29]. Making comparisons between these indicators, perhaps we could better distinguish between dimensions of complexities and answer the previously mentioned question.

[28] Loughran, Tim, and McDonald, Bill. "Textual Analysis in Finance and Accounting: A Survey." *SSRN Electronic Journal*, Oct. 2014, doi:10.2139/ssrn.2504147.

[29] Loughran, Tim, and McDonald, Bill. "Measuring Firm Complexity." *SSRN Electronic Journal*, Jul. 2020, doi:10.2139/ssrn.3645372

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Loughran, Tim, and McDonald, Bill. “Measuring Firm Complexity.” *SSRN Electronic Journal*, Jul. 2020, doi:10.2139/ssrn.3645372