THE DETERMINANTS OF FIRM GROWTH

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Economics

Abstract

Companies play a vital role in economic growth and prosperity of a nation. As such, many economists and governmental agencies have studied the factors affecting firm growth to implement favorable policies for the firms. This study investigates the impact of microeconomic factors such as firm size, risk, and investment in capital and technology on the growth of firms. This study finds that profit and innovation have a positive impact on firm growth while leverage has a diminishing positive impact on growth. Further, the study also concludes that young firms grow faster than older firms with marginal growth declining after a certain age of firms.

KEYWORDS: (Firm growth, leverage, profit, age, innovation)
JEL CODES: (xxx,xxx)

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I. Introduction

Companies play a vital role in economic growth and prosperity of a nation. Through the exploration and efficient allocation of resources, firms stimulate economic activity that generates employment which in turn contributes to the welfare of the society. The establishment and growth of firms have a direct impact on the prosperity of an economy and, as such, governments and international development organizations (such as the World Bank) have invested substantial resources in creating an environment where companies can foster and uplift the living standards of people. While these initiatives have promoted entrepreneurship and establishment of firms, it is imperative to understand the factors that determine the growth of a firm for efficient allocation of economic resources.

Over the years, economists have studied the effect of macroeconomic factors such as interest rates, exchange rates, and fiscal policies in the growth of firms. While these papers concentrate on the impact of macroeconomic variables in firm growth, this paper focuses on microeconomic factors such as firm size, risk, and investment in capital and technology to study its impact on the growth of firms. We also use short term lagged variables to analyze the effect of a firm's decision in one period that might affect several years in the future.

The objective of this paper is to analyze the growth of U.S. firms in a microeconomic context and identify numerous quantitative and qualitative factors that are relevant and important in determining firm growth. This study reveals that firm-level variables such as profitability, innovation, leverage, and firm age, have an impact on firm growth.

The thesis is structured as follows. In Chapter II, we review the existing literature on determinants of firm growth to build our hypotheses. In Chapter III, we explain the process of data collection and specify our model for analysis. Chapter IV is a discussion of our empirical findings supported by the regression results. In Chapter V, we use our results to explain the inconsistencies between different research papers in the literature. Finally, in Chapter VI, we provide the conclusion and areas for future work.

II. Literature Review

One of the earliest studies delineating the determinants of growth of firms, Gibrat's law (Mansfield 1962) states that firm growth is a random process. They argue that firm growth is independent of firm size. Many researches have investigated whether the Gibrat's law holds and overtime several studies have concluded the opposite finding.

In contradiction to Gibrat's law, Ahlström's model (Söderling 1998) identified firm growth as a function of growth competence and resources, growth potential and growth ambitions. Andersson et al. (2005) further elaborated this idea that companies that devote resources to build their competence are more likely to grow.

The research conducted by Mateev and Anastasov (2010) found firm-specific characteristics such as "leverage, current liquidity, future growth opportunities, internally generated funds, and factor productivity" to be significant in determining a firm's growth. In the following subsections, we will review the existing literature to make hypothesis statements.

Profitability

The ultimate goal of every firm is to generate profit, but the story does not end there. Firms can either distribute the profits to the shareholders or reinvest the profits to grow the firm. It is usual for firms to retain part of the profit for reinvestment and numerous theoretical models take it for granted that more profitable firms will grow while others will decline (Coad and Hölzl 2010). Nelson and Winter (1982) argued that profitable firms would be motivated to grow not only because of their financial means but also from their future profit creation to sustain growth. Indeed, there is an incentive for firms to grow as higher sales will culminate in higher profits.

However, it is surprising that there is no uniformity in empirical research supporting this notion of profitability and firm growth. The investigation by Goddard, Molyneux, and Wilson (2004) found that the theoretical model of profitability and growth were not necessarily observed in reality. Dobson and Gerrard (1989) investigated the relationship between profitability and growth for Leeds engineering sector in Scotland and concluded that the relationship runs in both direction; they also found a significant negative impact on the rate of return on assets.

Gupta (1981) posited that growth leads to an increase in the size of the firm, which in turn gives rise to economies of scale, making the firm more profitable. In a similar vein, Penrose's theory (1959) explained the relationship between growth and profitability from a managerial context. The theory posits that the caliber and interest of a firm in maximizing profit will determine the firm's growth. Glancey (1998) delved into the empirical examination of Penrose's theory and found evidence on a positive correlation between profitability and growth.

Since the literature does not yield a consistent relationship between firm profitability and growth, we cannot frame our hypothesis in any particular direction. Therefore, we will study its impact on our analysis. As of now, most papers claim a positive impact, and that is our expectation.

Leverage

The Pecking Order theory suggested by Donaldson (1961), and Myers and Majluf (1984) explains that companies finance their investments from a source that requires the least effort; i.e., from least cost to highest cost financing options. This means that firms prefer financing in the following order: internal financing (i.e., using the cash reserves of the firm), debt financing when the firm is short on cash, and raising external capital by issuing more equity.

Some literature argues that growing companies engage more in debt financing because these firms do not have sufficient cash reserves to fund their project and also do not want to go an extra mile in raising more capital. Therefore, there is a positive correlation between leverage and firm growth, especially in revenue growth. The research by Durinck, Laveren, and Lybaert (1997) on small and medium companies in Belgium showed evidence that the fast-growing companies (in terms of sales) relied more on external debt financing. Other similar studies conducted by Honjo and Harada (2006) in Japan using employment growth and Heshmati (2001) in Sweden using sales growth identified a positive impact of leverage on firm growth.

Similarly, Avarmaa (2011) investigated the impact of leverage and credit constraints in Baltic region companies from 2001 to 2008 and found a positive impact on sales growth, especially at low levels of leverage. However, the result also demonstrated that leverage does not have a significant impact on the growth of multinational companies.

The trade-off theory of capital structure of Kraus and Litzenberger (1973) posits that there is both tax benefits and financial distress cost of financing with debt for a firm. Further, the marginal benefit of financing with debt decreases as debt increases while the marginal cost increases. Thus, firms must find an optimal balance between the two to achieve sustainable growth.

The study by Lang, Ofek, and Stulz (1996) found a negative correlation between leverage and growth. They used Tobin's q ratio[1] as a measure of growth. The discrepancies

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[1] Tobin's q is the market value of a firm divided by total asset value of the firm.

between the prior studies and this one might be because of the difference in definition of firm growth, time period and market data the studies take into account.

From the literature, we found that there is a relationship between firm growth and leverage although the exact direction of correlation between the two varies from one research to another. On the upside, leverage provides the necessary capital for the firm to grow while, on the downside, it increases the bankruptcy risk of the firm. Based on the recent empirical works of Avarmaa (2011) on the trade-off theory of capital structure, we want to test if leverage has a diminishing effect on growth. Therefore, we frame our hypothesis[2] as follow:

Hypothesis 1: Leverage has a positive impact on growth that decreases as leverage increases.

Innovation

Innovation is commonly cited as a major determinant of firm growth. Studies show that firms that constantly innovate and use new technology have higher productivity and high growth.

In the empirical literature, innovation and technology factor has been measured from the firm's expenditure on new capital, the number of patents filings, research and development (R&D) expenditure, and intangible assets in the balance sheet. For instance, Coad and Rao (2006) used R&D expenditure and the number of patent filing as a measure for innovation to conclude a positive impact of innovation on firm growth based on Tobin's q.

[2] This hypothesis is important to make a quadratic leverage function in our model.

The study conducted by Cainelli, Evangelista, and Savona (2006) looked at Italian companies and found that innovation has a positive impact on firm productivity and growth. Moreover, Le Bas, Haned, and Colombelli (2011) also performed an empirical study using quantile regression for French companies over the period 1992 to 2004 and concluded that "innovating firms perform better than non-innovating firms in terms of growth." Similarly, using a sample of 754 European firms from 2003-2007 period, García-Manjón and Romero-Merino (2012) found empirical evidence for a positive effect of R&D on sales growth.

However, few studies have not found any significant correlation between innovation and firm growth. Geroski and Mazzucato (2002) studied the growth of U.S. car manufacturers in the 20th century and found no significant impact of innovation. They push the notion that the U.S. automobile sector is 'largely unsystematic and opportunistic.' As such, any innovation from one manufacturer is quickly replicated by others ensuing more competition. Other possible explanations for a different conclusion from this research is the aggressive competition in the U.S. automobile industry and quick technological transfer between the big automobile manufacturers.

Since most of the research conclude a positive impact of innovation on growth and pragmatic evidence of growth through innovation in firms such as Apple (Johnson et al. 2012), and Google (Anthony, Johnson, and Sinfield 2008), we frame the following hypothesis:

Hypothesis 2: Innovation has positive impact on firm growth

Age

The firm life cycle theory (Mueller 1972) contends that every company follows a life-cycle trajectory that is linked with the firm's growth. According to the theory, a young firm has a relatively larger set of investment opportunity that yields higher growth in comparison to a mature firm. A mature firm also faces the same opportunity but compared to its size the investment is relatively small. Therefore, older firms have shrinking investment opportunity and a declining growth rate.

Evans (1987) examined the validity of Mueller's theory using a sample of 100 manufacturing firm and found that growth decreases at a diminishing rate with firm size. Similarly, Oliveira and Fortunato (2006) studied Portuguese manufacturing firms surviving from 1990 to 2001 and concluded that "firms that were small and young at the beginning of the sample period exhibited more persistent growth than those that were large and old." Barba Navaretti, Castellani, and Pieri (2014) also provided the same insight into the dependence of firm growth on age. They used sample firms of France, Italy and Spain from 2001 to 2008 and found that "young firms grow faster than old firms, especially in the highest growth quantiles."

With the majority of studies reporting that older firms experience slower growth, we consider the hypothesis as follows:

Hypothesis 3: Age has a positive or negative impact on firm growth.

III. Data and Model Specification

For this study, we focus on the financial records and its impact on firm growth in S&P 100 companies. We used stockpup.com to scrape and compile quarterly financial statements[3] of every company that was listed in the S&P 100 index at any point before 2018. The dataset covers the period from 2000 to 2018 because many companies listed in the S&P 100 had financial records only after 2000.

To include sector diversification of companies in the study, we accumulated the industry classification for companies from NASDAQ's website and merged it with the existing dataset. This created 12 categories of sectors for companies in our dataset. Next, we manually collected the date of establishment of the companies in the following order of availability: 10K filing record followed by company website and Wikipedia.

Our study considered companies with more than 40 quarterly financial records (i.e., 10 years of record) to have sufficient data for every company for analysis. In addition, companies with missing variables were eliminated from our study because the missing data could not be imputed using the average from different years. Finally, our dataset contained a sample of 427 companies.

Dependent Variables

The dependent variable in our study is the firm growth. Firm growth can be defined in many ways, namely the growth in revenue, book value and employment. Our study considered the growth in revenue and book value as a measure of firm growth. We did not consider the growth in employment because employment statistics for every S&P100 company was not freely available. We used the natural logarithm to capture the

[3] Financial statements are fundamental data from balance sheet, cash flow, financial ratios filed in 10K filings.

percentage growth from the previous year to the current year as shown in Table 1 Definitions of Variables).

Independent Variables

Based on our hypotheses, four main factors affect a firm's growth. The first factor is profitability. To measure this as an independent variable, we use the Return on Equity (ROE) of the firm. ROE is calculated by dividing the net profit by shareholders' equity which tells us the amount of net profit earned for every dollar of equity. We chose this ratio because it gives us a relative figure of profitability that can be compared between firms.

The second factor is the leverage. For this, we chose liabilities to equity ratio as the independent variable. Liabilities to equity ratio tells us the amount of liability for a dollar of equity. Therefore, a higher ratio (usually above 1) will indicate more leverage and vice versa.

The third determinant of firm growth is the innovation of the firm. Innovation is difficult to precisely measure, mainly because it is more like an intangible asset. We use intangible assets ratio as a measure for innovation. Firms investing heavily in research and development will file for patents and copyrights which are intangible assets[4] to the firm. The intangible assets ratio is calculated by dividing the intangible assets by total assets. Similarly, the firm's expenditure on acquiring new capital can also be used as a measure of innovation. However, we could not use this metric because the cash flow data

[4] Intangible assets are those assets on the balance sheet, which cannot be seen or touched. These consist of patents, trademarks, know-how, R&D, goodwill.

only provides capital expenditures which also includes the cash from sales of capital and machinery.

The fourth and last independent variable is the firm age. We calculated the age of the firm at the end of each quarter based on the year of incorporation of the firm.

Control Variables

The first control variable is company size. This variable was measured using the natural logarithm (ln) of the total assets of the company. We took natural logarithm for two reasons. The first is to reduce the probability that extreme observations would bias our findings. Second, we wanted to convert the data into a linear form.

The second control variable is the average of the S&P 500 Index in a particular quarter. The index conveys investor confidence as well as the movement in prices of S&P500 companies and is cited by Investopedia as "a good indication of movement in the U.S. market as a whole" (Banton 2019). Therefore, we use this variable to control the effects of the U.S. stock market movement, specifically for companies included in the S&P 500 index.

The third and last control variable is the industry of the firm. We used 12 categories to classify the companies based on NASDAQ's website. The following are all the categories:

- Health Care
- Finance
- Consumer Services,
- Technology
- Miscellaneous
- Capital Goods
- Consumer Durables
- Energy
- Public Utilities
- Basic Industries

- Transportation
- Consumer Non-Durables

A summary of the definition of the various variables can be found in Table 1.

Table 1 Definitions of Variables

Variables	Definition
Dependent Variables	
Firm Growth	Growth in $Book\ value\ of\ equity\ per\ equity\ (BV)$ or $Revenue\ (Rev)$
Independent Variables	
Profitability (P)	$\text{ROE} = \frac{\text{Net Profit}}{\text{Shareholder's Equity}}$
Leverage (L)	$\text{Liabilities to equity ratio} = \frac{\text{Total Liabilities}}{\text{Shareholder's Equity}}$
Innovation (I)	$\text{Intangible Assets Ratio} = \frac{\text{Intangible Assets}}{\text{Total Assets}}$
Age (A)	Firm age on the quarter end
Control Variables	
Size	Ln of Total Assets
S&P500 Index	Index of S&P500 in that quarter

The Model

The main objective of this paper is to examine the factors that explain firm growth. The fixed effects model is a popular method for panel data analysis (Yaffee 2003). Many papers[5] studying the growth of firms use the fixed effects regression because it controls for differences between the companies and removes omitted variable biases. Our dataset is a panel data with the same set of cross-sectional data compiled for several companies for the period 2000 to 2018. As such, we require an approach that can examine the relationship between firm growth and determinants for not only one specific company over the period

[5] (Anton 2016), (Barba Navaretti, Castellani, and Pieri 2014), (Le Bas, Haned, and Colombelli 2011), (Honjo and Harada 2006), (Mateev and Anastasov 2010) are some paper that use the fixed effects model.

but for all companies. Given this complexity, we could have run separate regressions for all companies but doing so would require running more than 400 regression which is clearly not feasible for this thesis. However, if we run the Ordinary Least Squared (OLS) Regression for all the companies together, the unobserved factor difference between different companies will cause the omitted variable biases. That is, the differences between companies not explained by variables in our model will lead to differences in growth, causing omitted variables bias. Therefore, like other studies, we have implemented the fixed effects model in our analysis.

There are two ways of implementing the fixed effects model. In the first approach, we could introduce dummy variables for the time period and company. This is inconvenient because it will create more than 400 categorical variables. In the second approach, we take mean for every company and subtract it with the actual variable for every year. We resort to the second approach as it will give us the same result as the first one, but it will not create unnecessary dummy variables.

The basic model for firm growth is

$$\mathrm{g}_{\mathrm{i,t}} = f(P_{i,t-1}, \mathrm{L}_{\mathrm{i,t-1}}, I_{i,t-1}, A_{i,t}) \tag{3.1}$$

where $g_{i,t}$ represents the growth of firm i in year t. P is the return on equity, L is the liability to equity ratio, A is the age of the firm, and I is the intangible assets ratio. The explanatory variables are lagged for one year for every firm i and year t-1. We lagged the explanatory variables for one year because we were interested in capturing the effect of previous year's indicators in determining the growth of the firm one year later.

IV. Empirical Results

In this section, we will explain the descriptive statistics of our dataset and analyze the regression results.

Descriptive Statistics

Table 2 Descriptive Statistics

	Mean	Standard Deviation	Minimum	50%	Maximum
BV	18.831	26.556	-262.41	7.48	820.64
Revenue	4.394 B	9.103 B	77,668	1.642 B	138 B
ROE	0.155	0.171	-0.994	0.148	0.999
Intangible assets ratio	0.188	0.204	0	0.108	0.928
Liabilities-to-equity ratio	2.7805	5.544	0.033	1.567	570.041
Age	67.195	49.273	16	54.781	232.899
S&PIndex	1505.299	506.0915	735.09	1325.829	2913.979
Assets	53,208M	1,89,373M	27.721M	11,934.195M	2,615,183M

* Total samples = 29,284 observations

Table 2 illustrates the descriptive statistics of our dataset. There are 29,284 observations for a total of 427 companies. Some key highlights from Table 2 are as follows:

- The minimum age for the company in 2000 is 16 years and the maximum age in 2018 is 232. This tells us that our sample contains of companies in different stages of life cycle. While there are both matured and young companies, the average age for all companies is 67 years, and the median is 54 years.
- The book value of equity per share is positive and negative. Therefore, our dataset contains firms that did well and also firms that went bankrupt.

- Revenue is positive for all firms, as expected. While the minimum revenue is in thousands, the maximum amount is in billions. This is expected for companies in the S&P 100. In particular, the minimum revenue corresponds to companies having a negative book value of equity per share.
- There is a high standard deviation for revenue and assets between companies. This is expected as companies in early 2000 had smaller nominal balance sheets compared to 2018.

Table 3 Correlation Matrix

	Revenue	BV	ROE	Intangible assets ratio	Liabilities-to-equity ratio	Age	S&PIndex	Assets
Revenue	1							
BV	0.138	1						
ROE	0.093	-0.111	1					
Intangible assets ratio	-0.038	-0.052	0.041	1				
Liabilities-to-equity ratio	0.009	0.092	-0.025	-0.019	1			
Age	0.082	0.099	0.082	-0.043	0.022	1		
S&PIndex	0.081	0.191	0.096	0.120	0.011	0.078	1	
Assets	0.327	0.322	-0.054	-0.127	0.253	0.189	0.064	1

*Note: **Bold** indicates correlations significant at 10% level.

As can be seen in Table 3, the correlations between the different variables are low, except the ones in bold. There is no significant correlation between the dependent variable at 5% with an exception for liabilities to equity ratio and intangible assets ratio (at 10% none of the dependent variables have any significant correlation). There are some correlations with the control variable. In particular, assets have significant correlations with almost every variable. Therefore, in our empirical analysis, we also conduct regression without assets to see if there are any differences in the results.

Regression Analysis

Using Natural Logarithm to measure elasticity. In our firm growth model, three out of four explanatory variables are financial ratios. As per the descriptive statistics, these ratios range from 0 to 1, except for liabilities to equity ratio. A change of 1 in the ratios is a drastic change and interpreting the regression coefficient as a figure change does not explain much. That is, we cannot infer much from a statement like “a change of 1 in ROE causes the revenue to change by 10000” because it is unlikely for ROE to be higher than 1. Therefore, we need to look at these ratios in terms of percentage change rather than absolute change. We did this by taking natural logarithm for ROE and intangible assets ratio.

Similarly, interpreting the growth in absolute terms does not tell us much as the signification of the figure will be dependent on the size of revenue or book value of the company itself. For instance, an increase in revenue by 100 thousand might be significant for a middle-sized company, but it might not mean much to companies such as Apple. Therefore, we also need to measure the firm growth in relative terms, and again we used the natural logarithm to measure the percentage change in growth. Thus, our regression coefficient explained the elasticity of firm growth.

Natural Logarithm for negative range variables. Book value of equity per share and ROE were the two variables with negative ranges. Since natural logarithm for negative values does not exist, we added the minimum value of the variable plus 1 to the whole series. This approach is a common technique to deal with negative values of log transformation in data analysis (Wicklin 2011). This transformation works because adding the same value to the value series will result in the same distribution but in a form that can be captured by the logarithm.

Solving Multicollinearity and using a quadratic form for Leverage to observe diminishing marginal growth. Since the impact of leverage on growth depends on the leverage level itself, we used a quadratic form for liabilities to equity ratio by using a squared and linear variable. However, we could not take natural logarithm for both $Leverage^2$ and *Leverage* as they would be linearly correlated and cause multicollinearity. To avoid this problem, we did not use natural logarithm for the variable even though it would be harder to interpret the coefficient of this variable. We are expecting an inverse U-shaped curve for leverage and growth.

Cubic form for Age to observe both increasing and decreasing marginal growth. The literature presents both the positive and negative impact of age on firm growth. After running some simulation, we observed that age has both increasing and decreasing marginal growth. We used a cubic function for age by adding Age^3, Age^2, and *Age* in our model.

Accounting for bankruptcy and firms that no longer exist. In our dataset, there were 20 companies that filed for bankruptcy, out of which seven[6] ceased to exist and thirteen went through capital restructuring. The thirteen companies that went through capital restructuring had data for their bankruptcy period and did not require any

[6] The seven companies that ceased to exist are Alpha Natural Resources, General Growth Properties, Motor Liquidation Company, Lehman Brothers Holdings, Radioshack Corporation, Sunedison, Washington Mutual

adjustment in our analysis. For the seven firms that no longer existed, we forward filled[7] the value period after which the firm no longer existed. This means that our model penalizes the bankrupted firm for the period after they no longer exist. The same logic is also applied to firms that were acquired which essentially conveys that the firm is stagnant and no longer grows or shrinks. For merged entities, the former companies are treated as they cease to exist, and the merged company is treated as a new one. We used this approach because the dataset used treated it that way and we did not have much control over it.

All sectors regression

In our preliminary study, we found a significant correlation between asset, and other explanatory variables. We, therefore, used hierarchal regression for companies from all sectors to study the relationship between the factors affecting firm growth.

Table 4 contains the regression[8] results for companies in all sectors using revenue growth as the metric for firm growth. The meaning of the coefficients for the explanatory variables including all control variables are as follows:

- *Profitability:* 1% increase in ROE will lead to a 0.0403% growth in revenue.
- *Leverage^2 (**conforms** expected negative sign):* An increase in liabilities to equity ratio squared by one will cause the revenue to decrease by 0.0320%.
- *Leverage:* An increase in liabilities to equity ratio by one will cause the revenue to decrease by 0.9%.

[7] Forward fill means that we used the last data available to fill all the data missing after that period.

[8] $\ln(Rev) = \alpha + \beta_1 \ln\left(P_{i,t-1} + \min(P) + 1\right) + \beta_2\left(L_{i,t-1}\right)^2 + \beta_3(L_{i,t-1}) + \beta_4\ln(I_{i,t-1}) + \beta_5\left(A_{i,t-1}\right)^3 + \beta_6\left(A_{i,t-1}\right)^2 + \beta_7\left(A_{i,t-1}\right) + \beta_8 \ln(Assets) + \beta_9 S\&PIndex + e_{i,t}$

- *Innovation (**conforms** with expected positive effect):* 1% increase in intangible assets ratio will result in a 0.0189% growth in revenue.
- *Age^3 (**conforms** expected negative sign):* An increase in age^3 of the firm by one will lead to 0.000039% decrease in revenue.
- *Age^2 (**conforms** expected positive sign):* An increase in age^2 of the firm by one will lead to 0.0050 % increase in revenue.
- *Age:* An increase in age of the firm by one will lead to 0.000009% decrease in revenue.

All three models unveil a similar finding, although the magnitude of coefficients and p-values are slightly different. Controlling for firm size and S&P500 index, the major determinants of firm growth in all three models are lagged profit rates, lagged innovation level, lagged leverage and age. The more profitable and innovation firms were in the past, the higher their current revenue. It is worth pointing out that all three models have coefficients with consistent sign.

Table 4 Regression for all sectors revenue growth

	All Sectors					
ln(Revenue)	**Coef.**	**P>|t|**	**Coef.**	**P>|t|**	**Coef.**	**P>|t|**
ln(Profitability)	.0403	0.000	0.00907	0.000	.01004	0.000
$Leverage^2$	(.0320)	0.000	(.0058)	0.054	(.00727)	0.034
Leverage	.9	0.000	0.061	0.013	.0701	0.002
ln(Innovation)	.0189	0.000	0.0759	0.000	.0718	0.000
Age^3	(.000039)	0.000	(.000015)	0.000	(.000014)	0.000
Age^2	.0050	0.000	.000578	0.000	.000580	0.000
Age	(.000009)	0.000	(.00126)	0.030	(.00116)	0.000
S&P Index	(.0000)	0.000	(.0002)	0.000		
ln(Assets)	.7414	0.000				
_cons	6.2501	0.000	18.7906	0.000	16.9241	0.000
F-value		236.34		447.82		452.44

R	0.5821	0.0728	0.0750
Number of observations	29259		

Table 5 contains the regression[9] results for companies in all sectors using the book value of equity per share as the metric for firm growth. The meaning of the coefficients for the explanatory variables including all control variables are as follows:

- *Profitability:* 1% increase in ROE will lead to a 0.0383 % growth in book value of equity per share.
- *Leverage² (**conforms** expected negative sign):* An increase in liabilities to equity ratio squared by one will cause the revenue to decrease by 0.0090%.
- *Leverage:* An increase in liabilities to equity ratio by one will cause the revenue to decrease by 0.087%.
- *Innovation (**mixed results**):* with all the control variables, 1% increase in intangible assets ratio will result in a 0.0203% decrease in revenue. However, when we remove assets as the control variable, we get a positive impact.
- *Age³ (**conforms** expected negative sign):* An increase in age³ of the firm by one will lead to 0.000075% decrease in revenue.
- *Age² (**conforms** expected positive sign):* An increase in age² of the firm by one will lead to 0.000098% increase in revenue.
- *Age (**rejects** expected negative effect):* An increase in age of the firm by one year will lead to 0.00295% decrease in revenue.

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[9] $\ln(BV + \min(BV) + 1) = \alpha + \beta_1 \ln(P_{i,t-1} + \min(P) + 1) + \beta_2 (L_{i,t-1})^2 + \beta_3 (L_{i,t-1}) + \beta_4 \ln(I_{i,t-1}) + \beta_5 (A_{i,t-1})^3 + \beta_6 (A_{i,t-1})^2 + \beta_7 (A_{i,t-1}) + \beta_8 \ln(Assets) + \beta_9 S\&PIndex + e_{i,t}$

An interesting finding from Table 5 is that the results are different for the model that have all the control variables and ones that do not. Specifically, the signs for innovation differ across the models with and without assets as the control variable. This variation is observed because of multicollinearity issues in the model with all control variables. From Table 3, we see that firm assets have a high correlation with our independent variables which causes multicollinearity. After removing the variable, the problem is solved, and we get a positive impact of innovative on growth as expected.

Table 5 Regression for all sectors book value of equity per share growth

	All Sectors					
ln(BV)	**Coef.**	**P>|t|**	**Coef.**	**P>|t|**	**Coef.**	**P>|t|**
ln(Profitability)	.0383	0.000	.0160	0.000	.01676	0.000
$Leverage^2$	(.0090)	0.000	(.0019)	0.000	(.00106)	0.000
Leverage	.087	0.000	.0024	0.000	.00866	0.000
ln(Innovation)	(.0203)	0.000	.0376	0.000	.0349	0.000
Age^3	(.000075)	0.000	(.0000004)	0.000	(.000074)	0.000
Age^2	.000098	0.000	.00099	0.000	.000304	0.000
Age	(.00295)	0.001	(.0103)	0.000	(.00980)	0.000
S&P Index	(.00001)	0.032	(.00007)	0.000		
ln(Assets)	.7982	0.016				
_cons	6.2501	0.000	2.757	0.000	3.465	0.000
F-value		331.87		186.74		209.50
R		0.2963		0.0337		0.0346
Number of observations			29259			

Result Implication (Expected & Unexpected)

Table 6 All Sector Result Comparison

			All variables		No Control variables	
Hypothesis	**Expected**	**Overall Effect**	**Revenue Growth**	**BV of Equity Growth**	**Revenue Growth**	**BV of Equity Growth**
Profitability	+	+	+	+	+	+

Leverage^2	-	-	-	-	-	-
Leverage	+	+	+	+	+	+
Innovation	+	+	+	-	+	+
Age^3	-	-	-	-	-	-
Age^2	+	+	+	+	+	+
Age	+/-	-	-	-	-	-

The coefficient for lagged profit is positive and significant for all models. Therefore, the overall effect is positive. A potential explanation is that high profits in the past provide the opportunity for the firm to invest in new products that will generate more revenue. Further, the management will have pressure to maintain the profit rate in par with previous years which might lead to growth in revenue. Similarly, retained profits are added to the assets of the firm which increases the book value of equity. This explains the positive sign in the regression including all control variables.

The coefficient for lagged leverage squared is negative, and significant. Similarly, the lagged leverage is positive, and significant. The negative sign of leverage squared[10] conveys that the marginal growth in revenue decrease as leverage increases, which supports our hypothesis 1 "Leverage has a positive impact on growth that decreases as leverage increases." Graphically, leverage squared supports our claim that there is an umbrella shaped relation between revenue growth and leverage (see figure 1). This result makes sense because dataset also contains the great recession period between 2007-2009 during which several companies with high leverage such as AIG, Lehman Brothers, and Merrill Lynch went bankrupt. This finding is also consistent with Avarmaa's (2011) claim that high leveraged firms do not experience additional growth.

[10] The sign of the squared coefficient depicts whether the quadratic function is U or inverse U-shaped.

The sign of the coefficient for lagged innovation is significantly positive. More innovative firms experience higher revenue growth. This finding is consistent with hypothesis 2 "innovation will have a positive impact on firm growth." A potential explanation is that firms that innovate have a competitive advantage in the industry that attracts more customers leading to an increase in sales. For instance, when Apple launched the first iPhone, they not only charged higher prices but also generate higher quantity sales because the demand for the iPhone was inelastic until the competition from Android caught up. It is equally important to note that not all companies might encounter as significant effect as Apple did through innovation because there are other factors such as branding, market power[11], and the ease of technological transfer within the industry that play a significant role. This partially explains why our regression result shows a relatively low impact of innovation on growth (i.e., 1% increase in intangible assets leads to 0.0189% increase in revenue). Another possible reason for low impact is the limitation of intangible assets as a measure of innovation. We could not find a free or low-cost dataset consisting of patent filing records, and research and development expenditure of companies, all of which could have served as a better metric of measuring innovation.

The coefficient for firm age^3 is negative, age^2 is positive, and age is negative. The negative sign for age^3 and positive for age^2 indicate increasing marginal growth when age is small and decreasing marginal growth after a certain age (See footnote for a brief explanation[12]). These coefficients are significant, and they support hypothesis 3 "Age has

[11] Market power in this context means the level of competitiveness and dominance of firm in a particular industry (i.e., monopoly, oligopoly, perfect competition).

[12] The coefficient of age^3 and age^2 are the only ones that changes the sign for the second derivative of the cubic function. The second derivative for our regression from Table 4 is -0.000234x + 0.01 which shows that it is positive for age less than 42 and negative thereafter.

a positive or negative impact on firm growth." The result implies that startup and young firm experiences more growth which decreasing after a certain age, ultimately lead to a negative impact on other. This finding is consistent with the life cycle hypothesis (Mueller 1972).

Sector Based Analysis

Table 7 Sector Based Result Comparison

	Finance		Tech		Manufacturing		Others	
Hypothesis	**Rev**	**BV**	**Rev**	**BV**	**Rev**	**BV**	**Rev**	**BV**
Profitability	+	+	+	+	+	+	+	+
Leverage^2	-	-	-	-	+	-	-	-
Leverage	+	+	+	+	-	-	+	+
Innovation	-	+	+	+	+	-	+	+
Age^3	-	-	-	-	-	-	-	-
Age^2	+	+	+	+	-	+	+	+
Age	-	-	-	+	+	-	-	-

* Yellow indicates statistical insignificance at 20%.

In addition to the regression encompassing all sectors, we classified companies into four sectors – Finance, Technology, Manufacturing, and Others, to examine if the regression results pointed something different. The regression results are in Table 8 and 9 of the Appendix.

Overall, the regression result is not very different in terms of overall signs. However, two patterns stand out from the previous all sector regressions. First, there are more coefficients that are statistically insignificant even at 20%. Second, not all regression results conform to indicate the same effect of innovation, leverage^2, and age^2 on firm growth. However, it is important to note that these unexpected results are not statistically significant and cannot refute or suppress other expected results. Overall, this regression conforms with all sector regression analysis.

V. Explanation for the inconsistency in the literature

The literature does not have a consensus on the impact of different factors on firm growth. There is an argument on whether profitability has a positive (Coad and Hölzl 2010) or a negative (Goddard, Molyneux, and Wilson 2004) impact on firm growth. Likewise, the paper by Heshmati (2001), Avarmaa (2011), and Lang, Ofek, and Stulz (1996) conclude different findings for the impact of leverage on growth. Although empirical research on innovation is dominated with results indicating positive (Coad and Rao 2006) effect on growth, there are some that argue the opposite (Geroski and Mazzucato 2002). Finally, the literature posits no clear case for the impact of age on growth.

This study found that the controversial claims asserted by different research whittled down to four main reasons. First, we discovered that the use of different definitions for firm growth leads to a different conclusion. For instance, Table 6 shows that innovation has positive impact on revenue growth but negative on book value of equity per share. In Table 7, there are many insignificant results when using revenue as a growth metric. Particularly, using revenue growth leads to insignificant results for Finance and Technology sector. This finding is consistent with Dobson and Gerrard (1989) conclusion that "the precise definition of the variables" yields different outcomes.

Second, analyzing companies based on different sector also provides a different conclusion. This observation explains the contentious claims on innovation and profitability. The level of innovation and its impact on growth varies from one industry to another. For instance, innovation has a profound effect on the growth of tech companies while it is not as significant for restrictive industry such as healthcare. Likewise, profit in competitive industries might be reinvested more than in other industries which leads to incongruities in growth. Geroski and Mazzucato's (2002) conclusions deviated from others because, unlike other, they only looked at car manufacturing sector where competition and active technology transfer play a crucial role.

Third, the use of different metrics to measure the same determinant variable also reveals different outcomes. In the literature, some studies have used return on assets as a proxy for profitability while others have used return on equity and profit rate. These two metrics capture different effects and it is plausible to have arrive at different outcomes. For instance, Dobson and Gerrard (1989) used return on assets and concluded a negative effect of profitability on growth while Coad and Hölzl (2010) using profit rate found a positive effect.

Finally, the use of different sample set of companies also influences the conclusion of the research. The biases of different samples appear to predominantly affect the outcome of two factors - leverage and age. We found that leverage has a diminishing marginal effect on growth (i.e., impact of leverage on growth decreases as leverage increases). The literature contains results indicating both positive (Heshmati 2001) and negative (Lang, Ofek, and Stulz 1996) impact of leverage on growth. However, these papers directly use the leverage ratio instead of using the quadratic functions. Thus, these studies do not consider the marginal effect of leverage and are in turn biased by the average leverage of the sample.

As shown in Figure 1, sample weighted with low leverage firms will indicate a positive effect while the ones with high leverage firms will indicate a negative effect. To confirm this claim, we ran another regression without squaring the leverage and found a negative impact. This result was consistent with our claim because the sample contained highly leveraged firms[13] (i.e., mean ratio of 2.7805 and median of 1.567).

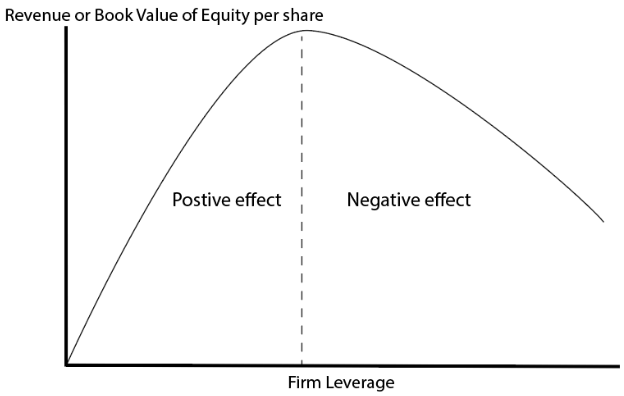

Figure 1 Effect of leverage on growth

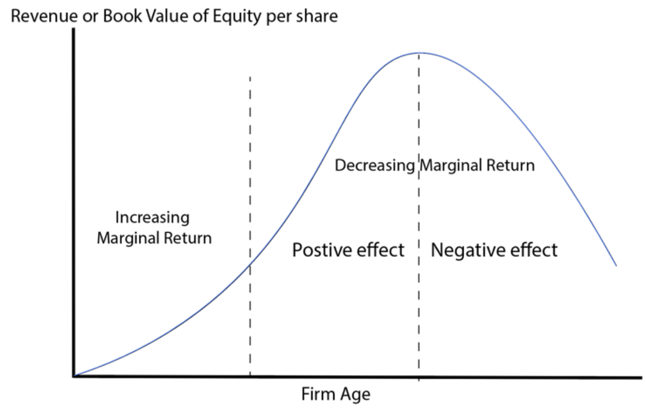

Figure 2 Effect of age on growth

Similarly, the literature has equivocal claim on both positive and negative impact of age on growth. Our research found out that the marginal growth experienced by the firms is dependent on whether the firm is young, matured, or old. As shown in Figure 2, young firms are more likely to experience increasing marginal growth, matured will experience growth with decreasing marginal growth, and old firm will endure contraction. Thus, it is plausible that age can have a positive or negative impact on growth depending on whether sample set is heavily weighted with young, matured, or old companies.

[13] Liabilities to equity ratio above 1 is usually considered high.

VI. Conclusion

In this study, we have examined the determinants of firm growth in S&P 100 companies. The research focused on profitability, leverage, innovation, and age to analyze its effect on revenue and book value of equity per share growth. Although there were discrepancies in the regression results for different models used in the study, the overall results showed a positive impact of profitability, innovation, diminishing marginal impact on growth for leverage, and both increasing and decreasing marginal impact on growth for age.

This research was restricted to S&P 100 companies as a comprehensive dataset containing the financial reports of all publicly traded companies in the U.S. was not freely available. Therefore, a broader analysis of different kinds of companies in size, growth, profitability, age and market capitalization could not be made. A potential future study could create such a broader dataset and compare how the results differ from this study. As mentioned in the narrative, free or low-cost dataset containing metrics such as patent filing records, and expenditure data on research and development, marketing, logistic, and staff training were not publicly available. These data could have provided us with better insights on the cause and effect of managerial decision on firm growth. Future research may delve into acquiring such as data to provide sturdy analysis on the determinants of firm growth.

In conclusion, this study finds that it is imperative for policies makers and managers of companies to understand what firm growth means to them and how different variables can affect it in different ways.

Appendix

Table 8 Sector Based Regression for revenue growth

	Finance		Tech		Manufacturing		Others	
ln(Revenue)	**Coef.**	**P>|t|**	**Coef.**	**P>|t|**	**Coef.**	**P>|t|**	**Coef.**	**P>|t|**
ln(Profitability)	.0096	0.240	.0112	0.256	.0345	0.000	.0703	0.000
ln(Innovation)	(.00015)	0.842	.0102	0.233	.0078	0.079	.0232	0.000
Leverage^2	(.0334)	0.000	(.0536)	0.000	9.06e-6	0.709	(.011)	0.000
Leverage	0.0049	0.000	.0181	0.000	(.0007)	0.632	.0003	0.062
Age^3	(.000002)	0.008	(.000004)	0.000	(1.9e-7)	0.006	(1.5e-6)	0.008
Age^2	.0001038	0.000	.00136		(.0000)	0.300	.0004	0.007
Age	(.01751)	0.000	(.00345)		.0141	0.000	(.043)	0.000
S&P Index	.0001	0.002	.0646	0.451	(.0001)	0.000	(.0001)	0.000
ln(Assets)	.7310	0.000	.0109	0.000	.7692	0.000	.8156	0.000
_cons	3.7563	0.000	5.291	0.000	3.5395	0.000	1.8502	0.000
F-value	234.21		98.30		208.51		136.61	
R	0.7901		0.8469		0.6506		0.6818	
Number of observations	3,941		3,991		11,969		9,358	

Table 9 Sector Based Regression for book value of equity per share growth

	Finance		Tech		Manufacturing		Others	
ln(BV)	**Coef.**	**P>|t|**	**Coef.**	**P>|t|**	**Coef.**	**P>|t|**	**Coef.**	**P>|t|**
ln(Profitability)	.1124	0.000	.05637	0.000	.0312	0.000	.0181	0.001
ln(Innovation)	.0050	0.582	.02156	0.004	(.0164)	0.150	.0112	0.007
Leverage^2	(.014)	0.003	(.0257)	0.000	.0000	0.205	(.1399)	0.000
Leverage	.0301	0.020	.1103	0.000	(.127)	0.000	.0023	0.000
Age^3	(.000008)	0.000	(.000001)	0.000	(4.01e-7)	0.000	(5.1e-6)	0.008
Age^2	.00031	0.000	.0003	0.000	.0001	0.000	.0007	0.000
Age	(.0216)	0.000	.0034	0.000	(.003)	0.081	(.0167)	0.000
S&P Index	.0000	0.000	.0000	0.781	(.0001)	0.817	(.0000)	0.011
ln(Assets)	.6277	0.048	.0111	0.000	.842	0.000	.7041	0.000
_cons	12.509	0.000	5.291	0.000	3.5675	0.000	5.8502	0.000
F-value	310.50		348.90		208.8400		256.58	
R	0.2110		0.3098		0.6409		0.1777	
Number of observations	3,941		3,991		11,969		9,358	

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