

# Capital Structure over the Life Cycle

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Whether firms in highly innovative industries — those with high risk, yet higher potential return — will be more likely to raise funds through stock markets than firms in mature industries is investigated within the context of the trade-off theory of capital structure using the product life-cycle as a theoretical framework. Empirically, the relationship of innovative activity to equity issuance is tested by regressing patent activity (as a proxy for innovation) on the ratio of funds raised through the stock market to total funds raised. The results are statistically and economically meaningful.

*Keywords:* corporate finance, capital structure, life cycle, trade-off theory

## Introduction

One aspect of capital structure literature that does not receive attention is that firms have different capital requirements over their life cycle. Firms' external capital decisions are hypothesized to change depending upon where they fall within the innovation life cycle. In the beginning of the life cycle, firms are more innovative and those in innovative industries will be more likely to raise funds through the stock market than mature firms that are further into the life cycle.

Banks ration credit, limiting the amount of funds to newer industries with higher levels of risk, even though there is a high potential return. Even in the presence of a high risk premium, banks have asymmetric returns in high risk/return industries as they are exposed to losing their entire investment in the event of default while returns are limited to a fixed interest rate.

At the beginning of the innovation life cycle, the industries emerging are classified as being radically innovative because the products or processes they are promoting are radical departures from others currently on the market. Innovations tend to be clustered in the beginning of the innovation life cycle (Keklik, 2003), while competition intensifies as the product begins production. After the weaker firms begin to drop out, successful firms become more attractive for debt financing. These supply constraints imposed by lenders do not reduce firms' requirements for capital. These radically innovative firms still have large capital requirements in spite of the inability to obtain the debt instruments mature industries typically can access. To avoid extinction, these firms will continue to seek capital, having a larger portion of equity to debt in their capital structure.

The trade-off theory (Kraus & Litzenberger, 1973) posits that firms will balance the tax advantages of debt with the increased probabilities of bankruptcy as they become more leveraged. Theoretically, an optimal level of leverage maximizes the firm's value, thus taking on more debt than the optimal will result in a lower valuation. The life cycle theory argues that radically innovative industries are more likely to default, which will lead to a lower optimal level of leverage. Since innovative firms have additional capital requirements above the optimal leverage ratio, they will be forced to raise the additional funds through equity/stock markets.

Firms in innovative industries can be empirically shown to have a higher likelihood of raising funds through the stock market, controlling for portfolio returns and other market conditions. While the data do not allow for a precise positioning of firms within the life cycle, the empirical results

support of the theory that firms at the beginning of the innovation life cycle will be more likely to raise funds through equity than firms at the end of the life cycle. This is performed using patents as a proxy for innovation, operating on the assumption that more innovation occurs in the early stages of the life cycle. Probit estimation methods with clustered standard errors are used to estimate this relationship between innovation and firm choice as to whether debt or equity financing is used. The results are straightforward; significant evidence suggests that the more innovative a firm is, the more likely it is to use the stock market than the bond market to raise funds when seeking external capital.

## **Financing**

In the earlier states of the product life cycle — when there are high levels of innovation — a company will not be able to raise capital through debt markets and are more likely to rely on equity markets for external capital. This is primarily a supply constraint because the level of risk to lenders is too high given the expected return. Lenders, while they may be able to see the venture as being profitable, have a limited upside in the form of an interest rate, yet risk losing their entire investment if the firm fails. In order to raise funds, these firms in new and innovative industries are likely have a higher reliance on equity in order to compensate investors for the additional risk.

Innovation is defined as any improvement over old products, processes, or ideas. The innovations earlier in the life cycle are larger departures from those currently seen, while those towards the end do not have much of an impact. Established firms that are constantly innovating are treated in the same manner as brand new firms if the radically innovative activities consume a large portion of their activities. The main distinguishing feature is that established firms may have more retained earnings to fall back on. Under the assumption that firms will use internal funds before seeking external capital, firms entering new industries will exhaust their retained earnings, and will be more likely to raise funds through equity than firms still engaged in an old industry. The relevant factor of the above is how large a percentage of activity the radically new technology consumes of a company. If a massive company like General Electric begins operating a radically new innovation, it may only be a small portion of their portfolio and would not have much influence on their external capital needs. On the other hand, a small company shifting their entire focus toward a radical innovation would be treated similarly to a brand new firm. Regardless of whether a new firm or established firm is engaged in the radically innovative activity, their external capital decisions will be similar if the innovations pertain to a large percentage of their activity.

Traditional theory suggests that increases in the interest rate are compensation for holding risk. Charging higher interest rates on loans for riskiness is a common practice. However, high risks like those found in new industries would require interest rates that would be higher than normal rates. Merton (1974) presented the first comprehensive theory on the risk structure of interest rates, finding that bonds are more difficult to price when there is significant risk of default. Therefore, investors find these bonds less desirable in spite of the higher interest rates received. Not only do firms in new industries have higher probabilities of default, they also have large amounts of intangible capital that is difficult to price. When an asset is difficult to price, investors will discount the price. Investors will not be satisfied with the current risk premium and either i) demand a higher interest rate or ii) not lend at all.

While difficulties in pricing risk do exist, once interest rates rise above a point, banks will no longer lend funds out of fear of adverse selection where the only firms accepting high interest rate loans will be bad risks. Stiglitz and Weiss (1981) conceptualized this with the introduction of a theory of credit rationing. Basic economic theory posits that market equilibrium is where supply meets demand; as prices rise, suppliers will produce more. However, debt markets act differently with investors retaining their excess funds rather than lending them out at higher interest rates. Lenders

care about two things: risk and return; as risk increases, the banks are induced to loan at a higher interest rate in order to compensate for the additional risk. The problem arises when interest rates rise as the rate increase itself may influence the riskiness of the project. Increased rates make debt service more expensive, tightening margins and threatening the likelihood of repayment. Lenders, therefore, are aware of the lemons problems where those who would borrow at the highest interest rates may be worse risks; the interest rates would be able to act as a screening device, keeping bad investments out. Banks may interpret the radical industries' willingness to accept high interest rates as a signal of poor investments, thereby rationing credit.

Barnhart and Dwyer (2012) find that firms in new industries have a much higher volatility in their returns, but have a much higher expected return compared to the rest of the market. Their findings indicate that a small number of companies generate outstanding stock market returns while a high number of firms failed. Bankers are aware of the high potential return, but fear volatility. The firm's need for capital allows speculative investors to reap the benefits of higher risk through the stock market, allowing for the diversifying investment while delivering the necessary capital to innovative firms. Into the third stage, the innovations are not substantial departures from previous innovations. This does not lend itself to high rates of return, yet presents lower risk to investors. At this time, firms still have capital requirements, but now have the ability to raise capital through debt and retained earnings to expand production. These options allow more flexibility in choosing the lowest cost of capital as they can attract bank financing. The difference from stage two in relation to bank financing is that the firms are able to receive a lower interest rate because of a low, measurable risk. Firms will choose the cheapest way to raise the necessary capital and with interest rates lower than the cost of equity, the firms will choose significantly more debt financing.

## Capital Structure

As the first widely accepted theory of capital structure, Modigliani and Miller (1958) showed that the value of the firm is not affected by how the firm is financed. The theory is that firms will raise external capital through whichever avenue is the least expensive, bringing the most capital at the lowest cost. The implication is that the underlying capital structure does not matter. Whether firms raise funds through equity or debt and how they pay dividends is irrelevant to firm value, and that firms will be indifferent to their capital structure. Modigliani and Miller reached this irrelevance proposition under some crucial assumptions: perfect capital markets in the absence of taxes, bankruptcy costs, asymmetric information, adverse selection, and agency costs.

Arguing that taxes are an important factor in how firms finance themselves, Kraus and Litzenberger (1973) introduced the trade-off theory of capital structure. The mix of financing depends on the tax savings and the states in which a firm would become insolvent. The significant tax advantages for firms are gained by issuing debt that far outweigh any of the costs incurred by investors' personal taxes. Paying interest on outstanding debt is tax deductible and lowers the cost to service the debt. On the dark side of leverage, Kraus and Litzenberger introduce bankruptcy costs into consideration. Modigliani and Miller (1958) assumed that firm value does not depend on how certain they are to repay their debt obligations; the value of a firm is not affected by its leverage since bankruptcy penalties do not exist in perfect capital markets. However, under the trade-off theory, as the leverage ratio increases, the value of a firm begins to fall because of the increased probability of becoming insolvent.

An illustrative, stylized model of the trade-off theory is shown in Figure 1. The total value of the firm on the vertical axis is plotted against the leverage ratio, debt to assets ( $D/A$ ) on the horizontal

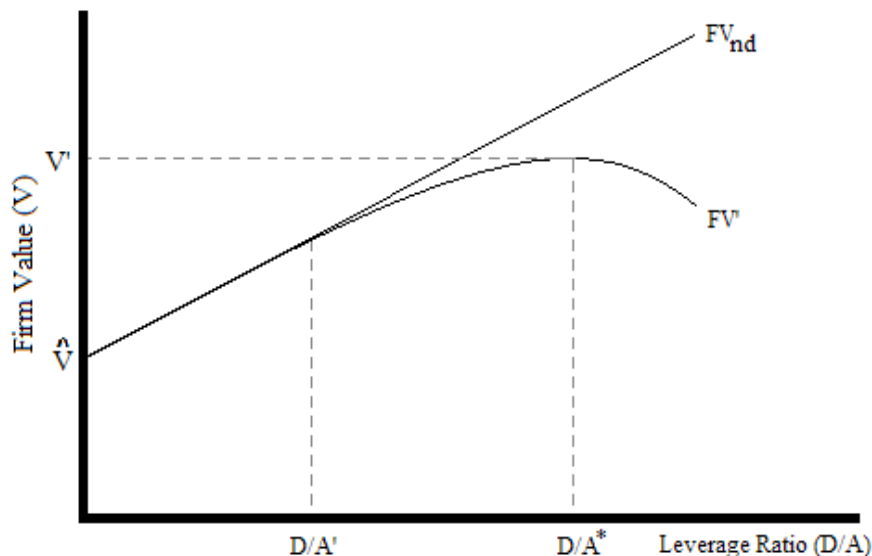


Figure 1. Trade-off theory

axis. The intercept,  $\hat{V}$ , is the value of a firm with no leverage and funded purely by equity or retained earnings. When a firm is at this point, it is not maximizing the value of the firm as borrowing would allow the firm to pursue additional profit opportunities.  $FV_{nd}$  represents firm value, with the *nd* subscript indicating no default that shows what a firm's value would be in the absence of any costs associated with increased leverage. With no chance of default, a firm could theoretically borrow unlimited funds, invest them, and watch the value of the firm grow. The flip side of the leverage is that while leverage can multiply profit rates, it can also multiply losses. The more leverage a firm maintains, the higher the probability a shock or poor investment will leave the firm insolvent.

$FV'$  is the firm value that incorporates bankruptcy costs and additional borrowing costs imposed by lenders to cover a higher risk of default. Eventually, the costs of increased leverage outweigh the benefits, causing the firm's value to drop.  $FV'$  would be close in value with  $FV_{nd}$  up until a point,  $D/A'$ , because at low levels of leverage, the probability of default is negligible. Firms, as profit maximizing entities, will attempt to maximize their value and select the optimal leverage ratio at  $D/A^*$  where the marginal benefits of debt equal the marginal costs of bankruptcy. At leverage levels between  $D/A'$  and  $D/A^*$ , the costs of leverage are non-negligible, but increasing at an increasing rate. Until  $D/A^*$  is reached, the benefits still exceed the costs; at leverage levels greater than  $D/A^*$ , bankruptcy costs exceed the tax benefits. If a firm has additional profitable opportunities and is in need of more capital than it would receive at the optimal leverage ratio, the firm would then turn to equity markets. The trade-off theory maintains that firms will reach their optimal leverage ratio in order to maximize their value. The only circumstances where they would utilize equity financing is if capital in excess of the optimal level was needed.

Adjusting the level of bankruptcy costs and tax benefits has important implications for the trade-off theory of capital structure. When the probability of default is altered, the trade-off theory predicts a change in the optimal level of leverage. Figure 2 illustrates how changing the probability of default for an innovative industry will alter the optimal leverage ratio. Two types of firms are assumed: one in a new industry and the other in an old industry. The distinction between the two types of firms is that the firm in the new industry has a higher probability of default, yet higher potential return due to a product in the beginning of the life cycle. This is contrasted by the firm in the old industry that

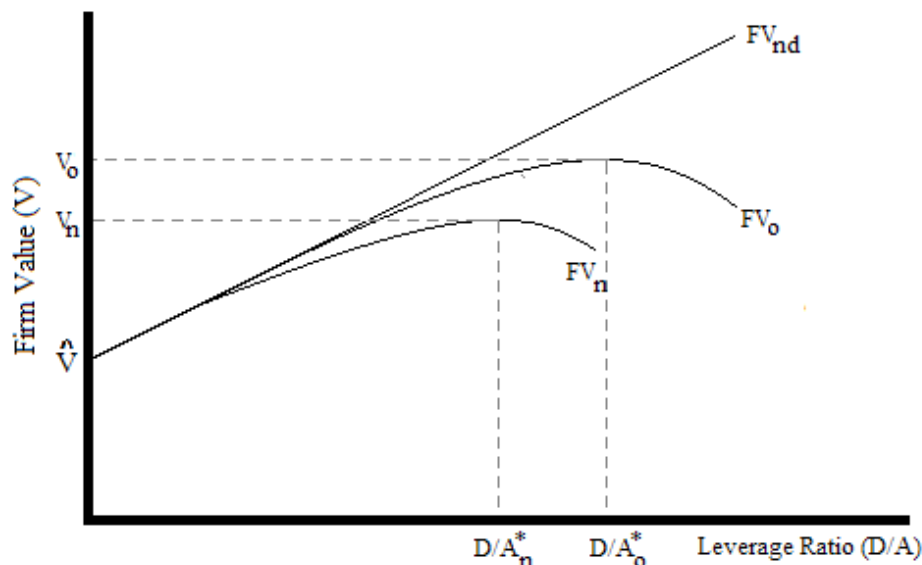


Figure 2. Trade-off with new industries

has a standardized product and concrete forecasts of future profits. Both firms enjoy the same tax benefits of debt and will both have a no default value curve at  $FV_{nd}$  and an unlevered value at the intercept,  $\hat{V}$ . Incorporating different probabilities of default gives two separate FV functions,  $FV_o$  and  $FV_n$ , where the subscripts respectively indicate old and new industries.  $FV_n$ , with a higher probability of default, pushes the optimal leverage ratio,  $D/A_o^*$ , to the left as the bankruptcy costs become greater than the tax benefits at a lower leverage ratio. Firms in radically new industries still have significant profit opportunities and will turn to equity markets for the large amounts of capital they require. Firms in old industries, on the other hand, do not have as many profit opportunities or capital requirements above their optimal leverage ratio and are less likely to seek equity financing. Firms in stagnant industries with few profitable growth opportunities are not expected to even reach the optimal leverage ratio as the tax benefits of borrowing are insignificant compared to profitable investments.

Note that increasing the costs of bankruptcy also lead to a lower market value of the firm;  $V_n$  is the market value for new industries while  $V_o$  shows the higher market value for old, established industries. The market value of new firms has to be lower in order to compensate investors for the increased risk and should be associated with higher expected returns. The firms will seek to bolster available debt funds with equity. Hsu (2009) proposes that technological innovations increase returns on stocks, finding that firms with more technological innovations (as proxied by patenting activity) are typically assigned higher risk premiums, in keeping with market valuations for firms in new industries as shown by  $V_n$ . New and radically innovative industries are associated with higher volatility and higher probabilities of default; therefore, they should also have higher expected returns. Empirical results show that firms involved in innovative industries have a higher likelihood of failure (Eisdorfer & Hsu, 2011) and leverage and volatility have an inverse relationship (Bradley, Jarrell, & Kim, 1984). These results are consistent with the reduced leverage ratio and valuation due to increased bankruptcy costs.

To restate, firms in the earlier stages of the innovation life cycle are hypothesized to be more likely to raise funds through the stock market than firms in the later stages. In the earlier stages of the innovation life cycle, when firms are engaged in radically new technologies, they will have high capital

requirements and be a questionable risk for lenders. Because of the limited upside in the form of an interest rate and a reasonable likelihood of default, debt will be less of an option; these highly innovative firms are then left with equity as a more viable option. Due to data limitations on pinpointing where firms fall within the innovation life cycle, it is also difficult to track firms' specific financing choices over the life cycle. Because of this, empirically testing the direct relationship between firms' position in the life cycle and their stock/bond choice is not possible. However, testing whether firms engaged in highly innovative industries are more likely to raise funds through the stock market versus the bond market is possible. Since more innovative activity will occur at the beginning of the life cycle, this will be an acceptable way to show support for the idea that firms in the earlier stages of the life cycle will be more likely to raise capital through the stock market.

## Empirical Methodology

The empirical section presents an unbalanced panel of stock/bond issuance, patent activity, and various control variables for the time period 1970 to 1992. 1970 was selected as the beginning of the time period because of the reliability of data on stock and bond issuance before that time is questionable. Having the observed time period stop at the end of 1992 was to exclude the wave of stock offerings in the mid-1990s that could skew the results. As most observers are aware, the mid-1990s saw an incredible number of technology companies issue IPOs. Since most of these companies were in brand new industries, this time period was marked predominately by firms in new industries issuing equity.

The setup of the empirical models is performed following the basic specifications of Choe, Masulis, & Nanda (1993). In this case, the dependent variable is *firm* level stock market decisions, with the important explanatory variable being *industry* patenting while controlling for other *industry*, and *market* conditions. Considering the two types of financing in each time period, firms had an option of financing their operations by using debt or equity. The dichotomous relationship of choosing to raise funds through equity or debt financing makes using a simple linear regression a potentially hazardous method of estimation. For this reason, a probit model is used to estimate the probability of raising funds through the stock market relative to bond financing based around the simplified regression equation:

$$P(\text{Stock Market})_{f,i,t} = \beta_0 + \beta_1 \text{Industry}_{i,t} + \beta_2 \text{Market}_t + \varepsilon_{t,i,t} \quad (1)$$

Where  $P(\text{Stock Market})_{f,i,t}$  is the probability of firms raising capital through the stock market, and is defined at *firm* level,  $f$ , in  $i$  industry in the time period  $t$ . Since the instances where firms are seeking external capital are of interest, and only two options exist, bond and stock, the probabilities of raising funds through the bond market,  $P(\text{Bond Market})_{f,i,t}$ , must be equal to  $(1 - P(\text{Stock Market})_{f,i,t})$ .  $\text{Industry}_{i,t}$  represents the industry level variables for all firms,  $f$ , within the industry,  $i$ . The industry level contains the important explanatory variable of industry innovation/patenting activity. An additional industry-level control of returns will also be included. Various time variant market conditions are controlled with  $\text{Market}_t$ ; within this are a number of market factors traditionally in the literature and discussed in detail in the section below (Complete data descriptions can be found in Table 1).

Table 1

*Data Description*

| Var Name    | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Mean   | Std Dev |
|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|---------|
| S/B Ratio   | Ratio of stock issuance to bond issuance for all public issuance 1970-1992. Computed as: total proceeds of stock issuance to proceeds from bond issuance plus stock issuance for each 6 month period. Binomial variable equal to one when the firm raises funds through stock market issuance and zero when through the bond market. Bond classifications included: Asset Backed, Convertible, High-Yield Corporate, Investment Grade Corporate, and Mortgage Backed. Source: Thomson Reuters SDC Database | n/a    | n/a     |
| PGrant      | Granted patents per 2 digit over The six month time periods. Source: NBER Patent database, Hall, Jaffe, and Trajtenberg (2001)                                                                                                                                                                                                                                                                                                                                                                             | 1.838  | 2.336   |
| Time        | Time factor; used to control for the time trend of stock market issuance. Calculated as time period minus 1969, resulting in time periods ranging between 1 – 22.5                                                                                                                                                                                                                                                                                                                                         | n/a    | n/a     |
| Ind. Return | Industry returns computed as a market return average 2-digit SIC industries over the six month time periods. Includes returns on all publicly held stocks in the United States listed on the NYSE, AMEX, and NASDAQ stock exchanges. Values listed as percentage. Source: CRSP US Stock Database.                                                                                                                                                                                                          | 0.037  | 0.257   |
| Bus. Cycle  | Dummy Business Cycle Variable equal to one when economy is in expansion and zero when a contraction. Source: NBER Business Cycle Dating Committee                                                                                                                                                                                                                                                                                                                                                          | n/a    | n/a     |
| 10 YrTBill  | Average 10 year T-Bill rate over each 6 month period and acts as the long run interest rate. Source: WRDS                                                                                                                                                                                                                                                                                                                                                                                                  | 8.94   | 1.98    |
| RF          | Risk Free Rate (1 Month T-Bill), averaged over the six month time periods. Source: Fama French, WRDS                                                                                                                                                                                                                                                                                                                                                                                                       | 0.0059 | 0.0018  |
| Mkt. Return | Average market (S&P 500) return over the 6 month period. Source: S&P 500                                                                                                                                                                                                                                                                                                                                                                                                                                   | 0.0095 | 0.0113  |
| MKTRF       | Excess return on the market as measured by a value weighted return of all securities minus the rate of return on one month T-Bills. Averaged over the 6 month period. Source: Fama French, WRDS                                                                                                                                                                                                                                                                                                            | 0.006  | 0.021   |

Because of the possible presence of intra-industry and time correlations in the error terms, clustering standard errors is important. The data include industry and time variant effects. Heterogeneity bias is treated by removing the inter-industry effects and time (year) effects. As such, the standard errors are clustered at the industry/time level. Within the dataset, there were 25,064 instances of firms raising capital across 71 industries and 46 time periods; clustering at the industry/time level results in a maximum possible 3,266 observations. However, some periods have no fundraising activity for a specific industry, leaving 2,106 total independent observations.

**Data**

The dependent variable in this model is the ratio of stock market financing to the total amount of financing received in each time period. The dataset incorporates all stock and bond issuance occurrences in the United States between 1970 and 1992 as reported in the Thomson Reuters SDC Database. The dependent variable, *SB.Ratio* is given as:

$$SB.Ratio_t = \frac{Stock\ Market\ Financing_t}{(Stock\ Market\ Financing_t + Bond\ Financing_t)} \quad (2)$$

Fund raising activity has been organized into 6 month time periods in order to gather a complete picture of their total external fund raising activity. Firms may have large capital requirements

and raise funds from numerous sources in a relatively short period. Each time period is organized as January through June and July through December, for a total of two time periods in each year between 1970 and the end of 1992 for a total of 46 time periods. For example, when  $t=1970$ , it indicates the first 6 months of 1970;  $t=1970.5$  indicates July through December of 1970; etc. These time designations are used for every variable in this model; firm fundraising, industry patenting, and market considerations are all factored over the 6-month time periods.

The value of the dependent variable for a firm that raises capital only through the bond market would equal zero, while a firm that raised all their funds through the stock market would equal one. As can be seen from firm's actions in capital markets, it was unusual for a firm to raise capital through both stock and bond issuance in the same time period. Of the 25,153 fund raising instances, only 89 firms raised capital through both the bond and stock market in one of the 6-month time periods. These 89 instances present an interesting anomaly as the only plausible explanation as to why a firm would seek both bond and stock market issuance in the same time period would be that the costs/benefits were exactly identical. This rare occurrence, 0.3%, demonstrates that firms are unlikely to seek funds through both avenues simultaneously. These are dropped from the analysis to allow for the use of binomial regressions, leaving 25,064 instances of firm level fund raising. This leads to a simpler dependent variable, where:

$$SB.Ratio_{f,t} = \begin{cases} 1, & \text{fund raising} = \text{stock market} \\ 0, & \text{otherwise} \end{cases} \quad (3)$$

Figure 3 displays the distribution of how many times a firm enters the market for external capital. The horizontal axis displays the number of time a firm appears in the sample while the vertical axis is the number of firms that are included in each group. Of the 12,131 firms that raised capital through either the bond or stock market in the time period the vast majority, 8,571, only went to the market a single time. Firms that raised capital less than five times between 1970 and 1992 represent 93.5 % of the observed firms. The large number of firms with limited observations precludes the ability to use a dynamic panel or fixed effects model. For example, the use of a fixed effects model results in the dropping of 96.7% of observations.

### Industry Level Variables

These data include all patents issued by the United States Patent and Trademark Office (USPTO) and compiled by Hall, Jaffe, and Trajtenberg (2001). The relationship between where a firm is in the life cycle is as follows: stock market issuance correlates with patenting, innovative industries patent more, and more innovation occurs at the beginning of the innovation life cycle. The empirical estimations of this paper are focused specifically on the relationship between patents and stock market issuance. The patent data used in this analysis includes only utility patents granted in the United States as these are issued for the invention of “any new and useful process, machine, manufacture, or composition of matter, or a new and useful improvement thereof...” (Patent Laws and Regulations, 2000, p. E-25) and are generally referred to as patents for invention. This data set excludes plant and design patents as these patents cannot be considered a radical departure from previous innovations.

Industry level patenting is important; path-breaking innovations generated by innovation come in clusters, providing more opportunities for innovation by others in the industry. While one firm in an industry might be the leader in patenting activity, a large number of other firms will attempt to bring a similar product to market. Industries with higher levels of patenting will contain firms with higher levels of innovation. Information as to which firms are going to survive and succeed is not known with any level of certainty, but accurate forecasts of the success of the wider industry is known by most investors. Pastor and Veronesi (2005) found that during technological revolutions investors

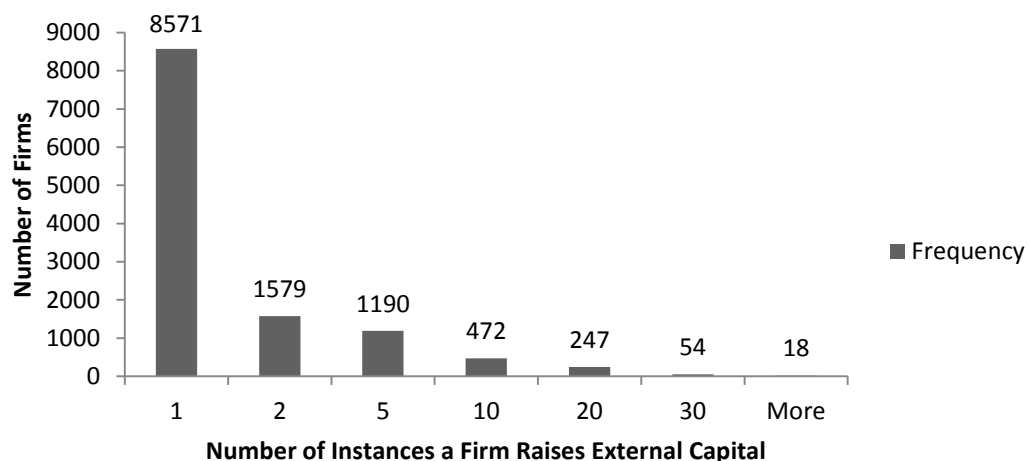


Figure 3. Fund-raising

will diversify their investments among many in the industry. This is done because some will be winners, others losers, and cannot be known a priori who will be the winners. Patent data from the USPTO are classified by internal codes that are not relatable to other variables. Hall et al. (2001) were able to relate the internal USPTO codes to industries and other outside factors through a 3-digit US Patent class. This US Patent class is assigned to the appropriate 2-digit SIC industry codes; the broader 2-digit codes were chosen because of the necessity to incorporate the spillover effects on closely related industries. Due to the way assignments are referenced by the USPTO, some patents were referenced in a number of industries. When this occurred, patents with applicability in multiple industries were included with the total count of patents for each industry they referenced; this results in total patent counts being overestimated. During the time period, the total amount of actual patents was just under 1.9 million while my assignments resulted in just over six million assigned patents. This is the optimal practice as there are innovations that have a wider application, and attempting to select a single industry for these would result in subjective assessments of the data. Patents are reported according to the year they were received; the time periods, however, are every 6 months. To reconcile this, the way the patents are assigned was to place the half of the yearly number of patents in the first half of the year (e.g., 1970, 1971, etc.) and then assign the second half of the year as the average of the two surrounding time periods (e.g.,  $1970.5 = (1970 + 1971)/2$ ). Assigning patents in the manner allows for continuous patenting data.

Following the market timing literature (Baker & Wurgler, 2002), when stock values are higher, firms are more likely to raise funds through equity. While market returns are also included, industry returns are also necessary to control for since individual industries do not necessarily correlate with the wider market. One of the main considerations for the inclusion of industry controls is that if an asset price bubble is emerging in a specific industry, the valuations an innovative firm would receive could be greatly overvalued. These high valuations could be an easy decision for a firm to raise capital through equity. Time variant stock returns for industries are included to pick up the industry level variation that could be overlooked by returns from the entire market. As industry returns rise, more stock issuances are expected because of the higher valuations associated with the industry.

Industry returns data are from the Center for Research in Security Prices (CRSP) and incorporates all publicly listed stocks in the United States on NYSE, AMEX, and NASDAQ exchanges. This index was then computed as a market cap-weighted price index according to the 2-

digit SIC codes. This computation is accomplished by computing the return accrued from the overall industry. The returns over the period were computed as a simple percentage change from the beginning of the period to the end of the time period based on the cumulative industry prices of publicly traded stock. Some of the smaller industries with less external capital raised, have no publicly traded stocks. This was the case for 59 of the fund raising instances; these without any corresponding public stocks were discarded from the analysis.

### Market Control Variables

In order to control for hypotheses proposed by market timing theorists, a number of variables are used to proxy for market conditions. These are time variant and include the business cycle, interest rates, market return, and other constructed variables commonly used in the literature. The business cycle plays a key role in the fundraising decisions surrounding firms due to its effects on both investor and company expectations. The expected impact of the business cycle on *SB.Ratio* is ambiguous. It could be negative since when the economy is in an expansion, equity tends to receive a higher market value, leading to more stock issuance relative to bonds. It could also be positive since in times of economic expansion lenders typically assign lower probabilities of default and bankruptcy. Supporting this idea, Choe, et al. (1993) found evidence that common stock offerings are positively correlated with the business cycle. With a positive correlation, supply constraints placed on innovative firms will be lessened and firms will raise more funds through the stock market.

The business cycle is controlled for using the official estimates of US Business Cycle Expansions and Contractions as released by the National Bureau of Economic Research (NBER). The NBER defines a contraction as significant declines in a number of factors: real GDP, real income, employment, industrial production, and wholesale-retail sales. The subjectivity of these measurements is used alongside the traditional definition of a recession as two consecutive quarters of decline in real GDP in order to more accurately date the peaks and troughs in the changes of economic activity.<sup>1</sup> The time between the trough and the peak was considered to be a time of economic expansion, while contraction was the time following a peak until the trough was reached again. A simplistic dummy variable is used with expansions equal to one and contractions equal to zero. Since the exact peak and trough are not likely to be assigned on exactly January 1 or July 1, they are going to fall somewhere within the 6 month time periods. For this reason, the 6 month time periods that included a peak were assigned the expansion value of one, while those including the trough received the contraction value of zero.

To account for changes in interest rates, the rates on 1-month and 10-year treasury bills are used. The reasoning for including interest rates is that there is a positive relationship between interest rates and costs to service debt; when these costs rise, firms should be more likely to look to equity financing since the costs of stock market financing have become less expensive relative to debt. The coefficients attached to the different interest rates are expected to be positive. The short-term and long-term are both used in order to be inclusive of the decisions firms may make. While long-and short-term interest rates typically move together, the long-term interest rates are expected to have more of an impact on stock market issuance since most future projects are based off long term debt contracts.

The other factor of stock/bond issuance is the current market return; if the market seems to offer a higher return on stocks, investors will pay more for a stock offering; the higher valuation means the firm has a higher likelihood of being overvalued and, therefore, is going to be more likely to raise funds through the stock market. This variable, *Mkt Return*, is measured as the weighted average equity

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<sup>1</sup> For a complete description of how the NBER dates the business cycle, please see the most recent NBER announcement, dated 09/20/2010.

return of the Standard & Poor's 500 Index over the 6-month time periods. The S&P 500 is used because it is one of the most followed indexes of equity returns, and its diversity makes it an indicator of the health of the United States economy. The expected coefficient of market return should be positive; when the stock market is booming and there are high returns, firms' value is increasing and will be more likely to raise funds through equity issuance.

An additional variable used for determining relative returns to both investors and firms is *MKTRF*, which is the difference between the market return and the risk free rate. The measurement of market return under this variable differs from the variable *Mkt Return* in that it is the value-weight return of all firms in the CRSP database incorporated in the United States and listed on the NYSE, AMEX, or NASDAQ, rather than the narrower S&P 500. A positive relationship is expected between *MKTRF* and *SB.Ratio*. The intuition is that when *MKTRF* is higher, equity is receiving a greater return relative to debt, and there is a reasonable likelihood that equity is overvalued by the market. Perhaps one of the most important single variables, this difference is a direct test of the difference between returns to equity and debt.

Table 2 shows the total number of stock and bond issuances by year along with a simplified ratio of instances of stock financing to total financing activities; this is computed as  $IPO/(Bond + IPO)$ . The bond market has significantly more activity than the stock market, with minimal activity from the mid to late 1970s. The total dollar value of the bond market issuances is substantially larger than the fundraising used through stock issuance; the ratio of funds raised through the stock market is in the column labeled *SB.Ratio*. Figure 4 shows the total number of fundraising instances graphically across time and Figure 5 displays the total dollar value of the fundraising activities.

## Results

In every estimation, evidence is found in support of my hypothesis that innovative firms are more likely to pursue financing from the stock market relative to the bond market. The first of these cohorts directly tests the market timing variables to control for market circumstances and is shown in Table 3. Industry returns are added and presented in Table 4. Each table provides coefficients, standard errors, statistical significance, and the marginal effects at the median for each variable, along with variance inflation factors (VIF) testing for multicollinearity.

Testing the hypothesis that more innovative firms are more likely to raise funds through stock market issuance uses the number of patents granted (*PGrant*) as a proxy for innovation. As such, as more patents are granted, firms are expected to be more likely to raise funds through equity issuance. *PGrant* enters into every estimation highly significant, effectively showing that firms in industries with large amounts of innovative activity will be more likely to raise funds through the stock market than those in industries without technological innovations. *PGrant* was significant at least at the 0.1% level in every estimation. The marginal effects did not vary much, and a one standard deviation increase from the median<sup>2</sup> in granted patents ranges between a 1.27 and 1.62 % increase in probability of raising funds through the stock market with an average of 1.42 %. Considering that the probability of raising funds through the stock market remained around 8.4 %, a one standard deviation change from patent grant's median of 1.42 % is substantial. Regardless of which controls were added to the model, there were only small changes in coefficients, *p*-values, or marginal effects observed for *PGrant*, resulting in strong support for my hypothesis

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<sup>2</sup> The median was used rather than the mean due to a skewed distribution of patents. Computing from the mean would create an upward bias and overstate the effect of patents.

Table 2  
*Data Summary*

|        | <b>IPO</b> | <b>Bond</b> | <b>IPO/Total</b> | <b>IPO (\$ Mil)</b> | <b>Bond (\$ Mil)</b> | <b>SB.Ratio</b> |
|--------|------------|-------------|------------------|---------------------|----------------------|-----------------|
| 1970   | 16         | 187         | 0.079            | 48                  | 9,397                | 0.005           |
| 1970.5 | 8          | 240         | 0.032            | 25                  | 13,778               | 0.002           |
| 1971   | 22         | 251         | 0.081            | 109                 | 13,686               | 0.008           |
| 1971.5 | 21         | 184         | 0.102            | 104                 | 9,505                | 0.011           |
| 1972   | 34         | 225         | 0.131            | 118                 | 10,336               | 0.011           |
| 1972.5 | 27         | 157         | 0.147            | 158                 | 8,829                | 0.017           |
| 1973   | 14         | 140         | 0.091            | 727                 | 7,118                | 0.085           |
| 1973.5 | 2          | 125         | 0.016            | 6                   | 8,491                | 0.001           |
| 1974   | 1          | 169         | 0.006            | 2                   | 13,170               | 0.000           |
| 1974.5 | 0          | 168         | 0.000            | -                   | 14,414               | 0.000           |
| 1975   | 0          | 252         | 0.000            | -                   | 22,073               | 0.000           |
| 1975.5 | 1          | 183         | 0.005            | 17                  | 11,961               | 0.001           |
| 1976   | 6          | 181         | 0.032            | 72                  | 16,374               | 0.004           |
| 1976.5 | 4          | 166         | 0.024            | 66                  | 13,050               | 0.005           |
| 1977   | 5          | 147         | 0.033            | 80                  | 12,747               | 0.006           |
| 1977.5 | 2          | 163         | 0.012            | 5                   | 12,111               | 0.000           |
| 1978   | 1          | 154         | 0.006            | 26                  | 10,947               | 0.002           |
| 1978.5 | 3          | 122         | 0.024            | 12                  | 9,302                | 0.001           |
| 1979   | 6          | 129         | 0.044            | 38                  | 13,077               | 0.003           |
| 1979.5 | 7          | 138         | 0.048            | 43                  | 12,213               | 0.004           |
| 1980   | 8          | 206         | 0.037            | 63                  | 21,710               | 0.003           |
| 1980.5 | 31         | 163         | 0.160            | 398                 | 15,067               | 0.025           |
| 1981   | 40         | 423         | 0.086            | 360                 | 25,063               | 0.014           |
| 1981.5 | 33         | 441         | 0.070            | 360                 | 22,637               | 0.015           |
| 1982   | 8          | 402         | 0.020            | 52                  | 20,109               | 0.003           |
| 1982.5 | 15         | 582         | 0.025            | 228                 | 42,632               | 0.005           |
| 1983   | 57         | 552         | 0.094            | 1,553               | 38,240               | 0.038           |
| 1983.5 | 121        | 507         | 0.193            | 1,894               | 33,857               | 0.050           |
| 1984   | 40         | 422         | 0.087            | 673                 | 34,487               | 0.019           |
| 1984.5 | 35         | 629         | 0.053            | 730                 | 60,809               | 0.012           |
| 1985   | 36         | 684         | 0.050            | 692                 | 58,270               | 0.012           |
| 1985.5 | 58         | 911         | 0.060            | 2,638               | 92,647               | 0.027           |
| 1986   | 83         | 931         | 0.082            | 2,573               | 124,712              | 0.020           |
| 1986.5 | 130        | 1087        | 0.107            | 5,764               | 148,183              | 0.036           |
| 1987   | 108        | 1023        | 0.095            | 8,652               | 127,891              | 0.060           |
| 1987.5 | 88         | 982         | 0.082            | 4,489               | 131,663              | 0.032           |
| 1988   | 57         | 1072        | 0.050            | 7,185               | 164,414              | 0.040           |
| 1988.5 | 55         | 1148        | 0.046            | 4,851               | 168,924              | 0.027           |
| 1989   | 54         | 1016        | 0.050            | 4,057               | 188,098              | 0.021           |
| 1989.5 | 67         | 1088        | 0.058            | 4,521               | 203,971              | 0.021           |
| 1990   | 66         | 857         | 0.072            | 4,870               | 160,651              | 0.029           |
| 1990.5 | 31         | 796         | 0.037            | 1,902               | 149,075              | 0.012           |
| 1991   | 76         | 878         | 0.080            | 4,063               | 227,327              | 0.017           |
| 1991.5 | 132        | 896         | 0.128            | 8,075               | 229,081              | 0.033           |
| 1992   | 160        | 951         | 0.144            | 11,220              | 334,536              | 0.031           |
| 1992.5 | 137        | 1089        | 0.112            | 6,246               | 307,170              | 0.020           |
| Total  | 1906       | 23217       | 0.076            | 89,767              | 3,373,805            | 0.026           |

CAPITAL STRUCTURE OVER THE LIFE CYCLE

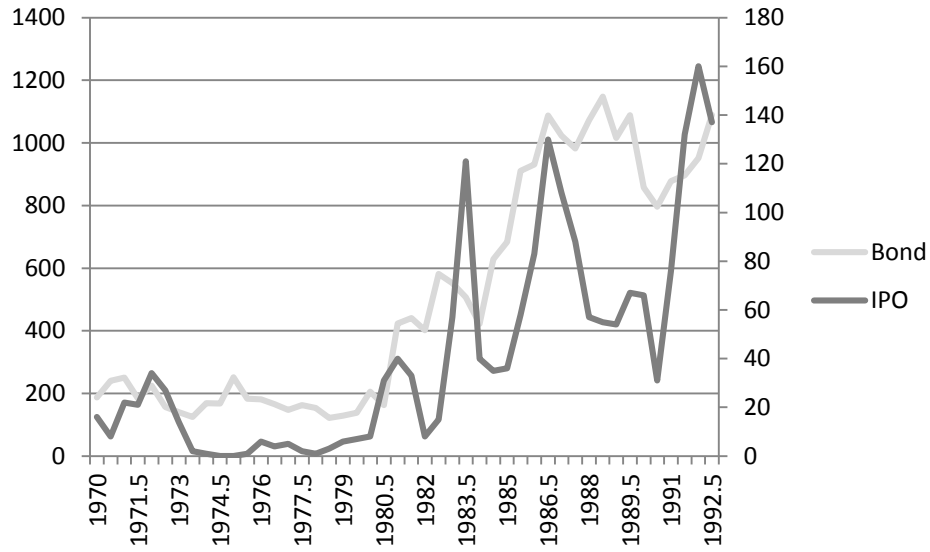


Figure 4. Bond and IPO activity over time: Total instances

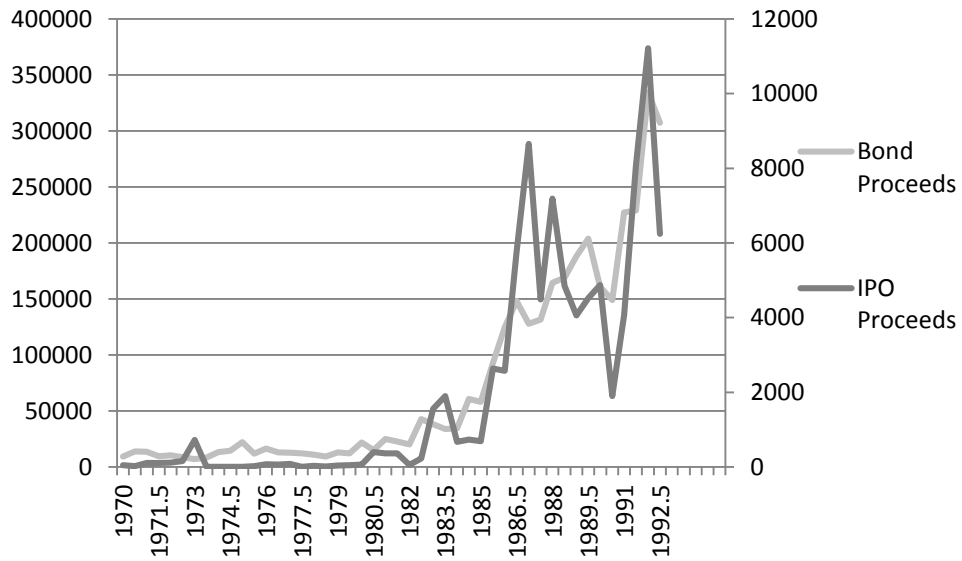


Figure 5. Bond and IPO activity over time: Total dollar proceeds

Table 3  
Base model

| Ratio              | 1             | 2             | 3             | 4              | 5               | 6              | 7              | 8             |
|--------------------|---------------|---------------|---------------|----------------|-----------------|----------------|----------------|---------------|
| <b>PGrant</b>      | <b>0.046</b>  | <b>0.046</b>  | <b>0.045</b>  | <b>0.045</b>   | <b>0.046</b>    | <b>0.045</b>   | <b>0.044</b>   | <b>0.046</b>  |
|                    | 0.009***      | 0.009***      | 0.009***      | 0.009***       | 0.009***        | 0.009***       | 0.009***       | 0.009***      |
|                    | 1.47%         | 1.38%         | 1.38%         | 1.31%          | 1.29%           | 1.35%          | 1.35%          | 1.38%         |
| <b>Bus.Cycle</b>   |               | <b>-0.110</b> | <b>-0.097</b> | <b>-0.135</b>  | <b>-0.197</b>   | <b>-0.140</b>  | <b>-0.098</b>  | <b>-0.146</b> |
|                    |               | 0.067         | 0.066         | 0.070'         | 0.072**         | 0.068*         | 0.066          | 0.068*        |
|                    |               | -1.55%        | -1.36%        | -1.85%         | -2.74%          | -2.00%         | -1.36%         | -2.11%        |
| <b>10Yr T-Bill</b> |               |               | <b>-0.015</b> | <b>0.055</b>   | <b>0.077</b>    |                |                | <b>-0.008</b> |
|                    |               |               | 0.014         | 0.028*         | 0.028**         |                |                | 0.014         |
|                    |               |               | -0.38%        | 1.33%          | 1.83%           |                |                | -0.20%        |
| <b>RF</b>          |               |               |               | <b>-88.419</b> | <b>-108.048</b> | <b>-40.408</b> | <b>-40.492</b> |               |
|                    |               |               |               | 29.0**         | 29.53***        | 14.99**        | 14.47**        |               |
|                    |               |               |               | -2.01%         | -2.38%          | -0.96%         | -0.97%         |               |
| <b>Mkt Return</b>  |               |               |               |                | <b>10.766</b>   | <b>9.145</b>   |                | <b>8.981</b>  |
|                    |               |               |               |                | 2.46***         | 2.43***        |                | 2.41***       |
|                    |               |               |               |                | 1.45%           | 1.33%          |                | 1.31%         |
| <b>Constant</b>    | <b>-1.526</b> | <b>-1.446</b> | <b>-1.323</b> | <b>-1.397</b>  | <b>-1.550</b>   | <b>-1.281</b>  | <b>-1.217</b>  | <b>1.441</b>  |
|                    | 0.039***      | 0.067***      | 0.143***      | 0.144***       | .149***         | .120***        | 0.118***       | 0.148***      |
| Pseudo R2          | 0.01          | 0.01          | 0.01          | 0.01           | 0.02            | 0.02           | 0.01           | 0.01          |
| Mean VIF           | 1.00          | 1.00          | 1.03          | 2.25           | 2.07            | 1.03           | 1.00           | 1.06          |

Bolded value is coefficient, second is SE with statistical significance, third is 1 StDev change

\*\*\* significant at 0.1%

\*\* sig at 1%

\* sig at 5%

'at 10%

Table 4:  
Base plus industry returns

| Ratio              | 9             | 10            | 11            | 12             | 13              | 14             | 15             | 16            |
|--------------------|---------------|---------------|---------------|----------------|-----------------|----------------|----------------|---------------|
| <b>PGrant</b>      | <b>0.047</b>  | <b>0.046</b>  | <b>0.045</b>  | <b>0.045</b>   | <b>0.046</b>    | <b>0.044</b>   | <b>0.044</b>   | <b>0.045</b>  |
|                    | 0.009***      | 0.009***      | 0.009***      | 0.009***       | 0.009***        | 0.009***       | 0.009***       | 0.009***      |
|                    | 1.47%         | 1.39%         | 1.39%         | 1.31%          | 1.27%           | 1.33%          | 1.35%          | 1.36%         |
| <b>Ind.Return</b>  | <b>0.058</b>  | <b>0.029</b>  | <b>0.023</b>  | <b>0.032</b>   | <b>-0.135</b>   | <b>-0.141</b>  | <b>0.019</b>   | <b>-0.140</b> |
|                    | 0.066         | 0.071         | 0.073         | 0.068          | 0.127           | 0.128          | 0.073          | 0.132         |
|                    | 0.20%         | 0.10%         | 0.08%         | 0.10%          | -0.41%          | -0.46%         | 0.06%          | -0.46%        |
| <b>Bus.Cycle</b>   |               | <b>-0.107</b> | <b>-0.095</b> | <b>-0.133</b>  | <b>-0.215</b>   | <b>-0.159</b>  | <b>-0.096</b>  | <b>-0.165</b> |
|                    |               | 0.068         | 0.067         | 0.070'         | 0.075**         | 0.071*         | 0.067          | 0.071*        |
|                    |               | -1.50%        | -1.33%        | -1.81%         | -3.01%          | -2.29%         | -1.34%         | -2.41%        |
| <b>10Yr T-Bill</b> |               |               | <b>-0.015</b> | <b>0.055</b>   | <b>0.077</b>    |                |                | <b>-0.008</b> |
|                    |               |               | 0.014         | 0.028*         | 0.028**         |                |                | 0.014         |
|                    |               |               | -0.38%        | 1.35%          | 1.81%           |                |                | -0.21%        |
| <b>RF</b>          |               |               |               | <b>-88.712</b> | <b>-107.734</b> | <b>-40.640</b> | <b>-40.396</b> |               |
|                    |               |               |               | 29.01**        | 29.37***        | 15.01**        | 14.49**        |               |
|                    |               |               |               | -2.02%         | -2.36%          | -0.96%         | -0.97%         |               |
| <b>Mkt Return</b>  |               |               |               |                | <b>11.690</b>   | <b>10.125</b>  |                | <b>9.971</b>  |
|                    |               |               |               |                | 2.677***        | 2.656***       |                | 2.663***      |
|                    |               |               |               |                | 1.57%           | 1.46%          |                | 1.45%         |
| <b>Constant</b>    | <b>-1.529</b> | <b>-1.449</b> | <b>-1.327</b> | <b>-1.404</b>  | <b>-1.538</b>   | <b>-1.270</b>  | <b>-1.220</b>  | <b>-1.430</b> |
|                    | 0.040***      | 0.068***      | 0.144***      | 0.145***       | 0.149***        | 0.120***       | 0.119***       | 0.147***      |
| Pseudo R2          | 0.01          | 0.01          | 0.01          | 0.01           | 0.02            | 0.02           | 0.01           | 0.01          |
| Mean VIF           | 1.00          | 1.02          | 1.04          | 2.01           | 1.95            | 1.08           | 1.02           | 1.11          |

Bolded value is coefficient, second is SE with statistical significance, third is 1 StDev change

\*\*\* significant at 0.1%

\*\* sig at 1%

\* sig at 5%

'at 10%

### Base Model

The basic model estimating the effects of innovation on stock market issuance is based around the market timing literature with results presented in Table 3. Controls used in this model include estimating the influence of the business cycle (*Bus.cycle*), short-term and long-term interest rates (*RF* and *10.YrT-Bills* respectively), and return on the market (*Mkt.Ret*). Because of the relationship between short-and long-term interest rates and the perceived importance of market returns, model selection includes a number of combinations.

The important, explanatory variable, *PGrant*, did not face much variation within the results from the models included in the first estimations. Results from these estimations show coefficients for innovation (*PGrant*) in a tight band from 0.044 to 0.046, with statistical significance at the 0.1% level in every estimation. Where this becomes important is in determining the changes in the likelihood of raising funds through the stock market relative to the bond market. An increase in one standard deviation change in patenting activity from the median will result in a higher likelihood of raising funds through the stock market between 1.29 and 1.47 %. The differences between the least innovative industries are a significant number of patents; the difference between the most and least patenting industries results in the most innovative being 14.25% more likely to raise funds through stock market issuance.

The business cycle (*Bus.Cycle*) plays an important role in the decisions firms make when they are seeking external capital. *Bus.Cycle* enters significantly (at the 5% level) into three out of seven regressions it is included in, with one of those being significant at the 1% level. Computing the change in the likelihood of raising stock versus bonds on the models where *Bus.Cycle* is significant, a discrete change results in a change in the likelihood ratio between -2.00 and -2.74%. Effectively this means that during expansions, firms are at least 2% more likely to raise funds through the bond market; the intuitive explanation for this is that lenders assign a lower probability of default when the economy is expanding and will ration credit less.

The inclusion of the two interest rates (*10YrT-Bill* and *RF*) provided some surprising results. Where the traditional expectation is that increases in the interest rate (in both the short and long term rates) will lead to higher borrowing costs for the firm, creating an incentive to seek equity financing, the opposite is seen. Sign flipping can be viewed on *10YrT-Bill* when short-term interest rates (*RF*) are included, yet are still statistically significant in every model it is included in. The interaction of these two interests rates are expectedly related and show some collinearity between them. On the two models where they are both included (5 and 6), the mean VIF jumps to 2.25 and 2.07. Using the rule of thumb that VIF values above 5 needs to be reevaluated, these models would be acceptable. However, individual VIF values for *10YrT-Bill* and *RF* are both around 3.5 and tolerance values below 0.3, meaning that these variables show some collinearity. Even though these two variables are collinear with each other, no adjustments to the model are made as they are not collinear with or change the variable of interest, *PGrant*. If an attempt is made to quantify the individual impact of these variables out of collinear estimations, confidence in the estimates would rise. As the impact of these interest rates is not being qualified, but rather they are only used to control for external factors, it is acceptable to leave the model as is, report the results, and acknowledge the limitations. This decision was made because the inclusion of the variables provides a better fit as both interest rates can influence the costs incurred by firms when seeking capital.

*RF* displays strongly negative coefficient values between -40.408 and -108.048 and they are significant at the 1% level. The one standard deviation change in the likelihood ratio from over 2% when *10YrT-Bills* are included drops to under 1% when it is excluded. This negative coefficient indicates that as the risk free rate increases, investors will require a higher return on any other investments since the risk premium is indexed off the risk free rate. These higher returns must come from a lower valuation assigned to firms looking for capital through equity issuance. The strength of

the coefficient indicates that the effects on the costs of debt service are far outweighed by investor requirements for equity returns.

The relationship between *10YrT-Bill* and *RF* shows the possibility of joint effects. The interesting thing to note is that the only time the coefficients attached to T-Bills are statistically significant is when both variables are included in the same model. By itself, X has a negative, insignificant coefficient while the inclusion of Y turns it into being positive and statistically significant. The coefficient for Y also changes as X are both in the same model as Y's coefficient increases in magnitude. A possible explanation of this phenomenon is that financing decisions are sensitive to the spread between the interest rates. These coefficients support the notion that as the spread widens between interest rates, firms would be more likely to raise funds through the stock market. The intuition is that since investments are risk adjusted to the risk free rate, as the spread widens between the variables, long-term debt becomes more expensive relative to other avenues of financing. Under the assumptions of the market time theorists, this could influence a shift away from debt to equity as firms attempt to maximize their value.

Past market returns (*Met Return*) are strongly associated with stock market issuance. The average coefficient of 9.8 is in keeping with the predictions of theory. As the market return rises, firms' valuations rise with it; at higher valuations, firms will be more likely to raise funds through equity issuance. Highly statistically significant at the 0.1% level, this variable has relatively high marginal effects, with a one standard deviation change from the median changing the likelihood of raising funds through the stock market between 1.31 and 1.45%. Even controlling for interest rates, high past market returns are a significant indicator that firms will be more likely to issue equity.

### Industry Returns Cohort

The second cohort of models on the determination of the stock/bond choice includes industry controls (*Ind.Returns*), with model selection being identical to the first cohort; results are reported in Table 4. Controlling for industry returns should pick up any industry factors that went excluded in the first cohort of models as those controls were purely based off the market. There are only minor changes for *PGrant* and the other control variables; this variation is subtle enough to not question the results from the first models.

According to VIF tests, the only models with elevated VIF levels are 13 and 14, which include *RF* and *10YrT-Bills* as the collinear factors, discussed in the base model cohort section. Including the industry return control variable should pick up any inter-industry variation. The results from this variable are insignificant in every model. Some differences among industries were expected to drive any debt/equity decisions. The dominance of market returns seem to point to the wider market as being more important in determining capital decisions than industry returns.

## Conclusion

In answering the question of when firms seek equity financing over debt financing when searching for external capital, it was hypothesized that radically innovative firms at the beginning of the innovation life cycle will be more likely to look to the stock market than firms at the end of the life cycle with less innovative activity. The primary contribution of this paper was linking this life cycle to firm capital structure and decisions firms make when attempting to raise external capital through the bond and stock channels.

By using patent activity as a proxy for innovative activity, statistically significant evidence suggests that innovative firms are more likely to raise capital through equity issuance than firms without innovative activity. These results were robust while controlling for industry returns and a variety of market factors, including short-and long-run interest rates, returns on the market and

business cycle factors. The impact of patents appeared as a much stronger predictor of whether a firm will seek stock market or bond market financing than some of the other variables found prominently in the literature. A limitation of this study is the inability to pinpoint where in the innovation life cycle firms are when they are seeking external capital. This is an avenue in which future research would be able to contribute; the determination of where the transition points occur and at what point firms begin searching for equity financing through the stock market would be of significant value. The other path in expanding this research is to formalize the relationship of the innovation life cycle to models of capital structure.

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