Technological Innovations and Capital Structure

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ABSTRACT

I assess empirically the implications of technological innovations, proxied by patent grants, for corporate financing, investment and stock returns. I show that industry patents are associated with more firm-level equity issues and reduced leverage. Firms in industries with more patents issue more equity at a given point in time. Within industries, however, equity issuers are not patent recipients themselves. Subsequently, equity issuers do not increase investment expenditures, dividends, or acquisitions. Rather, firms hold the proceeds of equity issues in cash reserves. Finally, patent recipients earn high abnormal returns. These findings cast doubt on traditional views of technological innovations as signals of investment opportunities or reductions of information asymmetry. Therefore, my findings suggest that technological innovations act as a catalyst for investor sentiment.

JEL classification: G32, O33
Keywords: Technological innovation, patent, capital structure.

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ABSTRACT

I assess empirically the implications of technological innovations, proxied by patent grants, for corporate financing, investment and stock returns. I show that industry patents are associated with more firm-level equity issues and reduced leverage. Firms in industries with more patents issue more equity at a given point in time. Within industries, however, equity issuers are not patent recipients themselves. Subsequently, equity issuers do not increase investment expenditures, dividends, or acquisitions. Rather, firms hold the proceeds of equity issues in cash reserves. Finally, patent recipients earn high abnormal returns. These findings cast doubt on traditional views of technological innovations as signals of investment opportunities or reductions of information asymmetry. Therefore, my findings suggest that technological innovations act as a catalyst for investor sentiment.

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Introduction

Since the pioneering work of Schumpeter, economists have become increasingly aware of the relevance of technological innovations as engines of industries' evolution. In particular, technological innovations have been shown to be an important positive determinant of market valuation of firms (see Hall, Jaffe and Trajtenberg (2004)). However, the implications of technological innovations for corporate financing are much less understood.

I assess empirically the implications of technological innovations for capital structure, corporate financing, investment and stock returns. Following traditional industrial organization literature, I proxy technological innovations with patent counts, both at the firm and at the industry level (e.g. see Hall (2000), Griliches, Hall and Pakes (1987)). My approach parallels a large body of literature in corporate finance showing that R&D expenditures correlate negatively with the level of leverage (Bradley, Jarrell and Kim (1984), Long and Malitz (1985), Titman and Wessels (1988), Fama and French (2002)).

My focus on industry patents offers several differences with previous studies. First, technological innovations as measured by patents represent successful R&D expenditures. In other words, patents measure outcomes, while R&D expenditures measure effort intensity. Second, R&D expenditures have typically been used to proxy also for options, investments and the degree of asset tangibility, as well as innovation intensity. Third, more than 55% of Compustat firms (and 15% of patent recipients) do not report R&D expenditures – in contrast, patent data is disclosed by the USPTO. These arguments and findings imply that patent data is better suited than R&D data to study the relationship between technological innovations and capital structure. Moreover, I explicitly distinguish between the industry effects and the individual effects of technological innovations on capital structure. Finally, I examine how leverage changes in response to innovation and, to the extent that new securities are issued, whether the proceeds are actually used to increase capital expenditures.

The recent surge in patenting activity has caught the attention of academics and practitioners alike. This has led the former to conclude that a "technological revolution" took place in most U.S. industries in the 1990s (Kortum and Lerner (1998)). At the same time, it is well known that financing decisions of firms are affected by industry characteristics, but it is not entirely clear how and why this is the case (Myers (2003)). Therefore, it is natural to ask whether the large variation in patenting activity, both across industries and over time, helps explain the cross-section and time series of capital structure and financing decisions of firms.

I show that the number of patents in the industry is associated with more firm-level equity issues and reduced leverage, even after I control for R&D. Firms in industries with more patents issue more equity at a given point in time. Importantly, a firm's propensity to issue equity increases only with industry patents, not the firm's own patenting activity. This effect is strongest for secondary equity offerings (SEO), although IPOs, too, are associated with industry patents. The economic magnitude of the effect is large. A ten percent increase in industry patents is associated with a 2.9 percent increase in equity issues as a proportion of assets. This effect is also strong after patent spikes, but not driven by patent spikes.

There are three main views as to why technological innovations should be related to subsequent equity issues and reduced leverage. First, technological innovations may signal new investment opportunities and therefore require more equity finance to avoid debt overhang problems (Myers (1977)). Second, technological innovations may call for more financial slack, for two different reasons. Patents may correspond to a reduction of information asymmetry. As a result, equity goes up in the pecking order of external financing (Myers and Majluf (1984)). Alternatively, technological innovations may negatively affect a firm's competitive position and therefore call for more financial slack (Telser (1966) and Bolton and Scharfstein (1990)). Third, technological innovations may act as a catalyst for investor sentiment, pushing up stock prices and prompting firms to issue equity when stock prices are high.

Consider first the view that patents signal growth opportunities. This view implies that industry patents, and particularly equity issuance following industry patents, should be associated with increased subsequent investment. In contrast, the other views imply that industry patents and equity issuance are associated with increased cash reserves. Therefore, I examine the uses of funds next.

I find that industry patents are associated with little subsequent investment. If anything, such a relationship is negative. Similarly, I find little association of industry patents with alternative uses of funds such as dividends, acquisitions, R&D or advertising. However, I find that industry patents are associated with increased cash reserves. These findings hold true, even when I focus on equity issuance following industry patents. Specifically, I instrument equity issues with industry patents, and in second stage regressions I show that equity issues are then channeled into increased cash reserves, and not into capital expenditures. These results are inconsistent with the view that industry patents proxy for growth opportunities.

I examine next some cross-sectional predictions of the asymmetric information and product market competition theories. I find little evidence consistent with asymmetric information theories. In particular, these theories should explain why industry patents reduce firm-level asymmetric information, but a firm's own patents do not. In contrast, I find some evidence that industry patents are associated with increased competitive pressure and reduced gross margins. However, the finer cross-sectional predictions of product market competition stories, namely that gross margins should be reduced more when competition is strongest, are not borne out in the data.

Finally, the product market competition and the asymmetric information views predict that no mispricing is associated with patents. In contrast, the investor sentiment view predicts that patents are associated with overvaluations, and that firms issue equity to take advantage of such high valuations. Therefore, I examine stock returns subsequent to patenting. First, I find that patenting firms earn *positive* subsequent abnormal returns, up to a monthly alpha of 0.43 percent after I control for the four factors of Fama and French (1996) and Carhart (1997). This finding is consistent with the idea that investors underreact to corporate events such as patent grants. In contrast, when studying portfolio returns at the aggregate level of the 43 non-financial Fama and French (1997) sectors, I find some evidence that industries in the top quartile of patent growth earn lower subsequent returns than industries in the bottom quartile. This latter result suggests that the market overreacts in the aggregate time series. Industries earn low returns after patent spikes. However, further tests are not able to discriminate whether low returns are associated with equity issues or industry patents.

Taken together, these results are consistent with the view of technological innovations as a catalyst of investor sentiment. Industries experience large equity issues after an abnormal level of patents, and earn low subsequent returns. As a result, such industries are considered "hot". Within industries, however, the equity-issuing firms are those with fewer or no patents. Had patent recipients issued equity, they would have done so at low valuations and would therefore have lost money.

These results suggest a story of limited attention by individual investors, who are slow to incorporate information about individual firms, but in the aggregate become too excited about particular industries at particular points in time.

On the other hand, my findings that patenting firms have lower leverage, cut retained earnings, pay more dividends, make more acquisitions, cut short term debt and working capital, and invest more in R&D collectively suggest that patenting firms are very successfully growing ones that do not resort to external capital markets because of their high internal cash flows, consistent with the view of Myers (1977, 2003).

This paper makes three main contributions. First, it shows that industry factors such as technological innovations affect firms' financing decisions, over and above firms' characteristics. Previous literature has focused instead on firms' characteristics controlling for industry factors only indirectly, for example by fixed effects (see Harris and Raviv 1991 and Myers 2003 for reviews).

Second, I develop an instrumental variable estimation that links the funds raised in response to exogenous factors such as industry patents to their subsequent use. In particular, I show that the equity issued after industry patents is channeled into cash reserves. This methodology allows researchers to trace the flow of funds inside the firms, eventually linking them to stock returns. Previous research within the field of corporate finance has typically looked at financing or investment separately, or alternatively, at asset pricing; providing only indirect links between the two sides of the balance sheet and subsequent stock returns. Instead, as it is now acknowledged (for instance, see Shleifer (2000)), stock markets can have important implications for optimal corporate financing and investment policies, and should therefore be studied jointly. More specifically, previous studies[1] find a negative association between firm-level R&D expenditures and firm-level book and market leverage, interpreting their findings in terms of strong growth opportunities for high R&D firms. However, those studies examine neither leverage changes, nor uses of funds, to the extent that new securities are issued.

Third, I document a new asset-pricing anomaly, that is, patenting firms earn high positive subsequent returns. This finding fits well with the literature on

[1] Bradley, Jarrell and Kim (1984), Long and Malitz (1985), Titman and Wessels (1988), Fama and French (2002).

underreaction to corporate news.[2] My findings show that investors do underreact to patent grants.

This paper is also related to a body of literature in industrial organization, reviewed for instance in Hall, Jaffe and Trajtenberg (2004), finding that patents are a positive determinant of market valuations of firms, even after one holds R&D expenditures constant.[3]

The next section describes competing hypotheses of the effects of technological innovation on capital structure, Section II describes the data, Section III presents the empirical results, Section IV discusses alternative explanations, and Section V summarizes and concludes.

I. The Competing Hypotheses

This paper addresses two related questions. First, how does technological innovation affect a firm's financing choices? Second, what are the sources of these effects? In this section I summarize the existing theory and its implications for these two questions.

A. Technological Innovations May Imply Lower Leverage

There are three main reasons why technological innovation could imply lower leverage.

First, technological innovation may imply reduced leverage because it comes with and signals strong investment opportunities (Myers (1977)). For example, non-patenting firms may need to invest to catch up with patenting ones. Alternatively,

[2] Other papers in this literature include Ball and Brown (1968) and Bernard and Thomas (1989) on earnings announcements, Miles and Rosenfeld (1983) and Cusatis, Miles and Woolridge (1993) on spinoffs, Lakonishok and Vermaelen (1990) and Ikenberry, Lakonishok and Vermaelen (1995) on share repurchases, Michaely, Thaler and Womack (1995) on dividend initiations and omissions, Eberhart, Maxwell and Siddique (2004) on unexpected R&D expenditures increases, and Kadiyala and Rau (2004) on various corporate events.

[3] There is also a body of literature studying the effects of R&D expenditures on stock returns (Chan, Martin and Kensinger (1990), Chan, Lakonishok and Sougiannis (2001), Eberhardt, Maxwell and Siddique (2004)). The evidence is mixed. Chan, Martin and Kensinger (1990) posit that R&D expenditures are likely to be more beneficial for high-tech firms than for low-tech firms. Chan, Lakonishok and Sougiannis (2001) do not find any significant relation between R&D intensity and subsequent abnormal stock returns, consistent with the efficient market hypothesis. In contrast, Eberhardt, Maxwell and Siddique (2004) find that unexpected R&D increases are associated with high abnormal returns and high abnormal operating performance, and interpret the findings as consistent with the idea that investors underreact to corporate news.

technological innovation may make assets in place obsolete, and make investment necessary to replace them.

Second, technological innovation might imply reduced leverage because it may require more financial slack. For example, because a new technology is more difficult to evaluate, it increases the asymmetric information problem at the industry level. As a result, firms may need to build up more financial slack, consistent with pecking order theory (Myers (1984) and Myers and Majluf (1984)). This channel predicts that firms reduce leverage by increasing the proportion of retained earnings, rather than by issuing new equity. On the other hand, industry patents could represent the *end* of asymmetric information, rather than the beginning, in which case a pecking order channel would predict reduction of leverage via equity issues. Alternatively, technological innovation may make product market competition tougher (Alchian 1950), and therefore require firms to build financial slack to be better able to compete and survive against predatory threats (Telser (1966) and Bolton and Scharfstein (1990))[4]. Also, technological innovation may make the assets in place worth less as collateral.

Finally, technological innovation may imply reduced leverage because industry patents may act as a catalyst for investor sentiment. The arrival of a new technology might be associated with overvaluations. Therefore, it may be a good time to issue equity (Malkiel (2003), Kindleberger (1996)). Note that here, unlike in the previous examples, it is crucial that the reduction of leverage occurs through new equity issues, rather than managing retained earnings.

B. Technological Innovations May Imply Higher Leverage

On the other hand, there are reasons why technological innovation may imply increased leverage.

First, technological innovation may imply strong investment opportunities. If firms follow pecking order, these investments will require outside *debt* finance.

Second, technological innovation may create overcapacity, and determine the need to restructure or exit. Therefore, one should expect industry patents to be associated with increased leverage and reduced financial slack (Jensen (1989, 1993)).

[4] Other papers exploring related issues are Titman (1984) and Maksimovic and Titman (1991).

Third, technological innovation may imply increased leverage because it may require less financial slack. For example, technological innovation may make product market competition tougher (Alchian (1950)), but require the reduction of financial slack because of the option-like payoff of leveraged equity (Brander and Lewis (1986), Rotemberg and Scharfstein (1990), Maksimovic (1988)). Note that here, unlike in the previous example, an increase in product market competition implies a positive correlation of industry patents and firm's leverage.[5]

II. Data Description and Construction of Variables

The primary data used in this analysis is an unbalanced panel of Compustat firms over the years 1970–1999, matched with the NBER's patent citations data file (summarized in Hall, Jaffe, and Trajtenberg (2001), and Jaffe and Trajtenberg (2002)). This database links patent data from the U.S. Patent Office to Compustat.

Table AI in the Appendix reports statistics for every year from 1970 to 1999 and illustrates several features of the data. The Table shows that the distribution of firms by patent grants is right-skewed, and that except for the first two years in the sample, the 70th percentile of the distribution is zero. One notable feature is that the proportion of matched firms is monotonically shrinking over the sample period. In 1990, only 10% of firms in the sample are recorded as having at least one patent grant, as compared with 30% in 1970. At the same time, the mean and the maximum of the distribution decrease from 1970 to 1980, and then pick up again until 1999. In other words, while the pool of matched firms has gone down, today's recipients are awarded more patent grants.

These findings probably reflect the facts that the match was done for the 1989 Compustat file, the composition of patents is rapidly changing and enforcement costs of patents for firms have gone down (see Jaffe and Lerner 2004 on this latter issue).

[5] Yet another channel through which innovation may matter is through increased (expected) profitability. An increase in (expected) profitability could have different implications according to different theories. Static trade-off theory implies that increased profitability reduces costs of distress, hence should be associated with lower equity (however see Strebulaev (2004), and Hennessy and Whited (2004), on dynamic trade-off theories). Pecking order theory (Myers and Majluf (1984), Myers (1984)) says that increased profitability reduces asymmetric information, hence should be expected to be associated with lower leverage and more equity – see Harris and Raviv (1991) and Myers (2003) for a full review of capital structure research. Therefore, to isolate the effects of technological innovations, in the empirical analysis below I control for profitability in a variety of ways.

In particular, the percentage of patents matched is quite high up until the late 1980s, hovering around 70%. Indeed, the technological composition of patents has changed quite drastically since the mid-1980s, with traditional fields declining to less than 50% of all patents. As Hall, Jaffe and Trajtenberg (2001) recognize, it is quite likely that these changes have been accompanied by a large turnover in the composition of assignees, with many of the new entrants not yet traded by 1989, the year of the match.[6] In addition, many entities patent not under their own names, but under those of subsidiaries. In turn, these subsidiaries may change as units are acquired and divested, but again no adjustment is made in the Compustat-NBER concordance. These features imply that the data is best suited for studying the cross-sectional determinants of leverage and financing, while an analysis of the deeper dynamic forces linking financing and innovative activity will have to await future research.[7]

Panel A of Table I reports the number of firms per patent class, where patent classes are defined for any year for firms that are granted 0, one to two, three to ten, eleven to one hundred, and more than one hundred patents. One purpose of this table is to construct portfolio breakpoints for the empirical analysis on stock returns below, whereby firms-years with zero patents represent roughly 80% of the sample, firms-years with one to two patents and three to ten patents about 7% each, and firms-years with eleven to one hundred patents about 5%. The remaining one percent of the sample comprises firms-years with more than one hundred patent awards. Although the breakpoints change over time, as noted above, alternative definitions of breakpoints do not affect the results. The definition reported has been chosen to facilitate the economic interpretation of the results.

Summary statistics for the sample are then presented in Panel B of Table I and in Table AII. The tables report conditional means and medians, tenth and ninetieth percentiles for all variables in all patent classes. The last column reports unconditional statistics. All variables are winsorized at the 1st and 99th percentiles to

[6] This aspect of the matching process implies that there is potentially a selection bias in the post-1989 data, in that patenting firms show up as non-patenting ones. This feature of the data could have two main implications for my empirical analysis below. First, if patents do indeed matter for financing, it biases against finding any results. Second, results for the 1990s might not be comparable with previous ones. As a result, in the empirical analysis below I re-estimate all regressions for different time-periods, before 1989 and after. I find that my results are similar across different time periods; hence I conclude that this is not a serious problem for my analysis below. I thank Bronwyn Hall for clarifying these aspects of the data in personal communication.

[7] Kortum and Lerner (1998, 2000) study the *aggregate* pattern of patenting and innovation, and the contribution of venture capital to innovation, in time series analysis.

protect the results from the influence of extreme outliers.[8] Panel B of Table I summarizes financing and investment variables for the firms in my sample, by number of patents granted to the firm. I define book debt as total assets (Compustat Annual Item 6) minus book equity. I define book equity as total assets less total liabilities (Item 181) and preferred stock (Item 10) plus deferred taxes (Item 35) and convertible debt (Item 79). When preferred stock is missing, it is replaced with the redemption value of preferred stock (Item 56). I then define book leverage as total debt to total assets, and drop firm-year observations when the resulting book leverage exceeds one. I define market leverage as book debt divided by the result of total assets minus book equity plus market equity. Market equity is defined as common shares outstanding (Item 25) times price (Item 199). These definitions follow Fama and French (2002). After that, using the identity that book equity equals balance sheet retained earnings plus paid-in share capital, I define net equity issues (e/A) as the change in book equity minus the change in balance sheet retained earnings (Item 36) divided by assets. Finally, I define newly retained earnings (ΔRE/A) as the change in retained earnings divided by assets, and net debt issues (d/A) as the residual change in assets divided by assets. These definitions follow Baker and Wurgler (2002).

Panel B of Table I illustrates that patenting firms have lower market leverage than firms with no patents. Median market leverage for firms-years with zero patents is 41%, as compared with 39% for firms-years with one to ten patents, and 38% for firms-years with more than 100 patents. This pattern is also true for book leverage for firms with less than 100 patents. However, firms with more than 100 patents have higher book leverage. Strikingly, patenting firms issue less equity than non-patenting firms. Median net equity issue for non-patenting firms is 0.60% (mean 4.5%), while the corresponding values for patenting firms are 0.50% (mean 2%). These differences between patenting and non-patenting firms are all statistically significant at 1% level. Interestingly, the effect is mostly confined to the comparison between patenting and non-patenting firms; conditional on patenting, some variables such as market leverage appear to be monotonically decreasing in the number of patents, while others do not.

Panel B also shows statistics for the uses of funds variables. Capital expenditures (Item 128) have an unconditional mean value of 9.72%. Firms with less

[8] None of the results that follow are affected by winsorizing the variables.

than 100 patents per year invest less than firms without patents (about 8.5% as compared to 9.96), but firms with more than 100 patents invest more (11.22%).

Of particular interest is the R&D reporting and R&D expenditures of patent recipients. In my sample, about 15% of firms with patent awards report no R&D in the year of the award. This pattern is more pronounced among firms with one or two patent awards, where only 71% of patent recipients disclose some R&D. As expected, median R&D expenditures increase monotonically, going from 1.65% of assets for firms with one or two patent awards, to 5.38% for firms with more than 100.

Table AII in the Appendix reports also summary statistics for other variables including cash flows and valuation variables such as Tobin's Q.[9] I measure cash flows as the sum of earnings before extraordinary items (Item 18) and depreciation (Item 14). I measure average Tobin's Q as market value of assets divided by the book value of assets (Item 6) – where the market value of assets equals the book value of assets plus the market value of common equity less the sum of the book value of common equity (Item 60) and balance sheet deferred taxes (Item 74). Notably, patents recipients are more profitable. Firms with more than 100 patent awards have a median EBITDA of 16.59% as compared with 12.40% of firms without patent awards. Interestingly, even firms with one or two patent awards have a larger profitability of 14.84%. Finally, I report statistics for market-to-book and Tobin's Q in Table AII. Consistent with previous empirical literature, they show that market valuations are higher for patent recipients, although the relationship does not look monotonic.

Panel A of Table II shows the distribution of patenting firms by industry, excluding financials and utilities. It is clear from Table II that there is a large variation across industries, and that the largest patenting activity takes place in such industries as Chemicals, Pharmaceuticals, Machinery, Aircraft and Automobiles. In particular, 63% of aircraft and 50% of chemical firm-year observations are associated

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[9] Table AII also presents such variables as profitability and market-to-book, defined in the following section. These variable definitions overlap somewhat in that they are used for similar purposes in different contexts. For example, the capital structure literature focuses on profitability and market-to-book, while the investment literature focuses on cash flow and Tobin's Q. I follow these conventions in my capital structure and investment tests for comparability with previous studies. As a result, the definitions of investment variables follow Kaplan and Zingales (1997) and Baker, Stein and Wurgler (2003), while the definition of capital structure variables follow Rajan and Zingales (1995), Baker and Wurgler (2002) and Fama and French (2002). It turns out that neither of my empirical results is affected by either alternative definition.

with at least one patent, as opposed to 1.1% in Agriculture and less than 1% in precious metals. Table II also shows that there is large variation *within* industries, in that even in some of the most innovative industries up to 50% of the firm-year observations are without patents.

Panel B of Table II reports summary statistics at the industry-year level, where industry is defined at the 4-digit SIC code level. First, for each industry-year I compute medians of the relevant statistics, thus generating a population of industry-year medians. Then, Panel B of Table II reports medians, means, and tenth and ninetieth percentile of this population. The industry-level statistics in Panel B of Table II confirm the firm-level results in Table I that technological innovations as measured by patents are associated with lower book and market leverage. Median book leverage is 49.44% in industry-year observations with zero patents, as compared with around 46% in industries-years with a positive number of patents (the difference is statistically significant at 1% level). Median market leverage shows a similar pattern: it is 44.35% in industries-years with zero patents, around 43% in industries-years with one to ten patents, and around 39% in industries-years with more than ten patents.

Strikingly, the picture is now very different in relation to securities issuance. Medians equity issues are largest in 4-digit SIC codes characterized by more than 10 patents. In particular, conditional on patenting industry-level equity issuance is monotonically increasing in the number of patents. Median equity issuance in industries with more than 10 patents is 0.54%, as compared with 0.47% in industries with three to ten patents, and 0.42% in industries with one to two patents. These differences are statistically significant at the 1% level. Interestingly, median equity issuance in industry-years with zero patents is 0.51%, that is, smaller than that in industries with more than 10 patents, but larger than that in industries with less than 10 patents. The latter result is mostly driven by such scarcely populated industries as mining, precious metals and others. Those industries have one or two companies per year, rely greatly on new equity and are not associated to patenting. In fact, Panel B of Table II documents another striking feature of the data, that is, industry-year observations with at least one patent are more densely populated by firms, and the relationship is monotonically increasing in the number of patents. On average, there are 16 firms (median 8) in industries with more than 100 patents, as compared with 9 firms (median 4) in industries with ten to one hundred patents, with 5 firms (median

3) in industries with less than ten but at least one patent, and with 3 firms (median 2) in industries with zero patents. Collectively, these findings imply that equity issuance at the industry level is increasing in the number of patents, due both to greater reliance on equity issuance in industries with more than ten patents, and by the fact that industries with positive number of patents are also more densely populated by firms, and the more so the more patents in the industry.

Therefore, patents are associated with more new securities issuance at the industry level, that is, there are more security issuances in industries with more patents. However, it is non-patenting firms rather than patenting firms that issue new securities. One illustration of this pattern is the drugs industry (SIC code 2831) where Merck Laboratories was awarded consistently more than 100 patents per year over the period 1970-1999, with little or no new securities issuance. By contrast, most securities issuances in the industry were associated with such firms as American Monitor, Enzo Biochem, Vega Biotech and others that were never granted any patent over the same period.

Table III lists the five firms with more patent awards by year ("top five"). The Table shows a very consistent composition of the top five. From 1970 to 1985 General Electric leads the top five, with a total of 13,767 patent awards. From 1986 to 1992, it is Hitachi who leads the top five with 5375 awards. Finally, after a come back of General Electric in 1992, from 1993 to 1999, it is IBM who leads the top five, with a total of 12,772 patents. Overall, with more than 25,000 awards, IBM is the firm with the largest number of patent grants over the sample period, followed by General Electric with slightly above 24,000.

Collectively, Tables I to III and Table AI in the Appendix show that there is a very large variation of patenting activity, both over time and across industries. Moreover, while receiving less than 10 awards is an exceptional event for most companies, there is a large persistence in patenting activity among firms with more than 10 patent grants per years (i.e. these firms are "always the same"). More importantly, Tables I, II and III show that there are similar patterns of book and market leverage both across and within industries, but that patterns of financing arrangements across industries do not necessarily reflect patterns of financing arrangements within industries. In fact, across industries technological innovations are associated with large equity issuances in largely populated industry groups, while within those industries most equity issuance is associated with non-patenting firms. In the next section I examine these patterns in more formal regression analyses.

III. Results

In this section, I examine the relationship between patents and corporate financing. After that I examine the relationship between patents and various uses of funds such as investments, acquisitions, dividends, and R&D expenditures. To do so more directly, I then develop an instrumental variable estimation technique that links patents, corporate financing and the subsequent use of those funds raised after patent grants. Finally, I examine patents and subsequent stock returns.

A. Patents and Corporate Financing

The main focus of the analysis carried out in this section is to study the effects of technological innovations, as measured by patents, on corporate financing and leverage.[10] Consistently throughout the empirical analysis, I treat patents as accounting variables such as (very specific) intangible assets, that is, I focus on patent counts by grant year.[11] The main independent variables in the analysis that follows are thus the log of one plus the number of patents granted per industry-year *minus own patents*, and the log of one plus the number of patents granted per firm-year. I aggregate patents at the industry level for two main reasons. First, by doing so I am

[10] Therefore, patents measure the annual *changes in the knowledge stock* of firms (and industries). As a robustness check, I re-do the analysis using the levels of the knowledge stock, as measured by the number patents granted between the years *t–2* and *t–5*, with similar qualitative results.

[11] This choice represents somewhat a departure from previous research in Industrial Organization that used instead the number of ultimately successful patent applications filed each year, largely because it takes a variable amount of time to get a patent (median two years), which in turn is frequently a function of exogenous factors (e.g., the budgetary status of the patent office, see Griliches 1989). However, patent applications are not published and third parties have no notice of prior art before patents are actually awarded (see Jaffe and Lerner 2004 about a policy proposal to mandate publication of patent applications). Therefore, I choose to focus on the grant year. For the purpose of this study, I also do not consider patent citations, which have been shown to have a positive impact on market valuations in addition to R&D and patent counts (Hall, Jaffe and Trajtenberg 2004). However, the specific features of citations data require a paper on its own. First, citations are forward-looking, while for the purpose of studying stock returns it makes more sense to form portfolios based on the number of patents granted the previous year (i.e. showing up in the balance sheet) rather than on the number of citations these patents will receive in the future (obviously unknown at the time of the award). Further, citations data is very rightly skewed, with very few patents getting all the citations and the largest majority of patents never receiving one (Jaffe and Trajtenberg 2002 and Hall, Jaffe and Trajtenberg 2001).

able to separate industry effects from individual effects of innovation on financing. Second, one might be concerned that measurement error is strongest at the firm level. As a result, firm-level patent counts may capture innovative activity only imperfectly. In contrast, at the *industry* level patenting activity proxies well for the extent of innovative activity, as found for instance in Kortum and Lerner (2000).[12] Finally, I take logs because the distribution is rightly skewed, to ensure that the results are not driven by values in the right tail. Industry is defined as the same four-digit SIC code, and comes from the CRSP files.[13]

The main control variables are the four variables that Rajan and Zingales (1995) establish to be correlated with leverage in seven major industrialized countries. They are market-to-book, asset tangibility, profitability and firm size. Market-to-book may be related to investment opportunities, to market mispricing or both, and is defined as assets minus book equity plus market equity all divided by assets. Tangible assets may be used as collateral, and so may be associated with higher leverage. Asset tangibility is defined as net property, plant and equipment (Item 8) divided by total assets and expressed in percentage terms. As discussed in Section I above, profitability is associated with the availability of internal funds and thus may be associated with less leverage under the pecking order theory. This relationship may also arise from the tax advantage retention of earnings, or from a dynamic trade-off theory with adjustment costs. Another explanation is that profitable firms face more free cash flow problems á la Jensen (1986), calling for a higher level of leverage in equilibrium. Profitability is defined as earnings before interest, taxes and depreciation (Item 13) divided by total assets and expressed in percentage terms. Size may be associated with more leverage if large firms are less likely to enter financial distress. Firm size is defined as the logarithm of net sales (Item 12).

Further, I include four more variables that have been studied by Bradley, Jarrell and Kim (1984), Long and Malitz (1985), Titman and Wessels (1988) and more recently by Fama and French (2002), among others. These variables do not substantially overlap, and are defined as follows. Dividends over book equity may be

[12] In other words, one can think of industry patents as an instrument for technological innovation at the industry level.

[13] I use CRSP definition because CRSP keeps track of dynamic industries' changes for the entire sample period, as opposed to Compustat that only tracks the latest SIC code, and whose coverage of historical definitions has started only recently, going back only to the early 1990s. My results are not qualitatively affected by the use of Compustat definitions, however. Finally, I also compute patents at the more aggregate level of the 43 non-financial Fama and French (1997) sectors, with similar results.

an additional proxy for profitability. Dividends over book equity are common stock dividends (Item 21) divided by book equity. Dividends over market equity and research and development expenditures may be further proxies for investment opportunities. Dividends over market equity are common stock dividends divided by market equity. Research and development expenditure is R&D expenditures (Item 46) divided by assets. Depreciation expense may proxy for non-debt tax shields and so may be associated with lower leverage. Depreciation expense (Dp/A) is depreciation (Item 14) divided by assets. Table IV explores the effects of these variables on changes in book leverage and components.[14]

In the spirit of Fama and MacBeth (1973), I estimate year-by-year cross-section regressions, and then use Fama-MacBeth time series standard errors, which incorporate estimation error caused by correlation of the residuals across firms, to draw inferences about the average slopes.[15] I estimate Fama-MacBeth regressions to take into account both the cross-correlation problem and the bias in the standard errors of regression coefficients that arises because the residuals are correlated over the years. The resulting standard errors are then robust to heteroskedasticity (because there is no heteroskedasticity correction for a sample mean), and to autocorrelation up to four lags using the Newey and West (1987) procedure.[16]

Table IV shows that firms in industries with more patents reduce leverage at a given point in time (Panel A), and that they do so by issuing more equity (Panel B). Thus, Table IV confirms the findings in Tables II and I by showing that it is not patent recipients themselves who issue equity, but firms in the same four-digit SIC code.[17] Specifically, more industry patents are associated with subsequent larger net equity issues. Additionally, I find that own patents are mostly associated with increased newly retained earnings, and with a reduction in leverage associated with increased net debt issues. Table IV shows cross-sectional correlations of patents and changes in book leverage and components. An interesting question that it raises is whether these

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[14] I report results including the Rajan and Zingales (1995) main set of control variables. My results are robust to inclusion of the Fama and French (2002) control variables.

[15] In the case of no serial autocorrelation, the Fama-MacBeth procedure is equivalent to pooled cross-section time series OLS estimation with year fixed effects.

[16] Both book and market leverage, as dependent variables, are highly persistent, while changes in leverage is not. The choice of lags follows Fama and French (2002) and others who note that the first-order autocorrelation of the regression coefficients is between 0.4 and 0.7, and the autocorrelation for longer lags decay as an AR1 process. However, my results turn out to be robust to *any* alternative choice of lags, with the obvious limitation that my sample period is thirty years.

[17] My results are unchanged if I aggregate patents at the more aggregate level of the 43 non-financial Fama and French (1997) sectors.

patterns carry over when controlling for unobserved industry heterogeneity. In fact, industries may differ for their propensity to patent inventions, as the decision to apply for patent protection is affected by (possibly unobserved) industry characteristics. Hence, in Table V, I estimate OLS pooled cross-section time series regressions of firm-level changes in book leverage and components, controlling for industry fixed effects and time dummies. The results confirm and extend those in Tables II and IV. After more industry patents, firms reduce leverage and they do so by issuing more equity. However, it is not the patenting firms who issue more equity, but firms in the same four-digit SIC code. The economic magnitude of the effect is large. A ten percent increase in industry patents is associated with a 2.9 percent increase in equity issues as a proportion of assets.

Next, I examine whether the patterns documented in Tables I, II, IV and V systematically affect the cross-section of leverage. Table VI establishes that both patent recipients and firms in industries with more patents have lower leverage, and this is true both for book leverage and market leverage. Going from zero to one patent decrease book leverage by 0.62%, and market leverage by 0.89%. A ten percent increase in the number of industry patents is associated with lower book leverage of 5.6%, and lower market leverage by 7.4%. Columns 6, 7, 13 and 14 in Table VI show that the results are robust to the inclusion of the second set of control variables of Fama and French (2002) including R&D expenditures.

These results show that firms with more patents, and firms in industries with more patents, have lower leverage at a given point in time. Firms in industries with more patents issue more equity at a given point in time. Dynamically, after more industry patents, firms issue more equity. However, it is not the patenting firms who issue more equity, but firms in the same four-digit SIC code, or the same Fama and French sector.

To sum up, I find that a firm's level of book and market leverage are negatively associated with that same firm's own patents, and also negatively associated with industry patents. In the previous Tables II, IV and V, I find that only industry patents are associated with active rebalancing of capital structure through equity issues, resulting in reduced leverage. Industry patents are also associated with a reduction of the proportion of newly retained earnings, but this effect goes in the opposite direction of increasing leverage. In contrast, a firm's own patents are not associated with changes in that firm's leverage. Hence, in what follows I focus on the main result for corporate financing decisions, namely that firms issue equity and reduce leverage in response to more industry patents, but not to their own patents.

There are three main views explaining why technological innovations should be related to subsequent equity issues, making an industry "hot". First, technological innovations may signal new investment opportunities, as in Myers (1977), and therefore patents may call for more equity to reduce the debt overhang problem. Second, technological innovations may signal high industry quality, thereby reducing informational asymmetry. As a result, equity goes up in the pecking order of external financing, consistent with Myers and Majluf (1984). Alternatively, technological innovations may make product market competition tougher, and therefore require firms to build up more financial slack, consistent with the analysis of Telser (1966) and Bolton and Scharfstein (1990). Third, technological innovations may act as a catalyst for investor sentiment, pushing up stock prices and prompting firms to issue equity when stock prices are high.

The "investment opportunities" view implies that industry patents, and specifically equity issuance following industry patents, should be associated with increased subsequent investment. The other views predict that industry patents, and specifically equity issuance following industry patents, should be associated with increased subsequent cash reserves.

To discriminate between these views, in Section B below I examine the uses of funds subsequent to patenting and equity issues.

B. Patents and the Uses of Funds

A natural question arising from the results in Tables IV to VI is whether patents proxy for increased investment opportunities. One way to address this question is to estimate models of investment and other uses of funds, to establish the preferred subsequent use of funds by firms that are granted patents in the previous year.

Table VII shows clearly that patents are not associated with subsequent investment. In particular, both industry and own patents are associated with significantly *less* subsequent capital expenditures. On the other hand, industry patents are associated with subsequent increased cash holdings. There is some evidence that industry patents are associated with subsequent research and development expenditures, at least in the sub-sample of firms reporting R&D. Interestingly however, industry patents are not associated with subsequent own patents (if anything, such a relationship is negative). Also, own patents are associated with more acquisitions, more dividends, and reductions in working capital. There is some evidence that own patents are associated with subsequent R&D expenditures, but this finding does not hold in the sub-sample of firms reporting R&D, weakening its relevance. These findings suggest that the funds raised following industry patenting activity are mostly kept in cash holdings, and not spent otherwise.

To make the link between sources and uses of funds more precise, I then develop a novel instrumental variables estimation procedure. We know from Tables IV and V that firms issue more equity after firms in the same four-digit SIC code are granted patents. The identifying restriction is that industry patents affect uses of funds only through net equity issues. Therefore, I estimate a "two-stage least squares" model of the form:

$$\frac{I_{i,t}}{A_{i,t-1}} = \alpha_{2t} + \beta_{21} Q_{i,t-1} + \beta_{22} \frac{CashFlow_{i,t}}{A_{i,t-1}} + \beta_{23} \frac{EquityIssue_{i,t}}{A_{i,t-1}} + \upsilon_{i,t} \quad (1)$$

$$\frac{EquityIssue_{i,t}}{A_{i,t-1}} = \alpha_{1t} + \beta_{11} Q_{i,t-1} + \beta_{12} \frac{CashFlow_{i,t}}{A_{i,t-1}} + \delta_1 \left(IndustryPatents_{t-1} \right) + \varepsilon_{i,t} \quad (2)$$

The intuition is straightforward. In the first stage, that is equation (2), I estimate the proportion of new equity that is issued as a response to industry patenting activity.[18] In the second stage, I use the fitted value from the first stage to establish the use firms make of *precisely that equity issued after industry patents*.

The results are presented in Table VIII. Consistent with previous results, reported in Table VII, firms cut capital expenditures and keep in cash the funds raised after other firms' patenting activity. Notice that the coefficient of equity issues is now four times higher than in the investment regressions (again with a negative sign), and in the changes in cash reserves regressions estimated in Table VII. Interestingly, equity issuers are now associated with cuts in dividends and reductions of working

[18] One concern with instrumental variable estimations is that the instrument might be weak, resulting in a spurious correlation in second-stage estimates. For the case analyzed here, of a single endogenous regressor and a single instrument, Staiger and Stock (1997) suggest declaring the instrument to be weak if the *F*-statistic of the restricted first-stage is less than ten. The restricted first-stage estimated model is

$$Equity\ Issue_{i,t}/A_{i,t-1} = \underset{(.24)}{3.20} + \underset{(.08)}{0.31}\ IndustryPatents_{j-i,t-1}$$

and the *F*-statistic is 19.68. Hence, I conclude the instrument is unlikely to be weak. See Stock and Yogo (2004) for a recent treatment of weak instruments in linear IV regressions.

capital. Finally, and consistent with previous findings in Table VII, there is some evidence that industry patents are associated with subsequent research and development expenditures, at least in the sub-sample of firms reporting R&D, but equity issues are not associated with more subsequent own patents (if anything, such a relationship is negative). These findings confirm and extend the previous results in Table VII, suggesting that instrumental variable estimations linking sources of funds to their subsequent uses are able to disentangle the effects of interest from other, confounding ones.

I also perform a number of robustness checks. To address the possibility that firms, and particularly equity issuers, may not invest immediately, but wait a few years until positive NPV projects materialize, I re-estimate the capital expenditures regressions including lagged own patents and lagged industry patents, up until the fifth lag. The results are unchanged and not reported to save space. The coefficients on both lagged own patents and lagged industry patents are always negative, and some of them are statistically significant at conventional levels. I also address the possibility that industries may differ in that patents may actually proxy for investment opportunities, but only in some sectors and not in others. Therefore, I break down the results on capital expenditures by the 43 Fama and French non-financial sectors. I find that own patents are associated with subsequent investment only in three sectors: Beer and Liquor, Tobacco Products, and Electronic Equipment. In contrast, industry patents (and equity issues) are associated with subsequent investment in only two sectors: Aircraft and Retail.

The results in this section rule out explanations of the relevance of industry patents as proxies for growth opportunity. My results so far are in accord with a product market competition view, whereby firms build up financial slack to face increased competition. This view is consistent with the theories of Telser (1966) and Bolton and Scharfstein (1990). Dynamic models of asymmetric information could also explain my results so far. These models can produce market-timing behavior if there are time-varying issuance costs and firms manage slack in a dynamic fashion. As a result, firms issue equity when valuations are high, for example to time market liquidity (as opposed to timing investor sentiment).[19] Finally, my results are also consistent with Stein (1996), who argues that firms should issue equity when stock

[19] However, this view should explain why industry patents reduce firm-level asymmetric information, but firms' patents do not. This view is discussed in greater detail in Section IV below.

prices are high. Furthermore, Stein (1996) argues that the proceeds of equity issues should not be automatically channeled into new capital expenditures if no positive NPV opportunity is available. These views imply different predictions for stock returns. Both product market competition stories and dynamic pecking order theories imply that stock markets are efficient, in the sense that stock returns of patenting firms reflect compensation for risk factors. Instead, the view that patents act as a catalyst for sentiment predicts that patents are associated with irrational valuations, so that it is a good time to issue equity for non-recipients, but not for patent recipients. To probe deeper into the relative validity of these views in relation to my findings, I examine stock returns in the following section.

C. Patents and Subsequent Stock Returns

In this section, I examine stock returns subsequent to patent grants. Most research of this kind uses event-study methodology, where firms' stock returns are analyzed following the announcement of the patent award. However, such studies face the difficulty that the market systematically anticipates patent grants (Austin 1993, Lerner 1997), and the further difficulty associated with proper performance measurement at long horizons in event time (Barber and Lyon 1997, Mitchell and Stafford 2000). I avoid these difficulties by taking a calendar-time approach, forming portfolios of firms that are granted patents in year $t-1$ and studying their subsequent stock returns in year t. As a preliminary analysis, in Table AIII in the Appendix I examine the joint distribution of the number of patents and the size of market equity, using NYSE quintiles. Conditioning on the number of patent granted, firms with less than 10 patents are more often small than large. The opposite pattern emerges for firms with more than 10 patent grants. In Table AIV I then examine the joint distribution of firms by patents and book-to-market equity. Conditional on book-to-market, the distribution is monotonically decreasing. For each patent class, high book-to-market firms earn higher returns than low book-to-market firms. In Table AV, I examine the joint distribution of the subset of patenting firms by size and book-to-market. I find that two patterns emerge, namely, small, high book-to-market ("value") firms and large, low book-to-market ("glamour") firms are the most frequent patenting firms. Combining this finding with previous tables, it appears that, conditional on patenting, small, "value" firms are likely to be granted less than 10 patents per year, and large, "glamour" firms more than 10 patents per year. As a result, it is unlikely that in my study of performance attribution I will uncover known patterns of the cross-section of returns, such as the fact that small, "glamour" firms earn low subsequent returns, as documented for instance by Fama and French (1996).

I then study the performance of patenting firms. An investment of $1 in the (equally-weighted) largest patents portfolio on July 1, 1971, rebalanced yearly, would have grown to $83.57 by June 30, 2001. In contrast, a $1 investment in the benchmark portfolio of non-patenting firms would have grown to $60.05 over the same period. This is equivalent to annualized returns of 15.90% for the largest patents portfolio and 14.62% for the non-patenting portfolio (and can be compared with the market return over the same period of 12.78%). A natural question that arises is whether this disparity can be explained by differences in risk or "style". In fact, while it is perhaps hard to believe that firms that are granted more than 100 patents have higher *idiosyncratic* risk, it is possible that these return differences can be systematically explained by co-movement with other factors. In particular, in addition to differences in exposure to the market factor ("beta"), a firm's market capitalization (or "size"), book-to-market ratio (or other "value" characteristics), and prior returns ("momentum") have all been shown to significantly forecast future returns. If the largest patents portfolio differs significantly from the benchmark portfolio in these characteristics, then "style" differences may explain at least part of the difference in annualized returns. Several methods have been developed to account for these "style" differences in a system of performance attribution. I estimate the four-factor model of Carhart (1997) by:

$$R_t = \alpha_t + \beta_1 RMRF_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 Momentum_t + \varepsilon_t \quad (3)$$

where R_t is the excess return to some asset in month t, $RMRF_t$ is the month t value-weighted market return minus the risk-free rate, and the terms SMB_t (small minus big), HML_t (high minus low), and $Momentum_t$ are the month t returns on zero-investment factor-mimicking portfolios designed to capture size, book-to-market, and momentum effects, respectively. Although there is ongoing debate about whether these factors are proxies for risk, I take no position on this issue and simply view the four-factor model as a method of performance attribution. Thus, I interpret the estimated intercept coefficient, "alpha," as the abnormal return in excess of what could have been achieved by passive investments in the factors.

The first row of Table IX, Panel A, shows the results of estimating (3) where the dependent variable R_t is the equally-weighted monthly return of the largest patenting firms portfolio (i.e. those with more than 100 patent grants in the previous year). For this specification the alpha is 43 basis points (bp) per month, or about 5.2 percent per year. This point estimate is statistically significant at the 1 percent level. The second, third and fourth rows of Table IX, Panel A, show the results of estimating (3) where the dependent variable R_t is the monthly return of firms that have received ten to one hundred, three to ten, and one to two patent grants, respectively. For all these specifications the alpha is 28 basis points (bp) per month, or about 3.36 percent per year. These point estimates are also statistically significant at the 1 percent level. The fifth column of Panel A shows the results for the benchmark portfolio, earning a positive but insignificant alpha of 0.12.

Panel B of Table IX shows the results for value-weighted returns. The first row of Panel B shows the results for the portfolio of firms with more than 100 patents per year. For this specification the alpha is 27 basis points (bp) per month, or about 3.3 percent per year. This point estimate is statistically significant at the 1 percent level. Next, the second row shows the results for the portfolio of firms with 10 to 100 patents per year. For this specification the alpha is 22 basis points (bp) per month, or about 2.6 percent per year. The third and the fourth row show the results for the portfolio of firms with less than 10 patents. For these specifications the alpha is still positive, but insignificant. Overall, the results for value-weighted portfolios confirm the findings for equally weighted portfolios, although the economic magnitude is lower.

I perform several robustness checks. I run Fama-MacBeth regressions, both with annual returns and monthly returns, and I find that own patents (but not industry patents) are associated with high subsequent results. Interestingly, the breakdown of different time periods shows that my results are stronger in the second half of the sample period, that is, from 1986 to 2000 (equally weighted alphas up to 0.50). At longer horizons (two and three years holding periods), alphas become statistically insignificant for portfolios of firms with less than 10 patents. However, alphas do remain positive and significant for firms with more than 10 patents, consistent with the findings in previous sections that there is a strong persistence in patenting for firms with more than 10 patents per year.

Overall, my findings are consistent with the notion that investors underreact to news about corporate events, as documented in previous studies by Ball and Brown (1968) and Bernard and Thomas (1989) on earnings announcements, Miles and Rosenfeld (1983) and Cusatis, Miles and Woolridge (1993) on spin-offs, Lakonishok and Vermaelen (1990) and Ikenberry, Lakonishok and Vermaelen (1995) on share repurchases, Michaely, Thaler and Womack (1995) on dividend initiations and omissions, Eberhart, Maxwell and Siddique (2004) on unexpected R&D expenditures increases, and Kadiyala and Rau (2004) on various corporate events. My findings show that investors do underreact to patent grants. These findings show that, if own patents were associated with subsequent equity issues, equity issuers would have lost money following the stock price increase. Therefore, these findings may help explain why patent recipients are not associated with subsequent equity issuers, but do not speak directly to my previous finding that industry patents are associated with equity issues. In particular, we already know that equity issues coincide with high valuations and low subsequent returns, both in the aggregate and at the individual firm level.[20] Recently, aggregate corporate liquidity has also been found to forecast low subsequent market returns (Greenwood 2004). However, equity issuers and firms hoarding cash could earn low subsequent returns for reasons that have nothing to do with patents. Therefore, I next examine aggregate industry returns.

At the end of June of each year t (1971-2000), I sort 43 non-financial Fama and French (1997) equally weighted industry portfolios according to previous percent changes in industry patenting activity (Δ). Panel A of Table X reports average industry portfolio returns over years when previous Δ is small (bottom 25%), medium (25^{th} percentile to 75^{th} percentile), and large (top 25%), in addition to the differences between the averages. It also reports intercepts of regressions of portfolio returns on the excess market return (CAPM α), and the three Fama-French factors (FF3F α). The results in Panel A show that industries with a large run-up in patents underperform industries with a small run-up, but by a small and insignificant monthly 0.04.

[20] See Baker and Wurgler (2002) and references therein.

The intuition is that industries with a large run-up in patents may underperform compared to industries with a small run-up. However, this result is economically and statistically insignificant. One reason for this could be that one has also to control for the within-industry level of patents. As shown in Table II above, industries differ a lot in terms of their propensity to patent. Hence, we might expect that a large run-up in patents means different things if the *level* of patents is also high, and the industry is therefore experiencing a patent spike. I then intersect the previous Δ sorts with independent sorts based on the abnormal number of patents (ANP), and the returns are reported in Panel B. ANP is defined with respect to the within-industry distribution of patenting activity, and can be high (top 25%), regular (25^{th} percentile to 75^{th} percentile), and low (bottom 25%). This procedure is equivalent to de-meaning the number of spikes within industries. Panel B also reports intercepts of regressions of portfolio returns on the excess market return (CAPM α), and the three Fama and French factors (FF3F α). I find that a trading strategy that buys industries with small Δ and high ANP, and contemporaneously sells industries with large Δ and high ANP, would have earned 0.40 basis points per month, with a CAPM α of 0.46. This result is not statistically different from zero, perhaps because such a strategy can be implemented in only 156 months out of the 348 months of my sample period, and therefore it has little statistical power. Yet, the economic magnitude of my result still indicates that industries in patent spikes earn low subsequent returns. Further, I find that a trading strategy that buys industries with small Δ and intermediate ANP, and contemporaneously sells industries with large Δ and intermediate ANP, would have earned 0.28 basis points per month, with a CAPM α of 0.32 and a Fama and French α of 0.33. This result is strongly statistically significant and the economic magnitude is large. Its magnitude is unchanged even after I control for the Fama and French factors, and the t-statistic is 1.98. Figure 1 provides a joint illustration of the results in Tables IV, V and X. Industries with a high level of patents and a large previous run-up in patents (i.e. industries in a *spike* in year $t-1$), together with industries with a medium level of patents and a large run-up in patents in year $t-1$, experience large subsequent equity issues from January to December in year t, and earn low returns from July of year t to June of year $t+1$. Thus, the results in Table X suggest that in the time series industries may overreact to large patent run-ups. However, the result is not robust when increasing the holding period of industry portfolios at two or three years. Also, further tests are not able to discriminate whether low returns are associated with equity issues or industry patents, perhaps because, as it is well known, there is little evidence of low returns for equity issuers in calendar time (Fama 1998).[21]

To conclude, although the evidence of low industry returns after patents run-ups is arguably weak, there are two main reasons why the view of technological innovations as a catalyst for sentiment may help explain all of the findings in a parsimonious way. First, there are large equity issues in industries with many patents, and the equity issuers are not the patent recipients themselves. As my results in Table IX show, had patents recipients issued equity, they would have done so at low valuations and would have lost money from the subsequent stock price increase. Second and not unrelated, in the cross-section non-patent-recipients are valued more than patent recipients, again based on my results in Table IX. As a result, it is good timing to issue equity for non-patent-recipients as opposed to patent recipients.

IV. Discussion

My results show that industry patents are positively associated with equity issues at the firm level, and with reduced leverage. Subsequently, I find that equity issuers do not invest, but keep the proceeds in cash. Then, I find that patent recipients earn positive abnormal returns. Finally, I find that industry portfolios earn low returns after patent spikes. These findings are consistent with the view that technological innovations such as patents act as a catalyst for investor sentiment. In particular, these findings suggest a story of limited attention of individual investors, who are slow to incorporate information about individual firms, but in the aggregate become too excited about particular industries at particular points in time.

On the other hand, my findings that patenting firms have lower leverage, cut retained earnings, pay more dividends, make more acquisitions, cut short term debt and working capital, and invest more in R&D collectively suggest that patenting firms

[21] In an effort to separate the two effects, I study stock returns conditioning on having zero patents (untabulated), but I find no significant difference between equity issuers and non-equity issuers. One possibility is that differences in stock returns between equity issuers and non-issuers are not captured in calendar time on an annual basis, because of large intra-year variation in issuance and patenting activity.

are very successfully growing ones that do not resort to external capital markets because of their high internal cash flows, consistent with the view of Myers (1977, 2003).

This section asks whether the evidence on industry patents, equity issues and stock returns can also be interpreted in light of theories of asymmetric information and product market competition, and tests some of the distinctive and specific predictions of both views.

A. Pecking Order Theory

The findings in Sections IIIA and IIIB above show that industry patents are associated with firm-level equity issues. In turn, equity issuers do not invest but keep the proceeds in cash, in what appears to be market-timing behavior in equity issues prompted by the number of patents in the industry. It is well established that dynamic theories based on adverse selection, along the lines of Myers and Majluf (1984), can produce market-timing behavior if there are time-varying issuance costs and firms manage financial slack in a dynamic fashion. To account for my findings, however, these models should address the somewhat counterintuitive fact that it is not patents recipients that issue equity, but firms in the same industry. That is, these theories should explain why industry patents reduce asymmetric information, but firms' patents do not.

However, as it has been increasingly acknowledged recently, asymmetric information theories should be more important for firms that are more likely to suffer from adverse selection problems, namely small, "value" (high book-to-market) firms, as suggested by Myers (2003) among others. To investigate this possibility, I form two independent sorts according to size and book-to-market quintiles. Then, for each of the 25 sub-samples I estimate the following equation

$$\frac{EquityIssue_{i,t}}{A_{i,t-1}} = \alpha + \beta\left(RZ_{i,t-1}\right) + \gamma\left(OwnPatents_{t-1}\right) + \varepsilon_{i,t} \tag{4}$$

where $RZ_{i,t-1}$ is the vector of Rajan and Zingales controls defined above, and γ is the coefficient of interest. Table AVI in the Appendix reports the estimated γ coefficient of equation (4) above for each of the 25 sub samples. Consistent with the hypothesis, own patents are associated with equity issues for small, "value" firms – but only for them (about 10% of firm-year in the sample). From these findings, I conclude that an asymmetric information view is unlikely to explain the generality of the findings.

B. Product Market Competition Theories

This section tests specific predictions of the product market competition view of industry patents. If industry patents affect corporate financing because they proxy for increased competition, then industry patents should negatively affect measures of operating performance, or of the market valuation of firms. More specifically, if firms issue equity in response to increased competition as proxied by industry patents to build up financial slack, then we would expect such slack to finance the reduced operating performance of firms. Similarly, if industry patents proxy for an increase in competition, then we would expect market valuation of firms to respond negatively to industry patents (but positively to own patents – as documented by the literature, see e.g. Hall, Jaffe and Trajtenberg 2004).

Table AVII in the appendix presents the results of pooled cross-section and time series OLS regressions where the dependent variables are gross margins, defined as sales minus cost of goods sold divided by assets, and Tobin's Q. Column one of Table AVII shows that industry patents are negatively correlated with gross margins, but the relationship is only statistically significant at the ten percent level. Interestingly, own patents are strongly positively associated with gross margins. Column five of Table IX shows that industry patents are not associated with Tobin's Q. In contrast, own patents are positively associated with Tobin's Q.

These results are only weakly supportive of the product market competition view. However, the weak statistical association of industry patents and gross margins, and of industry patents and Tobin's Q, could arise under a very different scenario. In fact, the nature of product market competition could be very different in different industries. Sundaram, John and John (1996) find that the average stock market price reaction to announcements of unexpected increases in R&D expenditures by competitors is zero. However, they find that such absence of correlation in the full sample results from averaging out the positive effects of competitors' R&D in industries where firms accommodate competition with "strategic substitutes", and the non-positive effects of "tough" competition with "strategic complements".[22]

Hence, in an effort to probe deeper into the merits of the product market competition view, I construct an empirical measure of the nature of the competitive interaction, the Competitive Strategy Measure (CSM), based on the work of Sundaram, John and John (1996).

The argument is as follows. If competitors accommodate a firm's strategic move, then a firm's profit margins will co-move negatively with its competitors' output. This is because the firm is accommodating competition with "strategic substitutes". In contrast, if competitors match a firm's strategic move, a firm's profit margins will co-move positively with its competitors' output, because competition is escalating with "strategic complements".

To compute the CSM measure, my first step is to derive a firm's marginal profit. To do so, I consider the ratio of change in a firm A's net income (call it $\Delta\pi^A$) to change in its net sales (call it ΔS^A), i.e. the change in a firm's profit margin. The $\Delta\pi^A/\Delta S^A$ ratio measures the change in a firm's total profit as a function of its own output. Next, I derive the change in the competitors' output (call it ΔS^B). I now have two measures, $\Delta\pi^A/\Delta S^A$ and ΔS^B for the years before t. The coefficient of correlation between $\Delta\pi^A/\Delta S^A$ and ΔS^B is a direct proxy of the second derivative of profit with

[22] An example will clarify the intuition (the following discussion is based on Sundaram, John, and John (1996)). Consider two duopolistic firms (say, firm A and firm B) who are engaged in Cournot (i.e. quantity-setting) competition in their cost-reducing R&D expenditures. When firm A is granted a patent, it signals to its competitors that it has succeeded in lowering its costs, and hence increasing its profits (see, e.g., Spence (1984)). Such profit increases should then have a positive impact on A's operating margin and market valuation.

The actual profit of A depends on how firm B reacts to A's patent. If B accommodates A, then the net effect of increased R&D spending is to increase A's profits and market share, and in the process reduce B's profit and market share. In the oligopoly literature, this situation is referred to generically as competition in "strategic substitutes" (Bulow, Geanakoplos and Klemperer (1985)). Under this competitive scenario, the operating performance and valuation effects resulting from A's patent would be positive for firm A and negative for firm B.

But B's reaction to A's patent may not be accommodating: B can respond by increasing its own R&D spending, in an effort to obtain a patent. If this happens, then the profit and market share effects on A become ambiguous. For instance, if A and B are *ex ante* identical and B reacts to A's move by adopting an identical strategy, then both their costs would fall, output increase, and market shares remain the same as before – but industry profits may fall. This is because the joint higher industry output lowers industry prices. In the oligopoly literature, such a competitive scenario is referred to generically as competition in "strategic complements". The operating margin and market valuation effects resulting from A's patent would be at best ambiguous and could even be negative, depending on the specifics of market structure.

Thus what defines competition in strategic substitutes and complements is the sign of the change in marginal profits of each firm with respect to changes in both its own and its competitor's output. When the change in marginal profits is negative, competition is said to be in strategic substitutes; when the change is positive, competition is said to be in strategic complements.

respect to own quantity and the competitors' quantity, $\delta\pi^A/\delta q^A\delta q^B$. [This second derivative is the basis for the precise definition of strategic substitutes and complements; when it is less than zero, it defines strategic substitutes, and when it is greater than zero, it defines strategic complements; see Bulow, Geanakoplos and Klemperer (1985)].

Given this construction, when the CSM measure is less than zero, it corresponds to strategic substitutes; when it is greater than zero, it corresponds to strategic complements.

The above discussion leads to the following testable implications: Industry patents will be positively related to operating performance and market valuations for firms competing in strategic substitutes; for firms competing in strategic complements, the correlation could be negative or zero.

Columns two to four and five to eight of Table AVII show that this is not the case. My results show that the effect of industry patents on operating performances and market valuations is constant across sub-samples. Specifically, industry patents are (weakly) negatively associated with gross margins both in the sub-sample of firms competing with "strategic complements", i.e. when the CSM measure is greater than zero, and in the sub-sample of firms competing with "strategic substitutes", i.e. when the CSM measure is smaller than zero, and the coefficient does not statistically differ in the two sub-samples. Moreover, industry patents are not associated with Tobin's Q, neither in the full sample, nor in the sub sample of firms competing in strategic complements.

Thus, although the (weak) negative association of industry patents with gross margins is consistent with the product market competition view, I conclude that the product market competition view is unlikely to explain the generality of my findings.

V. Conclusions

Technological innovations as measured by patents are an important positive determinant of firms' market valuations. In this paper I assess empirically their implications for corporate financing, investments, and subsequent stock returns. I establish the following facts. Firms in industries with more patents issue more equity at a given point in time. This effect is also strong after patent spikes, and it is not driven by IPOs or by repurchases. Importantly, a firm's propensity to issue equity increases only with industry patents, not the firm's own patenting activity. When I turn to the uses of funds, I find no evidence that equity issuers increase investment or acquisitions. There is some evidence that equity issuers increase research and development, but no evidence that such R&D expenditures lead to more own patents. Instead, I find evidence of increased cash reserves. Finally, I examine stock returns. In the cross-section, I find that patenting firms earn high subsequent returns. In the time series, however, industries earn low returns after a patents run-up. These results are at odds with traditional explanations of patent grants as proxy for investment opportunity or signal to reduce information asymmetry. These results suggest a story of limited attention by individual investors, who are slow to incorporate information about individual firms, but in the aggregate become too excited about particular industries at particular points in time.

Although a behavioral story can account for the whole of my findings in a parsimonious way, it is also natural to ask whether a theory based on rational stock markets can account for my results. A first class of models, started by Berk, Green and Naik (1999), links growth options, optimal investment decisions and security returns and finds that cross-sectional and time series patterns of stock returns can be explained by dynamic learning about future growth options. However, since such learning crucially happens through subsequent investment, it is puzzling in light of these models to find that equity issuers do not subsequently invest.

Models based on dynamic asymmetric information seem to go some way towards an understanding of my findings. In particular, it is well established that dynamic theories based on adverse selection, along the lines of Myers and Majluf (1984), can produce market-timing behavior if there are time-varying issuance costs and firms manage financial slack in a dynamic fashion. To account for my findings, however, these models should address the somewhat counterintuitive fact that it is not patents recipients that issue equity, but firms in the same industry. That is, these stories should explain why industry patents reduce firm-level asymmetric information, but a firm's own patents do not.

More promisingly, the product market competition view seems to have more chances to explain the whole of my findings. According to this view, technological innovation changes the competitive arena. In particular, industry patents increase the competitive pressure prompting firms to build up financial slack so that they are less prone to predation by deep-pocket competitors. This view explains why firms reduce leverage, although perhaps one would expect such firms to build up slack by managing earnings retention rather than issuing equity. However, the most distinctive prediction of this theory, namely that industry patents reduce operating performance, is only weakly borne out in the data. Additionally, further predictions on the cross-sectional variation of competitive pressure are not borne out in the data. Finally, the product market competition view has little to say about stock market returns and mispricing.

To sum up, although theories based on rational stock markets can explain some sets of the facts that this paper has established, such theories have trouble accounting for all of the facts in a parsimonious way.

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TABLE I

Distribution of Patenting Firms and Summary Statistics

This table presents summary statistics. Panel A reports the number of firms by number of patents granted for each year between 1970 and 1999. Panel B reports summary statistics, both conditional on the number of patents and unconditional. Each entry reports the median, mean, tenth percentile, and the ninetieth percentile.

Panel A – Number of patenting firms by year

	0	1 – 2	3 – 10	11-100	>100	N. Obs.
1970	1034	159	194	166	36	1589
1971	1085	175	213	179	42	1694
1972	1800	257	276	189	41	2563
1973	1949	281	281	201	38	2750
1974	2029	280	299	186	42	2836
1975	2075	293	292	179	45	2884
1976	2060	275	262	162	43	2802
1977	2022	289	251	136	36	2734
1978	2119	283	233	136	35	2806
1979	2298	259	187	121	21	2886
1980	2270	281	184	131	30	2896
1981	2409	234	218	124	30	3015
1982	2492	259	192	129	27	3099
1983	2631	251	192	120	25	3219
1984	2627	260	194	113	34	3228
1985	2609	229	174	122	34	3168
1986	2747	245	176	111	28	3307
1987	2762	241	190	124	33	3350
1988	2691	194	198	125	27	3235
1989	2593	211	198	133	36	3171
1990	2587	201	201	125	32	3146
1991	2629	210	176	142	35	3192
1992	2795	187	193	142	32	3349
1993	3027	183	186	143	37	3576
1994	3109	180	170	149	37	3645
1995	3250	150	172	142	39	3753
1996	3336	144	173	131	39	3823
1997	3241	153	132	128	41	3695
1998	2963	111	119	135	50	3378
1999	2831	97	101	116	52	3197
Total	74070	6572	6027	4240	1077	91986

TABLE I – *Continued*

Panel B – Firm-level summary statistics, conditional on number of patents by firm and unconditional

	0	1 – 2	3 – 10	11 – 100	>100	Overall
Book Leverage	47.73	43.20	44.63	47.24	49.90	47.07
	47.12	43.74	44.39	47.71	50.97	46.77
	18.04	20.14	22.05	26.62	31.53	18.92
	74.86	66.95	65.39	69.09	72.12	73.65
Market Leverage	40.90	38.56	39.46	38.18	37.92	40.34
	41.99	40.05	40.50	39.52	38.77	41.61
	8.78	11.38	12.10	12.23	12.00	9.36
	76.71	71.33	70.60	68.85	65.99	75.62
Net Equity Issues	0.60	0.50	0.53	0.58	0.51	0.58
	4.55	2.43	2.18	1.52	0.84	4.07
	–1.87	–1.84	–1.83	–2.29	–2.97	–1.90
	15.03	7.13	6.87	5.18	3.65	12.82
Newly Retained Earnings	2.34	3.81	3.60	3.54	3.74	2.64
	–1.41	2.09	2.04	2.47	2.81	–0.71
	–16.00	–6.07	–5.03	–3.33	–2.27	–13.41
	10.29	10.37	9.25	8.94	8.55	10.14
Net Debt Issues	3.00	2.64	2.87	3.22	3.74	2.98
	3.89	3.12	3.52	3.75	4.00	3.81
	–10.57	–8.47	–7.08	–5.67	–3.78	–9.79
	21.03	16.29	15.99	13.57	12.63	19.83
Capital Expenditures	6.08	6.02	6.33	6.89	8.52	6.19
	9.96	8.52	8.54	8.49	11.22	9.72
	1.34	2.06	2.52	3.40	4.03	1.51
	20.58	16.20	15.54	13.87	18.35	20.58
Δ Cash	0.11	0.25	0.26	0.24	0.52	0.14
	2.05	1.65	1.44	1.45	1.79	1.95
	–8.65	–6.13	–5.26	–4.11	–3.42	–7.78
	11.84	9.35	8.47	7.28	7.33	11.01
Acquisitions	0.00	0.00	0.00	0.00	0.00	0.00
	5.94	4.11	4.94	6.92	7.38	5.81
	0.00	0.00	0.00	0.00	0.00	0.00
	19.45	7.58	10.71	30.22	57.59	17.85
Dividends	0.00	0.00	0.00	0.00	0.00	0.00
	0.97	1.07	1.45	2.05	2.44	1.14
	0.00	0.00	0.00	0.00	0.00	0.00
	3.12	3.72	3.90	4.82	6.52	3.35
R&D dummy	35.06	75.15	84.92	93.43	98.71	43.96
R&D Intensity	0.00	1.65	2.16	3.23	5.38	0.00
	2.68	3.85	4.25	4.78	6.45	3.01
	0.00	0.00	0.00	0.46	1.20	0.00
	9.49	10.93	11.18	11.08	12.11	10.05
N. Obs.	74070	6572	6027	4240	1077	91986

TABLE II

Distribution of Patenting Firms by Industry and Summary Statistics

Panel A presents the number of patenting firms by industry, where industry is defined as the same Fama and French (1997) 43 non-financial group. Panel B presents summary statistics by number of patents at the 4-digit SIC code level. First, a population of medians by 4-digit SIC code and year is obtained. Then, each entry in Panel B reports the median, mean, tenth percentile, and ninetieth percentile of the population of medians.

Panel A – Number of patenting firms at industry level

	0	1 – 2	3 – 10	11 – 100	>100	N. Obs.
Agriculture	356	4	0	0	0	360
Food Products	1705	187	190	112	0	2194
Candy & Soda	284	36	32	38	0	390
Beer & Liquor	419	26	18	7	0	470
Tobacco Products	182	19	15	0	0	216
Recreation	925	158	80	71	25	1259
Entertainment	1198	22	8	3	0	1231
Printing and Publishing	1216	52	23	0	0	1291
Consumer Goods	1924	329	284	264	185	2986
Apparel	1625	137	47	6	0	1815
Healthcare	1298	19	7	0	0	1324
Medical Equipment	1511	273	275	135	36	2230
Pharmaceutical Products	1690	158	144	308	103	2403
Chemicals	1094	241	307	428	118	2188
Rubber and Plastic Products	835	143	99	27	0	1104
Textiles	959	152	133	17	0	1261
Construction Materials	2831	567	501	283	24	4206
Construction	1091	11	28	15	0	1145
Steel Works	1333	258	225	151	7	1974
Fabricated Products	412	96	43	19	0	570
Machinery	2293	656	741	473	62	4225
Electrical Equipment	1886	246	208	131	24	2495
Automobiles and Trucks	1029	266	294	271	121	1981
Aircraft	263	86	164	144	54	711
Shipbuilding, Railroad Equipment	139	14	24	39	0	216
Defense	126	29	24	15	10	204
Precious Metals	834	6	2	0	0	842
Non-Metallic and Industrial Metal Mining	760	28	57	39	0	884
Petroleum and Natural Gas	4794	132	78	145	65	5214
Utilities	3720	59	21	1	0	3801
Communication	1411	21	10	10	24	1476
Personal Services	858	17	12	0	0	887
Business Services	6188	148	144	52	4	6536
Computers	2227	305	284	216	94	3126
Electronic Equipment	3368	639	595	368	92	5062
Measuring and Control Equipment	1548	276	299	132	11	2266
Business Supplies	903	171	201	158	2	1435
Shipping Containers	489	135	184	75	11	894
Transportation	2368	11	2	0	0	2381
Wholesale	4192	92	43	29	2	4358
Retail	5723	37	23	0	0	5783
Restaurants, Hotels, Motels	2204	31	3	0	0	2238
Miscellaneous	3859	279	155	58	3	4354
Total	74070	6572	6027	4240	1077	91986

TABLE II – *Continued*

Panel B – 4-digit SIC summary statistics, conditional on number of patents by SIC and unconditional.

	0	1 – 2	3 – 10	11 – 100	>100	Overall
Book Leverage	49.44	45.70	45.88	45.74	46.96	47.84
	49.17	45.97	46.32	46.06	47.61	48.12
	26.65	28.03	29.64	31.13	33.43	28.34
	70.85	63.60	62.95	61.42	61.84	68.16
Market Leverage	44.35	42.47	43.26	39.75	39.20	42.93
	44.77	42.81	43.13	40.68	39.76	43.63
	16.24	18.05	19.68	19.86	18.63	17.33
	74.15	67.79	67.53	63.06	61.78	70.95
Net Equity Issues	0.51	0.42	0.47	0.54	0.54	0.50
	2.90	1.23	1.30	1.15	1.22	1.95
	–1.27	–0.92	–0.93	–0.64	–0.24	–1.08
	9.20	4.01	4.03	3.16	2.72	6.51
Newly Retained Earnings	2.51	2.98	3.11	3.24	3.20	2.81
	0.48	2.35	2.37	2.56	2.56	1.26
	–7.02	–3.10	–2.58	–1.68	–0.85	–5.08
	8.24	7.66	7.20	6.63	6.32	7.69
Net Debt Issues	3.05	2.61	2.91	2.84	3.08	2.91
	3.23	2.32	2.83	3.13	3.42	2.22
	–7.69	–5.51	–4.42	–3.25	–1.78	–6.00
	16.72	11.70	11.44	10.22	8.82	14.45
Capital Expenditures	6.05	5.89	5.97	6.11	6.17	6.01
	8.51	7.17	7.48	7.04	7.20	8.01
	1.80	2.39	2.88	3.48	3.67	2.17
	16.48	12.62	12.11	11.04	12.00	14.60
Δ Cash	0.16	0.13	0.28	0.21	0.21	0.17
	1.56	1.02	0.98	0.69	0.69	1.26
	–4.91	–3.30	–2.84	–1.86	–1.54	–3.87
	7.27	5.49	4.92	4.92	3.00	5.95
Acquisitions	0.00	0.00	0.00	0.00	0.00	0.00
	2.27	1.12	1.21	0.99	0.68	1.82
	0.00	0.00	0.00	0.00	0.00	0.00
	4.35	2.66	3.14	2.01	0.92	3.39
Dividends	0.16	1.10	1.26	1.43	1.30	0.66
	1.08	1.44	1.53	1.63	1.53	1.25
	0.00	0.00	0.00	0.00	0.00	0.00
	2.85	3.26	3.28	3.37	0.31	3.05
R&D dummy	0.21	0.45	0.60	0.77	0.88	0.38
R&D Intensity	0.00	0.00	0.63	1.69	2.84	0.00
	0.65	1.02	1.59	2.32	3.50	1.13
	0.00	0.00	0.00	0.00	0.09	0.00
	1.69	3.05	3.99	5.63	7.12	3.52
No firms per SIC-year	2.00	2.00	3.00	4.00	8.00	2.00
	3.30	4.74	5.14	9.11	15.77	5.05
	1.00	1.00	1.00	1.00	2.00	1.00
	7.00	10.00	10.00	16.00	31.00	10.00
N. Obs.	12506	1807	2079	2319	1156	19867

TABLE III

Largest Patenting Firms

This table presents the five firms that were granted the largest number of patents and the number of patents granted for each year between 1970 and 1999.

	First		Second		Third		Fourth		Fifth	
	Name	No	Name	No	Name	No	Name	No	Name	No
1970	General Electric	1038	A. T. & T.	782	IBM	632	Du Pont de Nemours	606	General Motors	533
1971	General Electric	1161	A. T. & T.	884	General Motors	846	IBM	789	Eastman Kodak	636
1972	General Electric	931	A. T. & T.	802	General Motors	755	Du Pont de Nemours	699	IBM	631
1973	General Electric	1058	General Motors	806	A. T. & T.	678	IBM	632	Du Pont de Nemours	537
1974	General Electric	1009	General Motors	710	IBM	568	A. T. & T.	543	Du Pont de Nemours	536
1975	General Electric	849	General Motors	626	Du Pont de Nemours	546	IBM	489	Xerox	466
1976	General Electric	811	Xerox	549	General Motors	546	Reynolds Spring	522	IBM	480
1977	General Electric	833	IBM	504	Xerox	493	Reynolds Spring	486	A. T. & T.	451
1978	General Electric	831	IBM	450	Xerox	418	Reynolds Spring	409	Hitachi	388
1979	General Electric	612	IBM	321	Reynolds Spring	318	General Motors	309	Hitachi	304
1980	General Electric	773	General Motors	429	IBM	383	Hitachi	380	Reynolds Spring	345
1981	General Electric	884	IBM	502	Hitachi	489	General Motors	378	Reynolds Spring	370
1982	General Electric	750	Hitachi	479	IBM	436	Reynolds Spring	398	General Motors	339
1983	General Electric	642	IBM	484	Hitachi	432	Reynolds Spring	401	Du Pont de Nemours	327
1984	General Electric	793	IBM	609	Hitachi	596	Reynolds Spring	473	General Motors	438
1985	General Electric	792	Hitachi	693	IBM	578	A. T. & T.	546	Reynolds Spring	538
1986	Hitachi	731	General Electric	722	IBM	598	Reynolds Spring	591	Fuji Photo Film	448
1987	Hitachi	845	General Electric	798	Reynolds Spring	787	IBM	591	General Motors	573
1988	Hitachi	908	General Electric	798	General Motors	642	Fuji Photo Film	589	IBM	549
1989	Hitachi	1054	General Electric	928	Fuji Photo Film	892	General Motors	765	IBM	623
1990	Hitachi	908	General Electric	893	Fuji Photo Film	768	Eastman Kodak	732	General Motors	699
1991	Hitachi	929	General Electric	915	Eastman Kodak	875	General Motors	854	Fuji Photo Film	733
1992	General Electric	982	Hitachi	956	IBM	843	Eastman Kodak	781	General Motors	763
1993	IBM	1085	Eastman Kodak	1034	General Electric	978	Hitachi	913	General Motors	822
1994	IBM	1298	General Electric	985	Hitachi	976	Eastman Kodak	965	Motorola	844
1995	IBM	1383	Motorola	1013	Hitachi	910	Eastman Kodak	817	General Electric	761
1996	IBM	1869	Motorola	1065	Hitachi	963	General Electric	824	Eastman Kodak	809
1997	IBM	1724	Motorola	1058	Hitachi	903	Eastman Kodak	806	General Electric	664
1998	IBM	2657	Motorola	1406	Eastman Kodak	1131	Hitachi	1094	Hewlett Packard	805
1999	IBM	2756	Motorola	1192	Hitachi	1008	Eastman Kodak	993	Micron Technology	933

TABLE IV

Patents and Annual Changes in Leverage and Components

This table reports results for Fama–MacBeth estimations of firm-level changes in book leverage and components on patents, market-to-book ratio, profitability, fixed assets intensity, and firm size. Book leverage is book debt to assets and is expressed in percentage terms. Industry patents are defined at the firm level as the log of one plus the number of patents granted per industry-year minus own patents. Industry is defined as the same four-digit SIC code. Own patents are defined as the log of one plus the number of patents granted per firm-year. The market-to-book ratio is defined as assets minus book equity plus market equity all divided by assets. Profitability is defined as operating income before depreciation divided by assets. Fixed assets intensity is defined as net property, plant and equipment divided by assets. Firm size is defined as the logarithm of net sales. Regressions include the constant term and lagged leverage, but their coefficients are not reported. The total change in book leverage is in Panel A. The net equity issue component is in Panel B. The newly retained earnings component is in Panel C. The net debt issues component is in Panel D. Financial data are from the annual Compustat industrial tapes. Patent data are from Hall, Jaffe and Trajtenberg (2002). SIC codes are from the CRSP tapes. The regressions are run for each year t+1 of the 1970–1999 period. The table shows means and standard errors (across years) of the regression coefficients. Standard errors are the time series standard deviations of the regression coefficients divided by $(30)^{1/2}$. *t-statistics* use standard errors that are robust to heteroskedasticity and autocorrelation up to four lags. Superscripts [a], [b], [c] indicate significance at 1%, 5%, and 10% levels, respectively.

Industry Patents $_{t-1}$	Own Patents $_{t-1}$	(ME/BE) $_{i,t-1}$	(EBITDA/A) $_{i,t-1}$	(PPE/A) $_{i,t-1}$	Log (S) $_{i,t-1}$	N. Obs.	R^2
			Panel A: Change in Book Leverage ($\Delta(D/A)_{j,t}$) %				
–0.140[a]		–0.345[a]	–0.094[a]	0.006	0.206[a]	91986	0.767
(.045)		(.118)	(.013)	(.004)	(.064)		
	–0.150[a]	–0.341[a]	–0.094[a]	0.007[c]	0.241[a]	91986	0.767
	(.049)	(.125)	(.014)	(.004)	(.059)		
–0.133[a]	–0.070	–0.334[a]	–0.095[a]	0.005	0.230[a]	91986	0.767
(.049)	(.065)	(.124)	(.014)	(.004)	(.055)		
			Panel B: Net Equity Issues ($(e/A)_{j,t}$) %				
0.114[a]		2.622[a]	–0.147[b]	0.025[a]	–0.643[a]	91986	0.138
(.031)		(.418)	(.065)	(.005)	(.185)		
	–0.422	2.649[a]	–0.148[b]	0.023[a]	–0.564[a]	91986	0.137
	(.272)	(.417)	(.065)	(.004)	(.156)		
0.163[a]	–0.538[c]	2.637[a]	–0.147[b]	0.025[a]	–0.541[a]	91986	0.138
(.047)	(.292)	(.420)	(.065)	(.005)	(.160)		

Panel C: Newly Retained Earnings ($(\Delta RE/A)_{j,t}$) %							
–0.100[c] (.056)		–0.034 (.208)	0.474[a] (.061)	–0.033[a] (.009)	0.506[a] (.175)	91986	0.193
	–0.300[b] (.145)	–0.028 (.209)	0.474[a] (.060)	–0.032[a] (.009)	0.555[a] (.203)	91986	0.193
–0.076 (.047)	–0.256[b] (.120)	–0.030 (.204)	0.473[a] (.060)	–0.033[a] (.010)	0.553[a] (.196)	91986	0.194
Panel D: Net Debt Issues ($(\Delta d/A)_{j,t}$) %							
–0.297[b] (.140)		1.142[a] (.126)	0.071[a] (.013)	0.028[a] (.009)	0.183[c] (.100)	91986	0.198
	–1.738[b] (.821)	1.204[a] (.145)	0.066[a] (.012)	0.029[a] (.009)	0.514[a] (.136)	91986	0.198
–0.138 (.127)	–1.655[c] (.827)	1.206[a] (.139)	0.064[a] (.012)	0.026[a] (.009)	0.517[a] (.132)	91986	0.199

TABLE V

Patents and Annual Changes in Leverage and Components

This table reports results for OLS estimations of firm-level changes in book leverage and components on patents, market-to-book ratio, profitability, fixed assets intensity, and firm size. Book leverage is book debt to assets and is expressed in percentage terms. Industry patents are defined at the firm level as the log of one plus the number of patents granted per industry-year minus own patents. Industry is defined as the same four-digit SIC code. Own patents are defined as the log of one plus the number of patents granted per firm-year. The market-to-book ratio is defined as assets minus book equity plus market equity all divided by assets. Profitability is defined as operating income before depreciation divided by assets. Fixed assets intensity is defined as net property, plant and equipment divided by assets. Firm size is defined as the logarithm of net sales. Regressions include the constant term and lagged leverage, but their coefficients are not reported. The total change in book leverage is in Panel A. The net equity issue component is in Panel B. The newly retained earnings component is in Panel C. The net debt issues component is in Panel D. Financial data are from the annual Compustat industrial tapes. Patent data are from Hall, Jaffe and Trajtenberg (2002). SIC codes are from the CRSP tapes. The standard errors (in parentheses) are adjusted for heteroskedasticity using Huber (1967) and White (1980) corrections and for clustering at the four-digit SIC level using the Huber (1967) correction. All regressions include industry fixed effects (at the four-digit SIC code level) and time dummies, not reported. Superscripts [a], [b], [c] indicate significance at 1%, 5%, and 10% levels, respectively.

Industry Patents $_{t-1}$	Own Patents $_{t-1}$	(ME/BE) $_{i,t-1}$	(EBITDA/A) $_{i,t-1}$	(PPE/A) $_{i,t-1}$	Log (S) $_{i,t-1}$	N. Obs.	Adj. R^2
Panel A: Change in Book Leverage ($\Delta(D/A)_{j,t}$) %							
–0.134[a] (.039)		–0.530[a] (.054)	–0.119[a] (.005)	0.012[a] (.003)	0.288[a] (.033)	91986	0.748
	–0.049 (.051)	–0.527[a] (.054)	–0.119[a] (.005)	0.012[a] (.003)	0.309[a] (.037)	91986	0.748
–0.145[a] (.041)	–0.080 (.053)	–0.527[a] (.054)	–0.119[a] (.005)	0.012[a] (.003)	0.307[a] (.037)	91986	0.748
Panel B: Net Equity Issues ($(e/A)_{j,t}$) %							
0.289[b] (.134)		4.154[a] (.220)	–0.260[b] (.032)	0.046[a] (.007)	–0.737[a] (.104)	91986	0.072
	–0.303 (.275)	4.163[a] (.223)	–0.262[a] (.033)	0.046[a] (.007)	–0.681[a] (.088)	91986	0.072
0.256[b] (.131)	–0.250 (.275)	4.164[a] (.223)	–0.262[a] (.033)	0.046[a] (.007)	–0.677[a] (.088)	91986	0.072

Panel C: Newly Retained Earnings ($(\Delta RE/A)_{j,t}$) %							
–0.137 (.090)		–0.797 (.153)	0.691[a] (.030)	–0.060[a] (.007)	0.363[a] (.066)	91986	0.214
	–0.314[b] (.126)	–0.783 (.154)	0.688[a] (.030)	–0.059[a] (.007)	0.451[a] (.078)	91986	0.214
–0.184[b] (.093)	–0.353[a] (.131)	–0.783[a] (.154)	0.688[a] (.030)	–0.059[a] (.007)	0.448[a] (.078)	91986	0.214
Panel D: Net Debt Issues ($(\Delta d/A)_{j,t}$) %							
0.013 (.306)		1.128[a] (.107)	0.079[a] (.016)	0.046[a] (.015)	0.124 (.110)	91986	0.028
	–1.193 (.827)	1.176[a] (.098)	0.071[a] (.014)	0.049[a] (.015)	0.422[a] (.157)	91986	0.028
–0.149 (.244)	–1.225 (.804)	1.176[a] (.098)	0.071[a] (.014)	0.049[a] (.015)	0.419[a] (.157)	91986	0.028

TABLE VI
Patents and Capital Structure

This table reports results for Fama–MacBeth estimations of firm-level book and market leverage on patents, market-to-book ratio, profitability, fixed assets intensity, firm size, R&D intensity, a dummy for disclosure of R&D expenditures, depreciation expenses, and common dividends. Book leverage is book debt to assets and market leverage is the result of total assets minus book equity plus market equity. Industry patents are defined at the firm level as the log of one plus the number of patents granted per industry-year minus own patents. Industry is defined as the same four-digit SIC code. Own patents are defined as the log of one plus the number of patents granted per firm-year. The market-to-book ratio is defined as assets minus book equity plus market equity all divided by assets. Profitability is defined as operating income before depreciation divided by assets. Fixed assets intensity is defined as net property, plant and equipment divided by assets. Firm size is defined as the logarithm of net sales. R&D intensity is defined as R&D expenditures divided by assets. RDD is a dummy set to one if the firm reports positive R&D expense. Depreciation expense is divided by assets. Common dividends are divided by book equity and market equity. Financial data are from the annual Compustat industrial tapes. Patent data are from Hall, Jaffe and Trajtenberg (2002). SIC codes are from the CRSP tapes. The regressions are run for each year t+1 of the 1970–1999 period. The table shows means and standard errors (across years) of the regression coefficients. Standard errors are the time series standard deviations of the regression coefficients divided by $(30)^{1/2}$. *t-statistics* use standard errors that are robust to heteroskedasticity and autocorrelation up to four lags. Superscripts ^{a}, ^{b}, ^{c} indicate significance at 1%, 5%, and 10% levels, respectively.

	Book Leverage							Market Leverage						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Own Patents $_{t-1}$	–2.040^{a}	–1.700^{a}	–5.597^{a}	–1.252^{b}	–5.022^{b}	–1.033^{a}	–0.972^{a}	–2.948^{a}	–2.500^{a}	–5.838^{a}	–1.668^{a}	–4.426^{a}	–1.607^{a}	–1.511^{a}
	(.313)	(.389)	(.860)	(.291)	(.910)	(.304)	(.327)	(.186)	(.241)	(.878)	(.272)	(.735)	(.194)	(.196)
Industry Patents $_{t-1}$		–0.558^{a}					–0.295^{b}		–0.738^{a}					–0.390^{a}
		(.207)					(.140)		(.140)					(.066)
(ME/BE) $_{i,t-1}$	–1.682^{a}	–1.644^{a}	–1.690^{a}	–1.449^{b}	–1.487^{b}	–1.734^{a}	–1.757^{a}	–9.657^{a}	–9.557^{a}	–9.661^{a}	–9.439^{a}	–9.471^{a}	–8.763^{a}	–8.743^{a}
	(.587)	(.560)	(.586)	(.685)	(.694)	(.596)	(.580)	(.648)	(.656)	(.647)	(.605)	(.601)	(.413)	(.414)
(EBITDA/A) $_{i,t-1}$	–0.435^{a}	–0.439^{a}	–0.432^{a}	–0.434^{a}	–0.432^{a}	–0.432^{a}	–0.433^{a}	–0.482^{a}	–0.485^{a}	–0.479^{a}	–0.478^{a}	–0.477^{a}	–0.446^{a}	–0.447^{a}
	(.076)	(.075)	(.077)	(.076)	(.077)	(.064)	(.065)	(.113)	(.112)	(.114)	(.113)	(.114)	(.094)	(.094)
(PPE/A) $_{i,t-1}$	0.069^{a}	0.061^{a}	0.067^{a}	0.069^{a}	0.068^{a}	0.059^{a}	0.058^{a}	0.075^{a}	0.065^{a}	0.074^{a}	0.075^{a}	0.074^{a}	0.045^{a}	0.044^{a}
	(.006)	(.007)	(.006)	(.006)	(.006)	(.009)	(.009)	(.014)	(.014)	(.014)	(.014)	(.014)	(.009)	(.009)
Log (S) $_{i,t-1}$	3.016^{a}	2.955^{a}	2.935^{a}	3.016^{a}	2.935^{a}	3.249^{a}	3.234^{a}	2.848^{a}	2.740^{a}	2.797^{a}	2.844^{a}	2.801^{a}	2.978^{a}	2.932^{a}
	(.220)	(.199)	(.209)	(.219)	(.209)	(.147)	(.140)	(.125)	(.129)	(.144)	(.128)	(.144)	(.188)	(.185)
Log (1 + Patents) $_{i,t-1}$ * Log (S) $_{i,t-1}$			0.461^{a}		0.455^{a}					0.369^{a}		0.323^{a}		
			(.122)		(.115)					(.122)		(.111)		
Log (1 + Patents) $_{i,t-1}$ * (M/B) $_{i,t-1}$				–0.565^{a}	–0.391^{a}						–0.924^{a}	–0.778^{a}		
				(.145)	(.151)						(.241)	(.216)		
(R&D/A) $_{i,t-1}$						–0.427^{a}	–0.394^{a}						–0.532^{a}	–0.496^{a}
						(.096)	(.089)						(.105)	(.098)
RDD $_{i,t-1}$						–5.127^{a}	–4.478^{a}						–6.394^{a}	–5.655^{a}
						(.697)	(.500)						(.803)	(.685)
(Dp/A) $_{i,t-1}$						–0.002^{a}	–0.002^{a}						–0.002^{b}	–0.002^{b}
						(.001)	(.001)						(.001)	(.001)
(Dividends/BE) $_{i,t-1}$						3.196	3.274						–75.53^{a}	–75.96^{a}
						(13.76)	(13.44)						(27.40)	(27.42)
(Dividends/ME) $_{i,t-1}$						–79.08^{a}	–79.61^{a}						36.36^{c}	35.40^{c}
						(14.15)	(14.24)						(18.60)	(18.47)
R^2	0.172	0.178	0.174	0.173	0.175	0.196	0.198	0.365	0.371	0.367	0.366	0.367	0.388	0.389
No of observations	91986	91986	91986	91986	91986	91986	91986	91986	91986	91986	91986	91986	91986	91986

TABLE VII

Patents and Uses of Funds

This table reports results for OLS estimations of investments, changes in cash holdings, acquisitions, dividends, changes in working capital, changes in short term debt, R&D and patents on patents, Tobin's Q, and cash flow. Industry patents are defined at the firm level as the log of one plus the number of patents granted per industry-year minus own patents. Industry is defined as the same four-digit SIC code. Own patents are defined as the log of one plus the number of patents granted per firm-year. Tobin's Q is defined as assets minus book equity plus market equity all divided by assets. Financial data are from the annual Compustat industrial tapes; Patent data are from Hall, Jaffe and Trajtenberg (2002); and the sample period is 1970 to 1999. The standard errors (in parentheses) are adjusted for heteroskedasticity using Huber (1967) and White (1980) corrections and for clustering at the four-digit SIC level using the Huber (1967) correction. All regressions include industry fixed effects (at the four-digit SIC code level) and time dummies, not reported. Superscripts [a], [b], [c] indicate significance at 1%, 5%, and 10% levels, respectively.

	Explanatory Variables					
Dependent Variable	Industry Patents $_{t-1}$	Own Patents $_{t-1}$	Cash Flow $_{i,t}$	Q $_{i,t-1}$	N. Obs.	Adjusted R^2
CAPEX $_{i,t}$/A $_{i,t-1}$	–0.002[a] (.001)	–0.000 (.000)	0.297[a] (.016)	0.006[a] (.001)	91986	0.208
Δ Cash $_{i,t}$/A $_{i,t-1}$	0.002[b] (.001)	–0.003[a] (.001)	0.300[a] (.019)	0.008[a] (.001)	91986	0.079
Acquisitions $_{i,t}$/A $_{i,t-1}$	–0.001 (.001)	0.005[a] (.001)	0.103[a] (.009)	0.004[a] (.001)	91986	0.153
Dividends $_{i,t}$/A $_{i,t-1}$	–0.000 (.000)	0.003[a] (.000)	0.048[a] (.004)	0.001[a] (.000)	91986	0.389
Δ Working Capital. $_{i,t}$/A $_{I,t-1}$	–0.001 (.001)	–0.004[a] (.001)	0.354[a] (.020)	0.001[a] (.000)	91986	0.132
Δ Short Term Debt $_{i,t}$/A $_{i,t-1}$	–0.000 (.000)	–0.001[a] (.001)	–0.017[a] (.004)	0.002[a] (.000)	91986	0.012
R&D $_{i,t}$/A $_{i,t-1}$	–0.007 (.015)	0.229[a] (.047)	–0.031 (.079)	0.007 (.007)	91986	0.089
R&D $_{i,t}$/A $_{i,t-1}$ [R&D≠.]	0.001[c] (.001)	–0.001 (.001)	0.034[a] (.007)	0.007[a] (.002)	49358	0.568
Own Patents $_t$	–0.171[a] (.022)		0.549[a] (.103)	0.012[a] (.004)	91986	0.328
Own Patents $_t$ [R&D≠.]	–0.211[a] (.030)		0.790[a] (.156)	0.010[c] (.006)	49358	0.348

TABLE VIII

Two-Stage Least Squares Models of Patents, Equity Issues and Uses of Funds

This table reports results for second stage OLS estimations of investments, changes in cash holdings, acquisitions, dividends, changes in working capital, changes in short term debt, R&D and patents on net equity issues, firm-level patents, Tobin's Q, and cash flow. In the first stage, net equity issues is instrumented by industry patents. Industry patents are defined at the firm level as the log of one plus the number of patents granted per industry-year minus own patents. Industry is defined as the same four-digit SIC code. Own patents are defined as the log of one plus the number of patents granted per firm-year. Tobin's Q is defined as assets minus book equity plus market equity all divided by assets. Financial data are from the annual Compustat industrial tapes; Patent data are from Hall, Jaffe and Trajtenberg (2002); and the sample period is 1970 to 1999. The standard errors (in parentheses) are adjusted for heteroskedasticity using Huber (1967) and White (1980) corrections and for clustering at the four-digit SIC level using the Huber (1967) correction. All regressions include industry fixed effects (at the four-digit SIC code level) and time dummies, not reported. Superscripts [a], [b], [c] indicate significance at 1%, 5%, and 10% levels, respectively.

	Explanatory Variables				
Dependent Variable	Net Equity Issues $_{i,t}$	Own Patents $_{t-1}$	Cash Flow $_{i,t}$	Q $_{i,t-1}$	N. Obs.
CAPEX $_{i,t}$/A $_{i,t-1}$	–0.008[a] (.003)	–0.005[a] (.002)	0.213[a] (.028)	0.021[a] (.005)	91986
Δ Cash $_{i,t}$/A $_{i,t-1}$	0.008[a] (.002)	0.001 (.001)	0.385[a] (.023)	–0.007[c] (.004)	91986
Acquisitions $_{i,t}$/A $_{i,t-1}$	–0.003 (.003)	0.003[c] (.002)	0.070[b] (.030)	0.010[c] (.005)	91986
Dividends $_{i,t}$/A $_{i,t-1}$	–0.001[a] (.000)	0.002[a] (.000)	0.039[a] (.003)	0.002[a] (.001)	91986
Δ Working Capital. $_{i,t}$/A $_{i,t-1}$	–0.005[b] (.002)	–0.007[a] (.002)	0.297[a] (.027)	0.012[b] (.005)	91986
Δ Short Term Debt $_{I,t}$/A $_{i,t-1}$	–0.001 (.001)	–0.001[c] (.001)	–0.030[b] (.015)	0.004[c] (.003)	91986
R&D $_{i,t}$/A $_{i,t-1}$	–0.039 (.038)	0.206[a] (.024)	–0.495 (.412)	0.077 (.072)	91986
R&D $_{i,t}$/A $_{i,t-1}$ [R&D≠.]	0.011[a] (.002)	0.009[a] (.002)	0.008 (.042)	–0.018[a] (.006)	49358
Own Patents $_t$	–0.590[a] (.076)		–5.907[a] (.872)	1.133[a] (.145)	91986
Own Patents $_t$ [R&D≠.]	–0.559[a] (.077)		–8.684[a] (1.35)	1.318[a] (.181)	49358

Table IX

Performance Attribution Regressions

At the end of June of each year t (1971-2000), stocks are sorted into five portfolios by number of patents granted in year *t-1*. Stocks are held in these portfolios for 12 months, i.e. portfolios are rebalanced yearly. Four-factor regressions of equally-weighted and value-weighted monthly returns are then estimated and the results reported below. For each portfolio, the figure shows the raw monthly excess return, the intercept α and the coefficients (factor loadings) on the explanatory variables RMRF, SMB, HML and Momentum. These variables are the returns to zero-investment portfolios designed to capture market, size, book-to-market and momentum effects, respectively. (Consult Fama and French (1993) and Carhart (1997) on the construction of these factors). The sample period is from July 1971 to June 2001. Panel A reports results for equally weighted returns, and Panel B reports results for value-weighted returns. Standard errors are reported in parenthesis and significance at the 5 percent and 1 percent levels is indicated by [b] and [a], respectively.

Panel A – Equally-weighted performance attribution regressions

	Raw	α	RMRF	SMB	HML	Momentum
Patents>100	0.86	0.43[a] (0.10)	1.00[a] (0.02)	0.03 (0.03)	–0.02 (0.04)	–0.16[a] (0.03)
10<Patents≤100	0.84	0.28[a] (0.09)	1.11[a] (0.02)	0.35[a] (0.03)	0.16[a] (0.04)	–0.14[a] (0.03)
2<Patents≤10	0.86	0.28[a] (0.09)	1.10[a] (0.03)	0.69[a] (0.05)	0.32[a] (0.05)	–0.17[a] (0.03)
1<Patents≤2	0.88	0.28[a] (0.10)	1.06[a] (0.03)	0.83[a] (0.06)	0.38[a] (0.05)	–0.17[a] (0.04)
0 Patents	0.79	0.12 (0.11)	0.95[a] (0.03)	0.89[a] (0.05)	0.29[a] (0.05)	–0.15[a] (0.05)

Panel B – Value-weighted performance attribution regressions

	Raw	α	RMRF	SMB	HML	Momentum
Patents>100	0.65	0.27[a] (0.10)	0.90[a] (0.02)	–0.20[a] (0.03)	–0.10[b] (0.04)	–0.11[a] (0.03)
10<Patents≤100	0.62	0.22[b] (0.09)	1.03[a] (0.02)	–0.25[a] (0.04)	–0.14[a] (0.04)	–0.15[a] (0.04)
2<Patents≤10	0.54	0.09 (0.11)	1.10[a] (0.03)	0.01 (0.04)	0.10[b] (0.05)	–0.25[a] (0.03)
1<Patents≤2	0.50	0.01 (0.11)	1.13[a] (0.03)	–0.08 (0.04)	0.07 (0.05)	–0.20[a] (0.04)
0 Patents	0.58	0.05 (0.07)	0.99[a] (0.02)	0.12[a] (0.03)	0.14[a] (0.03)	–0.13[a] (0.02)

TABLE X

Industry Portfolio Returns and Industry Patenting Activity

I sort 43 non-financial Fama and French (1997) industry portfolios according to previous percent changes in industry patenting activity (Δ). Panel A reports average industry portfolio returns over years when previous Δ is small (bottom 25%), medium (25^{th} percentile to 75^{th} percentile), and large (top 25%), and the differences between the averages. It also reports intercepts of regressions of portfolio returns on the excess market return (CAPM α), and the three Fama-French factors (FF3F α). These Δ sorts are then intersected with independent sorts based on the abnormal number of patents (ANP), and the returns reported in Panel B. ANP is defined with respect to the within-industry distribution of patenting activity, and can be high (top 25%), regular (25^{th} percentile to 75^{th} percentile), and low (bottom 25%). Panel B also reports intercepts of regressions of portfolio returns on the excess market return (CAPM α), and the three Fama-French factors (FF3F α). The first return is July 1972, the last return is June 2000. Returns are reported in percent per month.

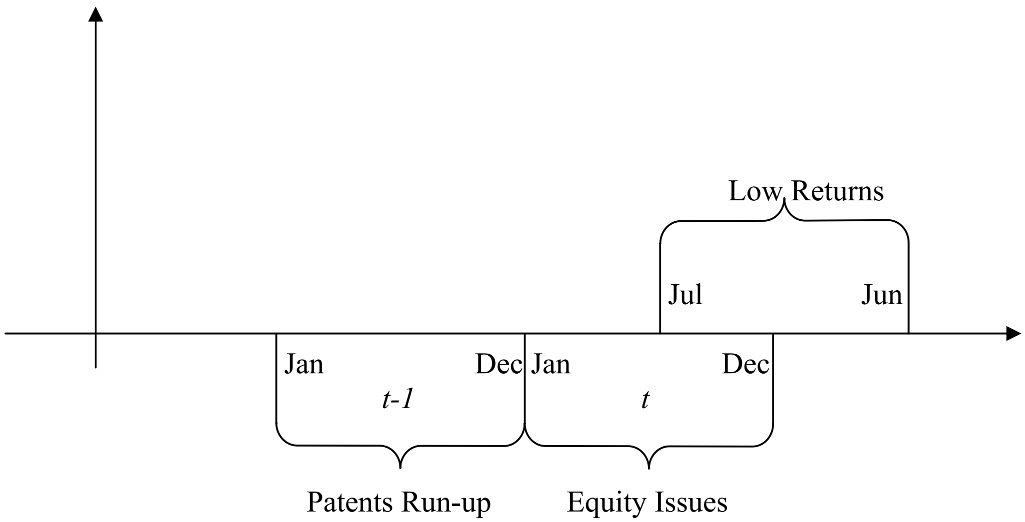
Panel A – Percent change in patenting

Percent Change in Patenting (Δ)					
Δ1 (Small)	Δ2	Δ3 (Large)	Δ1-Δ3 Raw (t-stat)	Δ1-Δ3 CAPM α (t-stat)	Δ1-Δ3 FF3F α (t-stat)
1.24	1.20	1.20	0.04 (0.31)	0.07 (0.60)	–0.05 (–0.49)

Panel B – Intersection with sort on abnormal number of patents by industry

		Abnormal Number of Patents (ANP)				
		ANP1 (High)	ANP2	ANP3 (Low)	ANP1-ANP3	(t-stat)
Δ1	(Small)	1.83	1.32	1.42	0.22	(0.76)
Δ2		1.25	1.16	1.23	0.02	(0.10)
Δ3	(Large)	1.24	1.04	0.88	0.11	(0.36)
Δ1-Δ3	Raw	0.40	0.28	0.01		
(t-stat)		(1.21)	(1.80)	(0.03)		
Δ1-Δ3	CAPM α	0.46	0.32	0.05		
(t-stat)		(1.36)	(2.02)	(0.17)		
Δ1-Δ3	FF3F α	0.14	0.33	–0.12		
(t-stat)		(0.42)	(1.98)	(–0.44)		

FIGURE I
Patents, Equity Issues, and Subsequent Returns



APPENDIX

TABLE AI

Summary Statistics of Patent Counts by Firm-Year

This table reports summary statistics on the distribution of the number of patents granted for each year between 1970 and 1999.

Panel A – Distribution of patent counts by year

	Median	70%	75%	80%	90%	95%	99%	Max	Mean	Std. Dev.	N. Obs.
1970	0	1	2	4	18	50	222	1038	11.1	53.9	1589
1971	0	1	3	5	18	57	261	1161	12.3	61.3	1694
1972	0	0	1	2	9	27	167	931	7.9	46.0	2563
1973	0	0	1	2	9	26	156	1058	7.1	42.8	2750
1974	0	0	1	2	7	22	160	1009	6.7	39.8	2836
1975	0	0	1	2	7	20	153	849	6.4	37.1	2884
1976	0	0	1	2	7	19	152	811	6.2	36.1	2802
1977	0	0	1	1	6	17	122	833	5.6	34.5	2734
1978	0	0	0	1	5	16	127	831	5.3	32.4	2806
1979	0	0	0	1	3	10	85	612	3.6	22.2	2886
1980	0	0	0	1	4	14	104	773	4.3	27.1	2896
1981	0	0	0	1	4	11	100	884	4.4	29.7	3015
1982	0	0	0	0	3	11	87	750	3.8	26.1	3099
1983	0	0	0	0	3	8	81	642	3.6	25.6	3219
1984	0	0	0	0	3	9	103	793	4.3	31.8	3228
1985	0	0	0	0	3	10	110	792	4.5	33.6	3168
1986	0	0	0	0	2	8	86	731	4.1	33.0	3307
1987	0	0	0	1	3	10	95	845	4.5	35.7	3350
1988	0	0	0	0	3	10	86	908	4.4	37.3	3235
1989	0	0	0	0	4	12	115	1054	5.4	44.6	3171
1990	0	0	0	0	3	10	101	908	5.2	43.2	3146
1991	0	0	0	0	3	12	114	929	5.7	46.4	3192
1992	0	0	0	0	3	12	97	982	5.3	44.0	3349
1993	0	0	0	0	3	11	101	1085	5.3	46.4	3576
1994	0	0	0	0	2	11	104	1298	5.4	48.5	3645
1995	0	0	0	0	2	10	105	1383	5.3	48.0	3753
1996	0	0	0	0	2	9	107	1869	5.5	53.0	3823
1997	0	0	0	0	1	8	114	1724	5.3	49.9	3695
1998	0	0	0	0	2	13	157	2657	7.3	71.0	3378
1999	0	0	0	0	1	12	151	2756	7.6	73.4	3197

Panel B – Distribution of patent counts over the entire sample period

Median	80%	90%	95%	99%	Max	Mean	Std. Dev.	N. Obs.
0	0	4	14	116	2756	5.55	43.5	91986

TABLE AII

Further Summary Statistics

The Table reports summary statistics of firm-level variables, conditional and unconditional. Each entry reports the median, mean, tenth percentile, and the ninetieth percentile.

	0	1 – 2	3 – 10	11 – 100	>100	Overall
Size	4.24	4.74	5.45	7.12	8.79	4.51
	4.27	4.82	5.48	7.00	8.48	4.56
	1.74	2.81	3.42	5.22	7.16	1.74
	6.84	7.03	7.56	8.77	9.26	6.84
Profitability	12.40	14.84	15.15	15.73	16.59	13.04
	10.53	14.27	14.47	15.69	17.53	11.37
	–4.11	3.82	4.98	7.69	9.10	–2.08
	24.66	25.84	24.81	24.83	27.49	24.81
Cash Flow	8.83	10.83	10.87	11.48	13.00	9.32
	9.09	10.84	10.86	11.63	13.89	9.50
	–6.90	1.49	2.49	4.50	6.29	–5.23
	20.76	19.81	19.21	19.33	22.86	20.55
Tangibility	28.90	27.87	29.31	31.90	35.52	29.20
	34.99	30.51	31.53	31.53	36.89	34.42
	7.33	13.19	15.15	15.15	20.44	8.34
	74.30	52.95	52.38	52.38	55.59	71.03
Firm Age	5.00	8.00	9.00	12.00	14.00	5.00
	6.38	8.67	9.82	11.58	9.88	6.74
	2.00	3.00	3.00	3.00	–15.50	2.00
	14.00	16.00	18.00	21.00	22.00	14.00
Depreciation Expense	2.08	3.18	7.26	44.45	363.70	2.76
	20.62	19.91	30.20	94.39	312.84	27.98
	0.19	0.44	0.87	5.45	48.20	0.23
	39.78	39.69	73.80	275.5	496.80	62.06
No of Employees	0.81	1.61	3.44	15.40	58.50	1.12
	4.87	5.89	9.40	24.70	114.36	7.49
	0.06	0.27	0.52	2.80	15.08	0.08
	9.10	10.50	19.27	55.54	316.90	15.00
Δ Short Term Debt	0.00	0.00	0.01	0.06	0.21	0.00
	1.03	0.49	0.52	0.56	0.73	0.93
	–5.10	–5.00	–3.92	–3.58	–3.25	–4.90
	7.99	6.42	5.63	4.92	4.53	7.45
Δ Working Capital	1.14	2.17	1.78	1.12	0.65	1.24
	2.56	3.16	2.68	2.01	3.07	2.59
	–9.72	–6.91	–6.28	–5.57	–4.68	–8.91
	16.52	14.29	12.11	8.95	8.20	15.52
Market to Book	1.16	1.12	1.12	1.25	1.33	1.16
	1.64	1.46	1.43	1.59	1.78	1.62
	0.75	0.75	0.75	0.80	0.88	0.75
	2.99	2.43	2.37	2.75	3.24	2.88
Tobin's Q	1.19	1.15	1.16	1.29	1.36	1.19
	1.79	1.66	1.68	1.91	2.07	1.78
	0.77	0.76	0.77	0.81	0.89	0.77
	3.43	2.81	2.80	3.56	4.26	3.35
N. Obs.	74070	6572	6027	4240	1077	91986

TABLE AIII

Distribution of Firms by Patents and Size

At the end of June of each year *t* (1971-2000), stocks are ranked independently by number of own patents granted in year *t-1* and size in year *t-1*. Panel A presents the distribution of firms in the sample by own patents and size. Stocks are held in these portfolios for 12 months, i.e. portfolios are rebalanced yearly. Equal weight annual raw returns are calculated from July to the following June, and the results presented in Panel B.

Panel A – Distribution of firms by patents and size (1970-1999)

	Patents					
	0	1-2	3-10	11-100	>100	Total
Small	52.79	3.88	2.24	0.27	0.00	59.18
2	11.42	1.41	1.53	0.41	0.00	14.78
3	7.38	0.84	1.21	0.73	0.02	10.18
4	5.06	0.61	0.99	1.47	0.11	8.24
Large	3.88	0.39	0.59	1.72	1.04	7.62
Total	80.53	7.14	6.55	4.60	1.17	100.00

Panel B – Annual raw stock returns of firms by patents and size (1970-1999)

	Patents				
	0	1-2	3-10	11-100	>100
Small	18.01	23.25	25.56	35.35	.
2	14.56	15.99	18.05	20.16	80.28
3	12.98	11.68	15.86	16.46	34.45
4	13.02	13.44	12.96	18.21	24.51
Large	13.27	12.06	11.92	13.36	16.88

TABLE AIV

Distribution of Firms by Patents and Book-to-Market

At the end of June of each year *t* (1971-2000), stocks are ranked independently by number of own patents granted in year *t-1* and book-to-market equity in year *t-1*. Panel A presents the distribution of firms in the sample by own patents and book-to-market equity. Stocks are held in these portfolios for 12 months, i.e. portfolios are rebalanced yearly. Equal weight annual raw returns are calculated from July to the following June, and the results presented in Panel B.

Panel A – Distribution of firms by patents and book-to-market equity (1970-1999)

	Patents					
	0	1-2	3-10	11-100	>100	Total
Low	21.26	1.69	1.47	1.35	0.43	26.20
2	14.78	1.52	1.48	1.17	0.29	19.22
3	12.41	1.27	1.18	0.81	0.20	15.87
4	12.56	1.17	1.11	0.62	0.15	15.61
High	19.52	1.50	1.32	0.65	0.10	23.10
Total	80.53	7.14	6.55	4.60	1.17	100.00

Panel B – Annual raw stock returns of firms by patents and book-to-market equity (1970-1999)

	Patents				
	0	1-2	3-10	11-100	>100
Low	9.92	12.73	12.54	11.53	12.00
2	16.07	17.57	16.30	21.30	18.47
3	16.53	21.41	18.57	16.90	12.54
4	19.02	21.85	21.15	17.00	31.97
High	22.41	23.20	27.26	22.95	32.56

TABLE AV

Distribution of Patenting Firms by Size and Book-to-Market

At the end of June of each year *t* (1971-2000), stocks of firms that are granted patents in year *t-1* are ranked independently by size and book-to-market equity in year *t-1*. Panel A presents the distribution of patenting firms in the sample by size and book-to-market equity. Stocks are held in these portfolios for 12 months, i.e. portfolios are rebalanced yearly. Equal weight annual raw returns are calculated from July to the following June, and the results presented in Panel B.

Panel A – Distribution of patenting firms by size and book-to-market equity (1970-1999)

	Book-to-Market					
	Low	2	3	4	High	Total
Small	4.79	5.70	5.51	6.62	10.17	32.81
2	3.63	4.09	3.48	2.76	3.31	17.26
3	3.49	3.80	2.81	2.16	2.15	14.41
4	4.96	4.30	2.98	2.27	1.79	16.29
Large	8.49	4.93	3.01	1.85	0.95	19.23
Total	25.36	22.82	17.78	15.66	18.38	100.00

Panel B – Annual raw stock returns of patenting firms by size and book-to-market equity (1970-1999)

	Book-to-Market				
	Low	2	3	4	High
Small	16.54	21.07	24.65	27.39	28.40
2	12.74	16.86	17.35	14.19	25.88
3	11.81	12.64	16.45	16.43	19.94
4	11.99	18.43	14.93	16.10	21.85
Large	10.20	15.86	15.91	20.14	20.13

TABLE AVI

Patents and Net Equity Issues by Size and Book-to-Market

At the end of June of each year t (1971-2000), stocks are ranked independently by size and book-to-market equity as of year t-1, using NYSE quintile breakpoints. For each portfolio, I run regression (1) in the text, where the dependent variable is net equity issues and control variables are own patents, market-to-book ratio, profitability, fixed assets intensity, and firm size. The Table reports the coefficient on own patents for each of the 25 independent ranks. The standard errors (in parentheses) are adjusted for heteroskedasticity using Huber (1967) and White (1980) corrections and for clustering at the four-digit SIC level using the Huber (1967) correction. Superscripts [a], [b], [c] indicate significance at 1%, 5%, and 10% levels, respectively.

Coefficients on own patents by size and book-to-market portfolios (1970-1999)

	Book-to-Market				
	Low	2	3	4	High
Small	–1.432	–0.509[a]	–0.458	–0.203	0.445[a]
	(1.01)	(.193)	(.293)	(.170)	(.126)
2	0.102	–0.383[b]	–0.271	–0.045	0.182
	(.370)	(.186)	(.181)	(.168)	(.157)
3	–0.471	–0.176	0.227	0.246	–0.135
	(.326)	(.166)	(.171)	(.203)	(.131)
4	0.025	–1.862	–0.676	0.198	0.088
	(.301)	(1.70)	(.750)	(.131)	(.078)
Large	–0.336[a]	–1.074	–0.064	–0.058	–0.060
	(.117)	(.992)	(.103)	(.111)	(.174)

TABLE AVII

Industry Patents, Gross Margins and Valuation

This table reports results for OLS estimations of determinants of gross margins and Tobin's Q on patents, CSM and size. Gross margin is defined as sales minus cost of goods sold divided by assets. Tobin's Q is defined as assets minus book equity plus market equity all divided by assets. Industry patents are defined at the firm level as the log of one plus the number of patents granted per industry-year minus own patents. Industry is defined as the same four-digit SIC code. Own patents are defined as the log of one plus the number of patents granted per firm-year. The competitive strategy measure (CSM) is defined as the coefficient of correlation between (i) ratio of change in firms' net income to change in firm's net sales, and (ii) change in the rest-of-industry's net sales, over the period the firm is listed in Compustat. A positive correlation indicates strategic complements, and a negative correlation indicates strategic substitutes. Firm size is defined as the logarithm of net sales. Financial data are from the annual Compustat industrial tapes. Patent data are from Hall, Jaffe and Trajtenberg (2002), and the sample period is 1970 to 1999. The standard errors (in parentheses) are adjusted for heteroskedasticity using Huber (1967) and White (1980) corrections and for clustering at the four-digit SIC level using the Huber (1967) correction. All regressions include industry fixed effects (at the four-digit SIC code level) and time dummies, not reported. Superscripts [a], [b], [c] indicate significance at 1%, 5%, and 10% levels, respectively.

	Gross Margins				Tobin's Q			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Industry Patents	–0.025[c] (.014)	–0.028[c] (.016)	–0.025 (.018)	–0.025[c] (.014)	0.002 (.011)	–0.002 (.011)	0.011 (.014)	0.002 (.011)
Own Patents	0.126[a] (.015)	0.133[a] (.023)	0.127[a] (.015)	0.126[a] (.014)	0.088[a] (.013)	0.097[a] (.020)	0.083[a] (.016)	0.087[a] (.013)
CSM				0.031[a] (.000)				–0.005[a] (.001)
CSM * Industry Patents				0.016 (.032)				0.011 (.078)
Size	–0.145[a] (.025)	–0.140[a] (.027)	–0.167[a] (.051)	–0.145[a] (.025)	–0.072[a] (.011)	–0.078[a] (.013)	–0.079[a] (.013)	–0.072[a] (.011)
Sample?	Full	CSM>0	CSM<0	Full	Full	CSM>0	CSM<0	Full
No Observations	85234	41643	42366	85234	85234	41643	42366	85234
Adjusted R^2	0.024	0.059	0.023	0.024	0.231	0.243	0.255	0.231