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# The Innovation Nexus: Is Environmental Patent Introduction Influenced by Revenue Growth, Profitability, R&D and Investment Intensity?

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## Abstract

Due to the recent upward trend in environmental sustainability initiatives, many corporations have capitalized on the benefits of appealing to the eco-conscious consumer market by offering them innovative products and services. Patent introduction, used as a proxy for environmental innovation, is a key dimension of measuring how well those corporations are doing to meet both consumer expectations and industry regulations. While some corporations have been more successful in patenting activity than others, there has been little research done on what drives patent introduction from a financial standpoint. Using R&D intensity as a percentage of revenue, net income growth, year-over-year revenue growth, and long-term investment intensity as financial measures, this paper examines the relationship between financial strength and innovation as an organizational outcome. Analysis will be conducted using regression in a STATA xta bond model, using dummy year variables to control for time-fixed effects.

Furthermore, by using a firm-industry ratio of patent growth year-over-year, a better analysis can be performed controlling for industry variations. Bridging the gap between quantitative measures and innovation output will better position corporations to execute patenting activity relative to the monetary resources they possess.

Key Words: Patents, Financial Slack, Revenue Growth, Investment Intensity

## Introduction

> "Sustainable change, after all, depends not upon compliance with external mandates or blind adherence to regulation, but rather upon the pursuit of the greater good."- Douglas B. Reeves

Sustainable change is generally enacted under strong and dynamic leadership; those who have the foresight to innovate and exploit opportunities within the marketplace can and will lead their firms to new and higher competitive ground. While much can be said about the different characteristics these leaders possess, four common dimensions include resource building, network establishment, knowledge integration, and strategy development.

Strong leadership is a key determinant of a firm's ability to innovate, however, there is rarely any mention of what drives corporations to innovate with strictly monetary resources.

Because a firm may possess excess resources in the form of slack (any form of resource endowment that is currently not being utilized for organizational purposes), they can potentially enhance the innovation activity of their organizations by utilizing those resources in more strategic ways. An example of this is when firms reinvest excess profits into R&D activities to open new revenue streams and promote innovation growth within the organization. The "excess resource theory" gives a solid foundation to further explore the implications that a firm's financial measures have on its ability to innovate, specifically with patents.

Given the recent upsurge in the popularity of green entrepreneurship, businesses are often centered on protecting and preserving the environment. This paper seeks to understand the implications that a firm's financials has on its ability to introduce clean technology patents to the marketplace and solve vexing environmental problems, including pollution, climate change, global warming, and greenhouse gas emissions. Though recent work demonstrates how large firms can gain competitive advantage through "greening," little has been said about how those firms undertake innovative activity in the first place.

Though environmental sustainability is a relatively new topic, it merits additional attention because it allows firms to reduce their material costs, increase revenues, foster consumer loyalty, and retain high-quality employees who are motivated to work in "green" areas. What is less understood is the converse; whether financial strength influences a firm to undertake patenting activity in the first place. This paper analyzes the relationship between a firm's clean energy patent activity, used as a proxy for environmental innovation, and its financial strength measured through growth in net income and revenue, as well as its R&D and long-term investment intensity.

Breaking down a firm's financial strength through these four variables enables a distillation of the relationship between a corporation's ability to invent and patent new forms of clean energy technologies based on its ability to manage its slack resources. Slack resources can be in the form of monetary endowments, unabsorbed assets such as physical capital, and excess equipment and property. If an organization is not harnessing its excess capacity, or slack, in an efficient and pragmatic way, it might be losing out on new customer bases, which can affect the company's bottom line. This thesis argues that if an organization can effectively manage its slack resources in a way that grows innovation activity, particularly through patents, then it should be able to open new revenue streams as well as grow profitability through its innovative technologies. It may also be able to enhance its competitiveness within its industry by strategizing where to put future investments and how to invest in R&D activity.

While this paper was initially focused on comparing the differences in patent activity between corporations and entrepreneurial ventures (those who had an IPO within the last 15 years), a shift in focus was required given the lack of substantive patent activity existing for only entrepreneurial firms. Since patent data for corporations within the past 30 years is accessible, it enables a streamlined comparison between different sectors. Accounting for this variation will be a crucial point of the regression, as some sectors are inherently more environmentally-minded while others lack the resources or strategy to innovate based on clean tech patents.

Finally, looking at firm revenue growth and profitability as potential determining factors of a firm's environmental patent activity provides a detailed account of whether firms can invest those excess resources into R&D activities, another potential explanatory factor of patent activity. Positioning firms to innovate and lead their organizations to new and better solutions for environmental problems is a key issue that must be addressed in a modern context, and this paper examines how that can be achieved. Specifically, capitalizing on the eco- conscious consumer market due to the effectiveness of its innovations may enable these organizations to further grow revenue streams and profitability from new products and services.

The next section delves deeper into what information exists on various relationships between a firm's innovation and its financial measures. Section 3 discusses methodology used as well as strengths and weaknesses to the approach used. Section 4 is dedicated to results from three separate regressions, and Section 5 discusses those results in detail. Finally, Section 6 concludes with important implications for organizational innovation strategy as well as key objectives for research centered around this topic in the future.

## Literature Review

This research builds from two existing themes in scholarly discourse, namely trends in environmental sustainability and a firm's innovation activity. First, this section discusses the role that entrepreneurship plays in capitalizing on the growing niche market of environmentally- conscious consumers. The second section aims to discuss a firm's innovation activity as a component of its financial measures. While some measures are more indicative of innovative activities than others, there is sufficient evidence documenting the various correlative relationships between all four financial measures and innovation. Finally, I address gaps that exist around innovation discourse throughout the literature review, and discuss how my thesis contributes to established research in Section 2.4.

*Environmental Sustainability from Entrepreneurial Innovation*

Innovation generally happens through entrepreneurship in large organizations because entrepreneurs enable "green" firms to innovate in the first place. Illustrating this point, a recent stream of research has proposed entrepreneurship as a solution to, rather than a cause of, environmental degradation (Cohen and Winn, 2007; Dean and McMullen, 2007; Larson, 2005). Research by Schaper (2005) points to a growing popularity of green entrepreneurship, or business focused on protecting and preserving the environment. Thus, entrepreneurs can contribute to the sustainability movement by creating new, more innovative products, services, and institutions. By capitalizing on this movement, entrepreneurial firms [that innovate] can reduce their material costs, foster consumer loyalty, and motivate their work forces, which will increase retention of high-caliber employees (Schaper, 2005).

Competitive advantage can [also] be achieved by realizing reduced costs or increased revenue through environmental innovations (York & Venkataraman, 2010). Since entrepreneurs can capture niche consumer markets by offering sustainable products/services, they may gain a competitive advantage in their respective industries by sourcing less material (cutting costs) and being innovative through patenting activity.

*Firm Innovation, R&D Spending, and Investment Intensity*

Competitive advantage is a key reason for undertaking innovative activity, but the question remains as to what drives or deters innovation from a financial standpoint. As was alluded to earlier, reduced costs or increased revenue through environmental innovations can help drive competitive advantage. However, is the converse true? This section attempts to examine the literature surrounding this research question.

A firm's R&D expenditure total is the first financial component that plays a determinant role in how innovative a firm is; for example, how many environmental patents are introduced on an annual basis. However, caution should be applied when analyzing the literature. According to Pakes and Griliches (1980, p. 378), "patents are a flawed measure of innovative output, particularly since not all new innovations are patented and differ greatly in economic impact." An important implication to be taken from this observation is that patents do not account for a firm's total innovation output. Thus, while a firm may have low patenting activity, it does not necessarily mean that firm is less innovative. Rather, it is feasible that the firm is highly innovative through its daily operations but has a low incentive to undertake patenting activity.

Moving along, past success from R&D investments leads to greater current R&D efforts by successful firms, whereby they produce further innovations and widen the gap between themselves and rivals (Shah, 1994). However, it should be noted that one feature of R&D activity is the lag time between spending and the introduction of new products and processes (Czarnitzki and Kraft, 2010). This is an important feature of R&D expenditures because knowledge building and resource allocation, both of which are crucial to R&D activity, take time to manifest into actual R&D outputs (i.e. patents).

Financial constraints should also affect R&D investment because of the high degree of uncertainty characterizing innovation output (Bartoloni, 2011). Thus, if a firm doesn't have sufficient cash flow to fund R&D expenditures, innovation and patent activity should be negatively affected, depending on the firm's ability to acquire equity or debt financing. Intuitively then, problems associated with financing innovative activities among younger, smaller firms will be more pronounced, especially if each firm has fewer internal resources (Bartoloni, 2011). This becomes important when analyzing the relationship between innovation and R&D, especially in situations where the firm does not have adequate resources to undertake patent introduction in the first place.

Finally, Kim et al. (1993) argues that successful firms deploy more aggressive strategies to achieve innovation [in part] through internal efforts to invest in R&D activity (Oke, Walumbwa, and Myers, 2012). However, Hambrick and MacMillan (1985) show the effectiveness of R&D in generating innovations vary between industries (Audretsch, 1995). Because each industry has different tendencies to introduce new products, it's important to control for industry type when correlating R&D and innovation variables. While the literature demonstrates that R&D expenditure activities are inextricably linked with innovation, there is no clear distinction drawn between R&D activity and *environmental* innovation in different firms. This is one of the gaps my research intends to address.

The second component that could potentially affect firm innovation is long-term investments. Investments include inputting cash into human capital, R&D, knowledge acquisition, and other long-term assets such as equipment and buildings. Unfortunately, literature around investment intensity as a variable that affects innovation is scarce. However, one study conducted by Parisi et al. (2006) suggests that investment spending on new machines promotes the probability of introducing a process innovation, but it is also enhanced by R&D spending. This demonstrates that innovation output in some form is aligned with a firm's investment activity. Caution should be applied, however, because investment intensity and R&D spending are treated as the same variable throughout the literature. Conversely, both measures are treated as separate dimensions in my regression.

### *Innovation's Role with Profitability and Revenue Growth*

Profitability is a key financial outcome of innovation. In Joseph Schumpeter's seminal work "The Theory of Economic Development" (1934), he illustrated the importance of innovations and organizational innovativeness as one of the key factors in determining long-term profitability (Tuominen et. al, 2004). Additionally, based on the knowledge-production function put forward by Griliches (1979), there is a linear relationship between patented inventions as inputs affecting the market value of the firm (Lotti, 2008).

Furthermore, studies by Jaffe (1986), Geroski et al. (1993), Holger (2001) and Leiponen (2000) found empirical evidence of a significant positive association between R&D (patents or innovations) and firm profit (Hanel, 2002). Thus, there seems to be an inherently positive relationship between innovation or patent introduction and profitability in a firm. However, the literature is almost non-existent in explaining a converse relationship; thus, a clear gap in the literature exists.

Revenue growth is another critical outcome of organizational innovation. Research by Crespell and Hansen (2008) suggests that firm resources that are effectively harnessed to achieve superior innovation performance can lead to revenue growth. Additionally, Beugelsdijk (2008) finds that innovation-focused HR policy helps to foster innovation by creating an environment whereby employees can try out new ideas to generate new products that positively impact revenue growth (Oke, Walumbwa, and Myers, 2012). While this research focuses primarily on resource and policy objectives that drive revenue growth, it shows there seems to be a correlation between revenue growth and innovation performance.

One requisite consideration for revenue growth is time lags. Geroski and Jacquemin (1988) argue that the effect of innovation performance on sales revenue growth may not be immediate and could last for many years (Oke, Walumbwa, and Myers, 2012). This will also have implications for my regression as it captures time-lag variation across firms. While the causal relationship with innovation as a determinant for future revenue growth is well- established, the converse is not well understood. Thus, this serves as another key gap in the literature that my thesis attempts to fill.

### *Contributions to Existing Literature*

Given the inherent gaps in the literature, my thesis contributes to the existing research in four distinct ways. The first contribution comes from analyzing the relationship between a firm's profitability and its innovation activity, and whether the net income a firm derives from its activities drives its ability to introduce patents into the marketplace thereafter. The second contribution is through a firm's revenue structure. As demonstrated through existing literature, introducing new innovations in the marketplace enables a firm to increase its revenue streams through multiple product channels. However, there is scant research on the relationship between a firm's revenue structure and how that influences innovation.

The third contribution is analyzing how a firm's investment increase is tied to its patent output. Again, research around this variable is scant, especially when investment increase is tied to a firm's revenue growth. Thus, investment intensity is a novel approach to use in assessing how a firm undertakes environmental patenting.

The fourth contribution is establishing a relationship between a firm's financial measures and its *environmental* innovation. While much research has been conducted on the relationship between financial strength and innovation activity, there is little knowledge of what drives a firm to undertake environmental innovation from a purely financial standpoint. While literature exists around the qualitative approaches to being environmentally innovative, quantitative measures are less established.

## Hypothesis Justification and Statements

Based on recent trends in corporate innovation, I explore the relationship between four financial measures – net income growth, revenue growth, R&D intensity, and long-term investment intensity - and one dependent variable, environmental innovation.

For my first independent variable, net income growth, I propose that a company's earnings growth will positively affect its environmental patent introduction. Geroski et al. (1993) shows that the number of innovations produced by a firm has a positive effect on its profitability; therefore, it is logical to consider whether the converse is true. Thus, we arrive at the first hypothesis:

> H1: *Greater firm profitability has a positive causal relationship on environmental patent introduction, whereby a one-year time lag is accounted for across all variables.*

Environmental patent introduction may also be influenced by a company's ability to diversify and capitalize on multiple revenue streams. Oke, Walumbwa, and Myers (2012) hypothesized that executing innovation strategy in turbulent environments enables firms to exploit opportunities and create new revenue streams. However, what is less understood is the ability to grow clean tech patenting activity from an increasing revenue stream. Based on the cyclical nature of revenues year-over-year, I conclude that there is a relationship between revenue growth and environmental innovation, whereby companies that have higher revenue growth are more likely to diversify their portfolio and introduce more environmental patents. Furthermore, since revenue growth's effects on patent introduction may not be immediately realized, I account for a lagged patent variable. Thus, the second hypothesis:

> H2: *Higher firm revenue growth positively affects environmental patent introduction, whereby a one-year time lag is accounted for across all variables.*

My third independent variable, R&D intensity, is another potential influencer of environmental innovativeness. According to Dean and McMullen (2007), there is increasing evidence of substantive environmental degradation and recent market developments in renewable energy, fuel cells, green building, natural foods, carbon emissions, and other sectors which suggests an increasing importance for environmental entrepreneurship. If a company has a higher R&D expenditure total in a given year, it may lead to higher patenting activity.

However, one important implication of this correlation is time lags. In the literature, there seems to be an inextricable link between a firm's R&D expenditure total and its patent activity, but not in the same year. This directly affects my research as my regression attempts to account for that time lag variation across firms to determine if those R&D expenditures are eventually realized through patenting activity in subsequent years.

Since my analysis uses environmental patents as a proxy for a firm's environmental innovation, the difference between patents and total innovative output needs to be established. While there is a .440 correlation between company R&D expenditures and patents, there is a .746 correlation between R&D expenditures and total innovations (Acs and Audretsch, 1988). Given the .306 correlative difference between patents and total innovation with R&D expenditures, my paper will further explore whether this correlation is valid when translated into the clean tech patent space. Thus, my third hypothesis:

> H3: *Greater R&D intensity, calculated as R&D expenditures as a percentage of revenue totals in the same fiscal year, will positively influence environmental patent introduction, whereby a one-year time lag is accounted for across all variables.*

Lastly, my fourth hypothesis suggests that a firm's investment intensity, calculated as a firm's long-term investments as a percentage of its revenue total in the same fiscal year, will positively affect environmental patent introduction. Since R&D spending is inextricably tied to a firm's patenting output, it is reasonable to conclude that a firm's investments are closely aligned with its patenting activity as well. This is because Lerner et al. (2008) suggest that long-term investments are embodied in a firm's R&D expenditures (hypothesis 3); however, investment intensity will be treated as a separate variable in this regression to account for variability across both dimensions and analyze how a firm differs between its actual R&D expenditure output and its increase in investments year-over-year. Thus, my fourth hypothesis:

> H4: *Investment intensity, calculated as a firm's long-term investments as a percentage of revenue totals in the same fiscal year, will positively affect environmental patent introduction, whereby a one-year time lag is accounted for across all variables.*

### *Data Collection and Measures*

To collect my dependent variable, environmental patents, I utilized a patent dataset called Clean Energy Tech. This database breaks down patent types according to country, firm, publishing date, and filing date. From this database, I aggregated total patent introduction ranging from 1981-2012. No fiscal years outside of this range, excluding 1976 and 1980, were pulled because no patent data existed. Furthermore, 1976 and 1980 fiscal years were thrown out of the sample because the number of patents that existed was not high enough to warrant their inclusion.

Based on the high volume of U.S. companies entered into the database, I used a simple proportional sales grossing test to determine which companies averaging the highest sales fell in the top 5% of those on the sales spreadsheet; thus, the sample included 133 companies (See Appendix A for company names). Trimming the sample to include 133 of the largest firms was appropriate given the extensive list of companies on the sales spreadsheet. Also, this sample is inclusive enough of large firms to give an accurate depiction of what the general pattern is between firm financial measures and its patenting activity. In performing output, I followed a template model established by my honors assistantship mentor, pulling aggregated data on patent name and number, company name, and publishing and filing date.[1]

For my independent variable collection, I utilized the Wharton Research Data Services (WRDS) site. WRDS contains numerous financial data points for any public firm dating back to 1950, and gives a detailed account of firm financial patterns over long periods of time. WRDS variable sections that were included in my analysis included Company Descriptor, Balance Sheet Items, Income Statement Items, Cash Flow Statement Items, and Miscellaneous Items. Each of these sections contained different variables for my analysis (See Appendix B for Variables Pulled). After variable collection, I had to organize datasets into one centralized location.[2]

To fully tabulate data from the Clean Energy Tech Patent Database, I worked with Jan Fransen, a U of M Computer Science librarian, to develop a pivot table wherein both company names and publishing date year were row labels in column A, and number of patents introduced by firm year were displayed in column B.

## *Analysis*

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[1] Since Clean Energy Tech patents wer[1]e pulled first in data collection, I manually looked up company names in the WRDS annual compustat file and tabulated a code list that was saved into a "lookup code" field. Then I developed a query to pull through my variables and observations for the time period, 1981-2012.

[2] Organizing the data from the two databases required two different approaches. For WRDS, a template was already established wherein a variable would be assigned a unique column, and one unique observation would be recorded per fiscal year per company. To make sure firms were matched and identified across both databases, a GV Key unique to each of the 133 companies was pulled through so that company inclusion was assured.

I use a quantitative analysis approach to analyze my four hypotheses. The statistical technique I use is a multivariate regression with time-fixed effects serving as dummy variables. Specifically, time-fixed effects are controlled for through the year in the regression, and account for firm variability in any given fiscal year. Additionally, macroeconomic trends (recessions, economic growth booms) are captured in the data based on the dummy variables. Finally, industry types are controlled for in the dependent variable to better understand whether particular firms in any sector have higher annual patent introductions on average than the aggregate average in that sector. Below is the regression equation for my model:

$$(1)\ \text{Patent Count}_{t} = \mathcal{B}0 + \mathcal{B}1\ \text{Revenue Growth}_{t/t-1} + \mathcal{B}2\ \text{Net Income Growth}_{t/t-1}$$
$$+ \mathcal{B}3\ \text{R\&D Intensity}_{t} + \mathcal{B}4\ \text{Investment Intensity}_{t}$$
$$+ \mathcal{B}5\ \text{Slack Control } 1_{t} + \ldots\ldots + \mathcal{B}12\ \text{Slack Control } 8_{t} +$$
$$\mathcal{B}13\ \text{Fiscal Year Dummy}_{t} + \epsilon$$

The number of firm employees is a key control variable in this analysis as it helps identify the inherent differences in firm size across my sample, and eliminates any effects that firm size might have on its ability to patent more aggressively. Other control variables included in the analysis include unabsorbed slack, capital expenditures, long-term debt, and working capital intensity.

A regression analysis is effective at explaining correlations between my independent variables – revenue growth, net income growth, R&D intensity, and long-term investment intensity – and dependent variable, environmental patent introduction. To evaluate the regression coefficients, I use a t-test paired with its associated p-value, which measures the strength of evidence against the null of no effect (Manchester, 2013). The p-value is thus a criterion that evaluates the statistical significance of regression results.

### *Strengths of Methodology*

There are five key strengths to my methodology. The first inherent strength is the data collection sources I used in my research. As opposed to a primary data or qualitative collection method, I used both Clean Energy Tech and WRDS, two widely recognized databases, which contained detailed information over a large period of time. In doing so, I collected firm data that may be a better representative sample of the larger population of firms in the U.S. Using a representative sample makes my results more generalizable to U.S. firms and is an important addition to the body of research on this topic. From this, the second strength is the sample size itself. With over 133 firms in my sample and 31 years of fiscal data, my number of observations exceed 2,000 data points and is large enough to minimize margin of error when running regressions.

The third strength of my methodology is that the multi-variable regression model can measure the variance explained in the model by the independent variable. Therefore, it gives a good indication of what residual variability exists that needs to be analyzed in further detail through other approaches, such as non-financial factors and other qualitative approaches.

Fourth, establishing a relationship between the independent and dependent variables is an inherent strength in a regression, because it enables control of other confounding factors. Thus, statistically significant relationships between the independent variable and dependent variable being measured can be established, whereby the regression model is a predictor of outcomes while accounting for variability among other explanatory factors.

Fifth, regression analysis also provides an opportunity to specify hypotheses concerning the nature of effects as well as explanatory factors (Evaluating Socio-Economic Development, Dec. 2003). It also can produce quantitative estimates of net effects, meaning it can measure to what extent the independent variable is correlated with the dependent variable and whether the relationship is positive or negative.

### *Limitations of Methodology*

There are two key limitations in my methodology. The first limitation is the interactive effect between my independent variables. An interactive effect exists whenever one variable combines with another and produces either a compounded or diminished effect on the dependent variable. Since my analysis includes many variables, it is difficult to discern which variables are interacting with one another to enhance the effects of financial slack on environmental patent introduction. This makes it difficult to suggest whether two or more independent variables are producing significantly higher patent introduction for a certain firm because the model excludes these interaction effects.

The second limitation of my methodology was the roll-up of patents under one company when I ran queries in the Clean Energy Tech Patent Database. For example, when performing a search of a firm with “Co.” as the end term, the results list would tabulate patents for the firm with other end terms including “Corp.”, “Corporation”, “Company”, and “LLC.” Given the vagueness of query terms used, most of the results lists would turn up more patents than I had wanted. This lack of precision and not being able to filter patent results regarding end terms mentioned above is a limitation that may hamper the ability to draw precise conclusions from the results based on a firm’s specific naming convention.

### *Assumptions of Model*

Assumptions that my methodology relies on include random sample size and exogeneity. Random sample size specifies that my firm pull in the

Clean Tech Patent Database was completely random and not influenced by any bias. Since I used a proportional test pulling the top 5% of sales grossing companies over an average period of time, my sample is representative of the general U.S. firm population.

Additionally, exogeneity is controlled for through the xtabond model used in my regression as endogenous variables are included to eliminate reverse causality. Thus, once reverse causation between y and x is eliminated, a one-way causal relationship between x and y can be discerned.

## Results

Table 1 shows the output from the regression run in the STATA xtabond2 model (See Appendix C for regression command). Using a one period lag on each variable, excluding log firm size, a measure of firm employee total, the table shows that four variables are statistically significant. However, one of the statistically significant variables, lagged cumulative patent years, is the dependent variable and will be excluded from further analysis because the variable is only showing that when lagged, the results are statistically significant from those observed when a raw patent year cumulative total is observed without any lag. Therefore, this shows that the inclusion of a one-year lag on each variable will be critical in discerning which variables when lagged are affecting patent introduction in the subsequent year.

| Patents_year_cum (L1.) | Coefficient | Corrected Standard Error |
|---|---|---|
| Patents Year Cumulative | .2404*** | .0809 |
| Revenue Growth | .3791** (.0007) | .1863 |
| Net Income Growth Research | .5301 | .0012 |
| Intensity Investment | .0000*** (.1190)** | .9587 4.84e-06 |
| Intensity Unabsorbed Slack | .0381 | .0545 |
| Log Firm Size SG&A Expenses | .2440 | .0412 |
| Excess Physical Resource | .1807 | .2754 |
| Excess Human Resource | 13.57 | .4110 |
| Capital Assets | (.1784) | 18.38 |
| | | .1684 |

*/**/*** Denotes significance level .1, .05, and .01, respectively.
Caution: Number of instruments may be large relative to number of observations.
Note: See Appendix D for Robustness and Instrument Tests, Appendix E for Correlation Table, and Appendix F for Summation Table.

TABLE 1: Regression Model Using One-Period Lag

Revenue growth, one of the four independent financial measures, is statistically significant at a 95% confidence level. The second independent variable, investment intensity, measured as an increase in investments over revenue growth, is also statistically significant but at a 99% confidence level. This demonstrates that long-term investment intensity is highly causal in nature and inextricably linked to a firm's environmental patent introduction.

Unabsorbed slack, a control variable measuring a firm's current asset total over current liability total, is also statistically significant at a 95% confidence level, meaning it may be a contributory factor to environmental patent introduction, even though this paper does not hypothesize on the effects stemming from this variable.

After running the initial regression, there were two other tests performed. The first was a regression from Table 1 with the inclusion of two new variables, long-term debt and working capital. These variables help measure a firm's propensity for risk in the form of debt and its ability to utilize working capital in direct proportion to its revenues. The initial intent on re- running the regression was to determine the statistical significance differential on the independent variables by including two more control variables. Table 2 shows the output below.

| Patents_year_cum (L1.) | Coefficient | Corrected Standard Error |
|---|---|---|
| Patents Year Cumulative | .2399** | .0961 |
| Revenue Growth | .3137** (.0007) | .1347 |
| Net Income Growth Research | .0909 | .0010 |
| Intensity Investment | .0000** (.1857) | 1.784 |
| Intensity Unabsorbed Slack | .0297 | 7.50e-06 |
| Log Firm Size | .2164 | .1461 |
| SG&A Expenses | | .0570 |
| | | .3326 |
| Excess Physical Resource | .1921 | .2278 |
| Excess Human Resource | 7.104 | 18.02 |
| Capital Assets | (.1590) | .3336 |
| Debt-to-Assets | .0460 | .0387 |
| Working Capital/Sales | .5469 | .7720 |

*/**/*** Denotes significance level .1, .05, and .01, respectively.

TABLE 2: Regression with Long-Term Debt and Working Capital Variables

While long-term debt and working capital variables are not statistically significant, it should be noted that unabsorbed slack, one of the significant variables from the original model, has statistical significance diminished below a 90% confidence level. Revenue growth and investment intensity are still statistically significant but at a 95% confidence level, suggesting the inclusion of new variables only diminished the significance of investment intensity from a 99% to 95% confidence level. Net income growth and R&D intensity are statistically insignificant showing a failure to reject the null hypothesis.

The second test alluded to earlier involves interaction effects. Since the interaction potential between variables in my regression seems endless, I ran one test between the interaction of two independent variables, R&D intensity and revenue growth, to measure the statistical significance differential existing between the interaction-effect test and the original model. From this test, I could determine if more interaction combinations needed to be tested based on their bias in the output.

Based on the results in Table 3, the interaction effect between revenue growth and a firm's research intensity is statistically insignificant. While there is the potential of other variables moderating each other to produce different effects, it is not merited from this analysis because of the high p-value stemming from the IV. Additionally, it is not logical to assume that net income or R&D intensity will combine with other variables to produce a causal result when those variables by themselves elicit high p-values that are statistically insignificant.

| Patents_year_cum (L1.) | Coefficient | Corrected Standard Error |
|---|---|---|
| Patents Year Cumulative | .2489*** | .0696 |
| Revenue Growth | .2557 | .2307 |
| Net Income Growth Research | (.0003) | .0011 |
| Intensity Investment | (.0702) | 1.673 |
| Intensity Unabsorbed Slack | .0000** (.1679) | 6.73e-06 |
| Log Firm Size | .0124 | .1091 |
| SG&A Expenses | .2090 | .0449 |
| Excess Physical Resource | .2368 | .2681 |
| Excess Human Resource | 8.936 | .4362 |
| Capital Assets | (.0434) | 18.48 |
| Debt-to-Assets | .0192 | .2015 |
| Working Capital/Sales | .4373 | .0321 |
| <u>Interaction Variable:</u> Revenue Growth x Research Intensity | (.1914) | .4825<br>2.505 |

*/**/*** Denotes significance level .1, .05, and .01, respectively.
Note: Statistical significance for revenue growth as a mutually exclusive variable is kicked out because the number of instruments for this test soared to 417 from 390 in Table 2. Because of this, instrumentation can bias significance if the number of observations is relatively low in comparison.

TABLE 3: Regression with Interaction-Effect Test

## Discussion

This section develops the results section by discussing findings from the regression, evaluating which variables have a higher influence on patent introduction, and proposes other frameworks that may potentially contribute to organizational patent activity.

*Regression Analysis*

Firms that have higher annual revenue growth do not necessarily have higher environmental patent counts in the subsequent year. Figure 1 demonstrates this effect below.

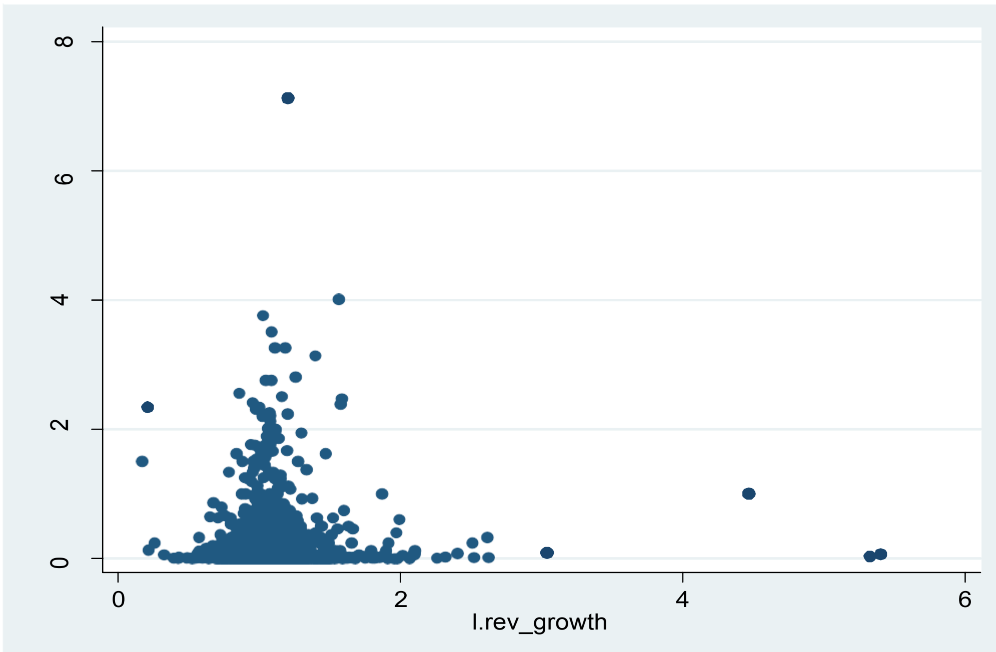
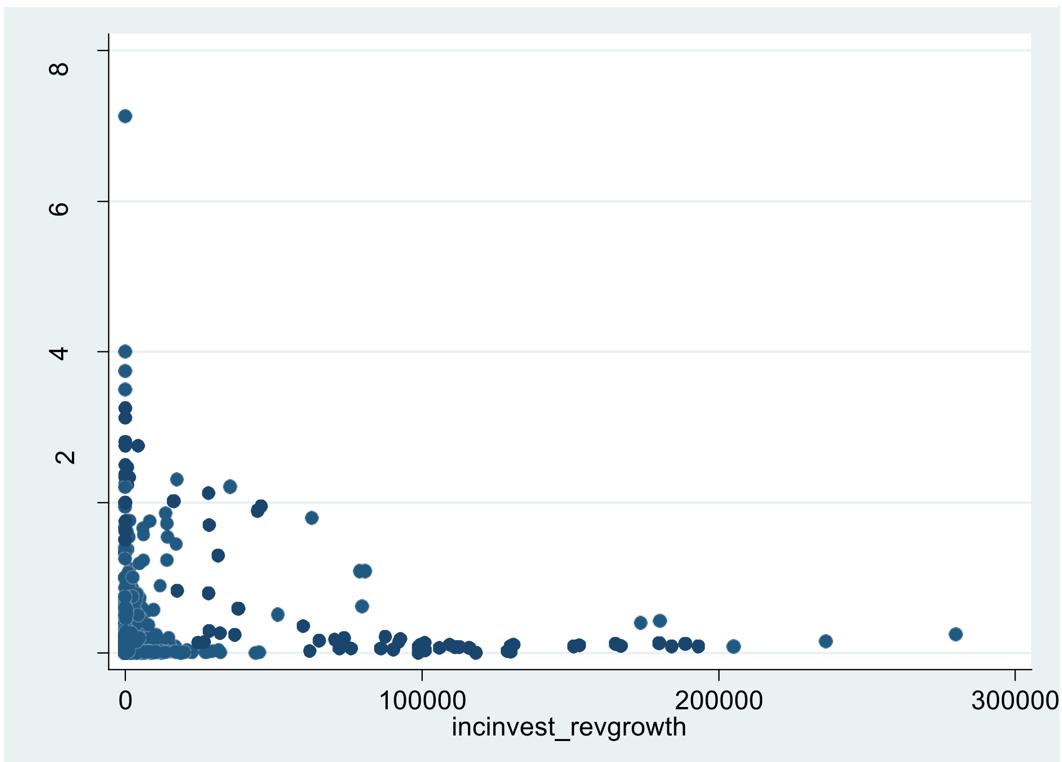



FIGURE 1: Effects of Firm Revenue Growth on Environmental Patent Count

Based off the graph, there is an inverted U relationship between a firm's revenue growth year-over-year and its patent accumulation. Two possible explanations exist for this relationship. The first involves the upward slope of the inverted U; when firms are growing revenues up to a certain threshold (in this case, a revenue growth of approximately 1), they do not possess the monetary endowments or financial slack in the form of revenue streams that other firms have. Because of this, they lack the inherent resources needed to engage in extensive patenting activity and therefore introduce less environmental patents in the subsequent fiscal year.

The second explanation deals with the downward slope after the threshold is met. When firms have excess financial slack to the point where they are growing revenues at twice the pace of their competitors (revenue growth of 2 rather than 1), they become careless with where they deploy excess monetary resources and lose strategic focus in how to grow patenting activity. Because of the inverted U relationship, Hypothesis 2 is supported only to the extent that the firm has a revenue growth ≤ ~1.0. After that, higher revenue growth begins to diminish patent accumulation. These factors point to the need for firms to understand how to allocate and spend monetary resources to grow patenting activity and open new product/service channels for consumers.

Another key insight from the results section involves the robustness and strength of the investment intensity variable. Regardless of which test was performed, investment intensity was significant at either a 95 or 99% confidence level, showing it is a variable that is highly causal in nature of environmental patent introduction. Figure 2 depicts this pattern below.




*Note: The graph is scaled to 100,000 increments because the increase in investment variable is a raw data measure of increase in investments YOY. From this, interpretation of the graph shows that an increase in investment of $1,000 divided by its growth rate (i.e. 1.0) in revenue gives a data point of 1,000 on the x-axis.

FIGURE 2: Effects of Firm Investment Intensity on Patent Accumulation

An interesting trend that emerges from the graph is higher patent count emerges when increase in investments is closely aligned with revenue growth. Thus, a higher investment intensity compared to its revenue growth rate does not imply higher patent accumulation. In fact, the converse seems to be true in which organizations that incrementally increase their investments year-over-year relative to their revenue growth introduce more environmental patents. This implication also has a strategic component to it because firms that are substantially increasing investments YOY (i.e. > $100,000) may not be investing wisely, which diminishes their patenting activity. Therefore, firms need to be cognizant of these effects if they want to develop more environmental patents.

Hypotheses 1 and 3, dealing with profitability and R&D intensity, respectively, were not supported in any regression test, showing that neither is a contributory factor to environmental patent introduction. Both findings are surprising to the extent that one is a measure of financial capacity (profitability) and the other is a measure of its propensity for risk (R&D intensity).

The finding about R&D intensity is especially interesting because the literature suggests that R&D spending is directly correlated and even causal of a firm's innovativeness, including its patenting activity. One reason this inherent gap between findings may exist is because my thesis analyzed *only* the environmental patent activity of firms, not its entire patenting engagement. This may suggest that a firm's ability to develop environmental patents is distinct from its ability to develop other types of patents. This conclusion will be elaborated on in the final section.

One interesting finding from the regression is that unabsorbed slack, a control variable, was statistically significant at a 95% confidence level. Even though this thesis does not measure the impact a firm's unabsorbed slack has on its ability to introduce environmental patents, it should be noted that this variable has important implications for future research. Figure 3 illustrates the relationship between firm slack and environmental patenting.

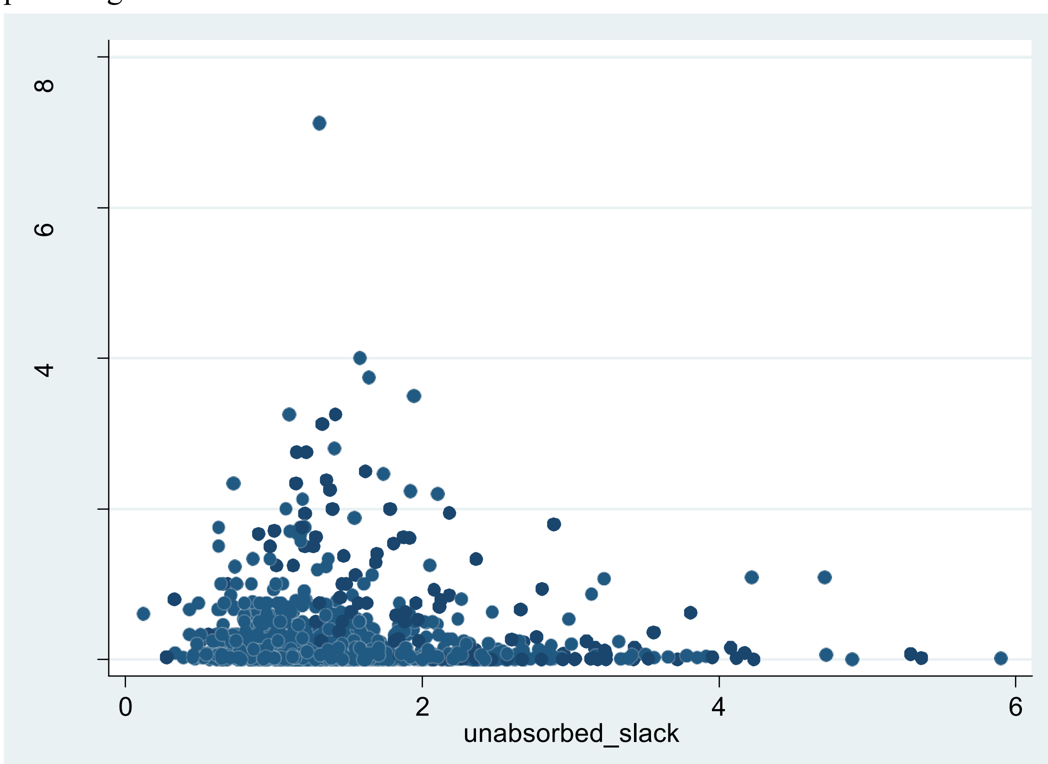


FIGURE 3: Effects of Firm Unabsorbed Slack on Environmental Patenting

An interesting trend from the graph is that unabsorbed slack is related to revenue growth (Figure 1), because both variables follow an inverse-U relationship regarding patent accumulation. However, the explanation for the pattern is different because unabsorbed slack measures a firm's current assets with relation to its current liabilities.

If a firm's ratio is roughly equal to 2, then it is achieving its highest patent accumulation based off the graph. Further analysis shows that if a firm's ratio is < 2, it is still increasing patent accumulation. Two explanations exist for this relationship. First, if liabilities exceed assets (i.e. the slack ratio < 1), then the firm is utilizing whatever assets it has to introduce more environmental patents to survive. Second, once assets exceed liabilities (unabsorbed slack ratio > 1), then the firm can appropriate excess slack to areas within the organization that are engaging in patenting activity. Once the unabsorbed slack ratio > 2, the firm may become haphazard in investing excess slack into patenting activities. Figure 3 shows this trend in diminishing patenting activity after this threshold is reached. Thus, organizations need to be cognizant of what their unabsorbed slack is, and how that can contribute to patenting activity.

The next section discusses key qualitative factors that could potentially affect an organization's innovation and patenting activity.

*Mental Framework Models of Different Entrepreneurial Typologies*

Since financial measures do not depict a complete picture of what does and does not contribute to environmental patent introduction, many other factors may contribute to the inherent innovativeness of any organization, including entrepreneurial typologies. These typologies focus on what qualities entrepreneurs possess to become more proactive within the organizations they work in and make them more environmentally-minded.

Sustainable entrepreneurs are different from wealth-maximizing entrepreneurs because they supposedly display a different mentality as evidenced through donations to environmental causes, employee-friendly working conditions, an interest in wider social issues instead of solely bottom-line profits and a concern for the longer-term implications of their business activities (Harvey, 2007). Additionally, "ecopreneurs" are typically social activists, who aspire to restructure the corporate culture and social relations of their business sectors through proactive, ecologically oriented business strategies (Isaak 1998:88). Thus, entrepreneurial ventures are beginning to transform the marketplace and adapting traditional practices and operations to fit their business models and individual frameworks of thinking.

Given the importance of green entrepreneurs in the transition towards a sustainable society, Walley & Taylor (2002) attempt to analyze how green entrepreneurs are motivated, and which, if any, influences are most relevant in that context. According to their research, green entrepreneurs are best characterized by a combination of internal motivations and external (hard and soft) structural influences (2002). Additionally, there are four typologies of green entrepreneurs: ad hoc enviropreneur, innovative opportunist, ethical maverick, and visionary champion. Each typology differs in what types of soft (personal networks) and hard (economic incentives) structural elements influence each “sustainable entrepreneur.”

This typology is important because it sets up a framework within which entrepreneurs gravitate toward entirely different principles than other types of entrepreneurs (wealth- maximizing), and thus, it is inherently easier for them to bring innovative and unique ideas into the marketplace. These ideas and innovations eventually become the impetus for radical changes in industries and sectors, and allow sustainable entrepreneurs to reap those benefits through revenue growth and higher profit margins.

The research to date has uncovered that sustainable entrepreneurs may be guided by a completely different motivational framework than those who work in the corporate world, and therefore, may find it easier to contribute to the environmental movement through innovative and unique logics of thinking and action. However, the literature fails to provide empirical evidence as to whether these entrepreneurs capitalize on their unique skills by bring new green products and services to market. One important implication stemming from this lack in knowledge is analyzing how typologies influence innovative frameworks of thought and action, and thus, contribute to new environmental-based solutions in the marketplace (in the form of patents).

Since innovation has been found to be partially guided by these entrepreneurial typologies, it is important to discuss what future organizations may strategically do to enhance their innovativeness and promote new avenues of growth. The conclusion builds on this implication and gives key research objectives for future projects to adopt to fully account for an organizations’ environmental innovativeness.

## Conclusion

Based off Figure 1, corporations that have revenue growth up to a certain threshold are most likely to see higher patenting activity within the clean technology space. Once that threshold is reached, however, organizations need to be weary of how any excess resources are going to be allocated to continue to grow patenting activity. One way to do this is by inputting cash into long-term investments. Because long-term investment strategies are closely tied to a firm’s ability to introduce clean tech patents, firms need to be aware of how it can grow those investments through excess revenues. However, as was discussed in Section 5.1, caution needs to be applied when investing excess resources. Keeping investments closely aligned with revenue growth will be a key indicator of whether the organization can grow its patenting activity (Figure 2).

Many organizations should not be discouraged to undertake patenting activity if they do not possess the excess capacity to invest; rather, they should look to hire an entrepreneur who possesses the framework necessary to innovate and change the status quo within their organizations as discussed in section 5.2.

Since my analysis ignored the implications of entrepreneurial typologies and organizational cultures, I would suggest these two factors as potential variables in any future research around this topic. Additionally, controlling for corporate social responsibility (CSR) efforts as well as innovation and hiring policies could help discern whether qualitative or quantitative factors, including financial measures, are better at explaining the introduction of environmental patents. Because this analysis focused exclusively on firm financial measures, while controlling for macro-economic trends and sector variations, it would be interesting to analyze what other factors contribute to an organization's patent activity and whether those factors can interact with financial measures to produce a higher patent count.

Finally, analyzing the difference between environmental patent introduction and other types of patent introduction through a firm's financial measures could be an interesting proposal for future research topics. Trying to explain the inherent differences that exist between different patenting activities is hard to analyze unless a two-sample t-test was performed to discuss the statistical significance between different patenting types. Only then could organizations better formulate strategies to decide which patent type is beneficial to their organization and whether that activity is highly affected by its financial slack in the form of revenue growth, profitability, R&D and long-term investment intensity.

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# Appendices

## *Appendix A: Companies Included in Sample*

| | |
|---|---|
| 3M COMPANY | CONOCOPHILLIPS |
| ABBOTT LABORATORIES | CONSOLIDATED EDISON COMPANY OF NEW YORK, INC. |
| AGILENT TECHNOLOGIES, INC. | CSX CORPORATION |
| ALCOA INC. | DEERE & COMPANY |
| AMERICAN AIRLINES, INC. | DELL INC. |
| AMERICAN ELECTRIC POWER COMPANY, INC. | DELPHI CORPORATION |
| AMERITECH CORPORATION | DELTA AIR LINES INC |
| AMOCO CORPORATION | DIGITAL EQUIPMENT CORPORATION |
| ANHEUSER-BUSCH COMPANIES, INC. | DIRECTV GROUP INC, (THE) |
| AQUILA, INC. (OLD) | DISNEY (WALT) COMPANY |
| ARCHER-DANIELS-MIDLAND | DOW CHEMICAL COMPANY (THE) |
| CO ASHLAND INC. | DUKE ENERGY CORPORATION |
| AT&T CORP. | E.I. DU PONT DE NEMOURS & CO |
| AT&T INC. | EASTMAN KODAK CO |
| AT&T WIRELESS SERVICES, INC. | EDISON INTERNATIONAL |
| ATLANTIC RICHFIELD COMPANY | EL PASO CGP COMPANY |
| BELLSOUTH CORPORATION | EL PASO CORPORATION |
| BOEING COMPANY (THE) | ELECTRONIC DATA SYSTEM CORPORATION |
| BRISTOL-MYERS SQUIBB COMPANY | EMERSON ELECTRIC CO |
| BUNGE LIMITED | ENRON CORPORATION |
| CARDINAL HEALTH, INC. | EXXON MOBIL CORPORATION |
| CATERPILLAR INC. | FARMLAND INDUSTRIES, INC. |
| CBS CORPORATION | FEDEX CORPORATION |
| CELLCO PARTNERSHIP | FLUOR CORPORATION |
| CENTERPOINT ENERGY, INC. | FORD MOTOR COMPANY |
| CHEVRON CORPORATION | FOX ENTERTAINMENT GROUP INC |
| CHRYSLER CORPORATION | GENERAL DYNAMICS CORPORATION |
| CISCO SYSTEMS INCORPORATED | GENERAL ELECTRIC COMPANY |
| COCA-COLA COMPANY (THE) | GENERAL MOTORS CORPORATION |
| COCA-COLA ENTERPRISES INC. | GEORGIA-PACIFIC CORPORATION |
| COMPAQ COMPUTER CORPORATION | GOODYEAR TIRE & RUBBER COMPANY (THE) |
| CONAGRA FOODS, INC. | GTE CORPORATION |

| | |
|---|---|
| HALLIBURTON COMPANY<br>HESS CORPORATION<br>HEWLETT-PACKARD COMPANY<br>HONEYWELL INTERNATIONAL INCORPORATED<br>INTEL CORPORATION<br>INTERNATIONAL BUSINESS MACHINES CORPORATION<br>INTERNATIONAL PAPER COMPANY<br>JOHNSON CONTROLS, INC<br>KIMBERLY-CLARK CORPORATION<br>KRAFT FOODS INC.<br>KRAFT, INC.<br>LEAR CORPORATION<br>LOCKHEED CORPORATION<br>LOCKHEED MARTIN CORPORATION<br>LUCENT TECHNOLOGIES INC.<br>MARATHON OIL CORPORATION<br>MCDONNELL DOUGLAS CORPORATION<br>MCI, INC.<br>MCKESSON CORPORATION<br>MERCK & CO. , INC.<br>MICROSOFT CORPORATION<br>MOTOROLA, INC.<br>NORTHROP GRUMMAN CORPORATION<br>NORTHWEST AIRLINES CORPORATION<br>NYNEX CORPORATION<br>OCCIDENTAL PETROLEUM CORPORATION<br>PEPSICO INC.<br>PFIZER INC.<br>PHARMACIA CORPORATION<br>PROCTER & GAMBLE CO (THE)<br>QWEST COMMUNICATIONS INTERNATIONAL INC.<br>RAYTHEON COMPANY<br>RCA CORPORATION RELIANT ENERGY, INC.<br>ROCKWELL AUTOMATION, INC. SAFEWAY INC | SARA LEE CORPORATION SCHLUMBERGER LIMITED<br>SEARS, ROEBUCK AND CO. SOUTHERN COMPANY (THE)<br>SPRINT NEXTEL CORPORATION STANDARD OIL COMPAN<br>(THE) SUN MICROSYSTEMS, INC. SUNOCO, INC.<br>TARGET CORPORATION TECH DATA CORPORATION<br>TENNECO INC.<br>TEXACO INC.<br>TEXAS INSTRUMENTS INCORPORATED TEXTRON INC.<br>TIME WARNER INC. TRW INC.<br>TXU CORP.<br>U S WEST COMMUNICATIONS, INC. U S WEST, INC.<br>UNION PACIFIC CORPORATION UNITED AIR LINES, INC.<br>UNITED PARCEL SERVICE, INC.<br>UNITED TECHNOLOGIES CORPORATION UNOCAL CORPORATION<br>VERIZON COMMUNICATIONS VISTEON CORPORATION<br>WALGREEN CO<br>WAL-MART STORES, INC. WEYERHAEUSER COMPANY<br>WORLDCOM INC - MCI GROUP WYETH<br>XEROX CORPORATION YUM! BRANDS, INC. |

*Appendix B: Variable Definitions*

| Variable Name | Variable Calculation | Source |
|---|---|---|
| Patents Year Cumulative | Firm Patent Count (Filing Date yr t) / Sector Patent Average (Total / # Fiscal yrs) *Using STATA Cum. Function | Clean Energy Tech, 2012 |
| Revenue Growth | Revenue (t) / Revenue (t-1) | Wharton Research, 2013 |
| Net Income Growth | Net Income (t) / Net Income (t-1) | WRDS, 2013 |
| R&D Intensity | R&D Expense (t) / Revenue (t) | WRDS, 2013 |
| Investment Intensity | Increase in Investments (t) / Revenue (t) | WRDS, 2013 |
| *Controls:* | | |
| Unabsorbed Slack | Current Assets (t) / Current Liabilities (t) | WRDS, 2013 |
| Firm Size (Logged) | Log (Employees) (t) | WRDS, 2013 |
| SGA Expenses | SGA Expenses (t) / Revenue (t) | WRDS, 2013 |
| Excess Physical Resource | Property/Plant/Equipment (t) / Revenue (t) | WRDS, 2013 |
| Excess Human Resource | Employees (t) / Revenue (t) | WRDS, 2013 |
| Capital Expenditures | Capital Expenditures (t) / Current Assets (t) | WRDS, 2013 |
| Long-Term Debt | Long-Term Debt (t) / Current Assets (t) | WRDS, 2013 |
| Working Capital | C. Assets – C. Liabilities (t) / Revenue (t) | WRDS, 2013 |

*Appendix C: Stata Syntax for Regression*

```
xtabond2 patents_year_cum l.patents_year_cum l.revenuegrowth l.netincomegrowth
l.research_revenue l.unabsorbed_slack logfirmsize l.SGAexpenses l.ExcessPhysicalResource
l.incinvest_revgrowth l.emp_revenue l.Capital_Assets _IDataYearF_1982 _IDataYearF_1983
_IDataYearF_1984 _IDataYearF_1985 _IDataYearF_1986 _IDataYearF_1987
_IDataYearF_1988 _IDataYearF_1989 _IDataYearF_1990 _IDataYearF_1991
_IDataYearF_1992 _IDataYearF_1993 _IDataYearF_1994 _IDataYearF_1995
_IDataYearF_1996 _IDataYearF_1997 _IDataYearF_1998 _IDataYearF_1999
_IDataYearF_2000 _IDataYearF_2001 _IDataYearF_2002 _IDataYearF_2003
_IDataYearF_2004 _IDataYearF_2005 _IDataYearF_2006 _IDataYearF_2007
_IDataYearF_2008 _IDataYearF_2009 _IDataYearF_2010 _IDataYearF_2011
_IDataYearF_2012 if patents_year> 0, gmm (l.patents_year_cum l.revenuegrowth
l.netincomegrowth l.research_revenue l.unabsorbed_slack logfirmsize l.SGAexpenses
l.ExcessPhysicalResource l.incinvest_revgrowth l.emp_revenue l.Capital_Assets, lag (2
```

.) collapse) iv (_IDataYearF_1982 _IDataYearF_1983 _IDataYearF_1984 _IDataYearF_1985 _IDataYearF_1986 _IDataYearF_1987 _IDataYearF_1988 _IDataYearF_1989 _IDataYearF_1990 _IDataYearF_1991 _IDataYearF_1992 _IDataYearF_1993 _IDataYearF_1994 _IDataYearF_1995 _IDataYearF_1996 _IDataYearF_1997 _IDataYearF_1998 _IDataYearF_1999 _IDataYearF_2000 _IDataYearF_2001 _IDataYearF_2002 _IDataYearF_2003 _IDataYearF_2004 _IDataYearF_2005 _IDataYearF_2006 _IDataYearF_2007 _IDataYearF_2008 _IDataYearF_2009 _IDataYearF_2010 _IDataYearF_2011_IDataYearF_2012), no level small two-step robust

Note: 1982, 2011, and 2012 dropped due to co linearity

### *Appendix D: Sargan and Hansen Tests for Robustness Checks*

Sargan test of overid. restrictions: chi2(295) = 838.07 Prob > chi2 = 0.000
(Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(295) = 34.56 Prob > chi2 = 1.000
(Robust, but weakened by many instruments.)

| | | | | | |
|---|---|---|---|---|---|
| Hansen test excluding group: | chi2(267) | = | 34.56 | Prob > | chi2 = 1.000 |
| Difference (null H = exogenous): | chi2(28) | = | 0.00 | Prob > | chi2 = 1.000 |

### *Appendix E: Correlation for Table 1 Variables*

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| patents_ye~m --. | 1.0000 | | | | | | | | | | | |
| L1. | 0.7058 | 1.0000 | | | | | | | | | | |
| revenuegro~h L1. | 0.0553 | 0.0307 | 1.0000 | | | | | | | | | |
| netincomeg~h L1. | -0.0037 | 0.0016 | 0.0107 | 1.0000 | | | | | | | | |
| research_r~e L1. | -0.0013 | 0.0001 | -0.0138 | -0.0183 | 1.0000 | | | | | | | |
| unabsorbed~k L1. | 0.0466 | 0.0329 | 0.1476 | -0.0419 | 0.4145 | 1.0000 | | | | | | |
| logfirmsize | -0.0395 | -0.0258 | -0.2395 | 0.0125 | -0.0508 | -0.2879 | 1.0000 | | | | | |
| SGAexpenses L1. | -0.0482 | -0.0413 | -0.0123 | 0.0109 | 0.7626 | 0.3350 | 0.0369 | 1.0000 | | | | |
| ExcessPhys~e L1. | -0.1412 | -0.1513 | -0.2384 | 0.0126 | -0.1010 | -0.1559 | 0.0104 | -0.0891 | 1.0000 | | | |
| incinvest_~h L1. | 0.2540 | 0.2250 | -0.0086 | -0.0041 | 0.3280 | 0.2647 | 0.0313 | 0.2132 | -0.1251 | 1.0000 | | |
| emp_revenue L1. | -0.1558 | -0.1606 | -0.0593 | -0.0205 | -0.0308 | -0.0496 | 0.3239 | 0.0421 | -0.0418 | -0.1599 | 1.0000 | |
| Capital_As~s L1. | -0.1287 | -0.1332 | -0.1063 | 0.0140 | -0.2306 | -0.3088 | 0.0938 | -0.2162 | 0.6275 | -0.1235 | 0.2264 | 1.0000 |

## *Appendix F: Summation for Table 1 Variables*

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| patents_ye~m | | | | | |
| --. | 2053 | .1764332 | .4233537 | .0011416 | 7.125 |
| L1. | 1992 | .1575467 | .4158698 | 0 | 7.125 |
| revenuegro~h | | | | | |
| L1. | 1911 | 1.089032 | .2142231 | .2372953 | 2.928797 |
| netincomeg~h | | | | | |
| L1. | 1911 | .9781152 | 18.22667 | -628.2976 | 282.5 |
| research_r~e | | | | | |
| L1. | 1641 | .0454329 | .0438153 | 0 | .2720584 |
| unabsorbed~k | | | | | |
| L1. | 1806 | 1.438424 | .6020442 | .3227299 | 5.906186 |
| logfirmsize | 2016 | 4.064004 | 1.056249 | -4.268698 | 6.776279 |
| SGAexpenses | | | | | |
| L1. | 1736 | .1798097 | .1253152 | .0009253 | .8040985 |
| ExcessPhys~e | | | | | |
| L1. | 1976 | .4286785 | .4381393 | .0055133 | 3.882611 |
| incinvest_~h | | | | | |
| L1. | 1616 | 4800.66 | 21906.64 | -32.58853 | 279843.6 |
| emp_revenue | | | | | |
| L1. | 1954 | .0050569 | .0039289 | .0001499 | .0618716 |
| Capital_As~s | | | | | |
| L1. | 1795 | .2432442 | .350946 | .004362 | 8.86035 |