What Are the Metrics of Innovation?

Summary

We ask in this paper the fundamental question of what are the proper metrics for innovation. More specifically, we explore whether the widely used innovation metrics of R&D intensity and number of patents granted by year properly reflect the level of innovation of an organization. We look at the correlation coefficient between those two metrics and the Innovation Ranking of the Top-10 Innovative companies as ranked by Booz & Allen from 2010 through 2014. Overall, and with one single exception, we find little to negative correlation between either the number of patents or the R&D intensity on one hand and the Innovation Ranking of those organizations. Further, we show that on the other hand, the innovation ranking is strongly correlated with the 4-year percent change in market capitalization of those companies.

Keywords: Innovation; Innovation Metrics; Definition of Innovation; Patents; R&D Intensity;

Introduction

The management and improvement of innovation is widely considered as a critical and strategic priority as well as an enabler of a company's competitiveness. However, as the old adage often attributed to Lord Kelvin, Peter Drucker and Edward Deming goes, "if you can't measure you can't improve it". Corporations have typically used the number of patents granted per year and the R&D intensity measured as a percentage of their total sales, as "conventional" metrics of innovation. Indeed, R&D intensity (or sometimes called R&D effort) continues to be widely used by market-based accounting research as a proxy for innovation (Ferreira, 2010) (Gallego-Álvarez, 2011) (Hendro, 2008). Also, strategy& (formerly known as Booz & Company) has been conducting its Global Innovation 1000 study since 2005. From 2005-2009, the "top innovators" were ranked according to their R&D spending in dollars. After showing year over year that there were no statistically significant relationship between R&D spending and financial performance (strategy&, 2015), strategy& started a new innovation ranking process based, not on any proxy metric, but rather based on a subjective survey of the Global Innovation 1000 survey respondents to name the top-10 companies they thought were the world's most innovative (strategy&, 2015). Besides R&D intensity, other metrics being widely used by companies to measure their innovation (or innovativeness), include the number of patents filed/granted in the past year, percentage of sales from products introduced in the past year, and number of ideas submitted by employees. A fair number of scholarly articles focus on the issue of developing metrics for this kind of innovation (Chiesa, Coughlan, & Voss, 1996) (Hughes & Chafin, 1996) (Demirag, 1996).

Strategy&'s Innovation Ranking for the last five years presents to us for the first time the opportunity to test whether the two most widely proxy metrics, namely the R&D spend and the Number of Patents granted per year have any correlation with the innovativeness of any organization, at least as perceived by the very same respondents of the Global Innovation 1000 survey, who for the most part are senior executives in the most successful corporations in the world.

In this short paper, we present the results of such a statistical study where we assessed the statistical relationship between on one hand each of the R&D intensity, measured as the R&D spend divided by the total sales for any given year, and the total number of patents granted during that same year and the Innovation Ranking of the top 10 innovative companies as ranked by the strategy& Global Innovation 1000 surveys from 2010 through 2014.

Research Procedure & Methods

We collected the Innovation Ranking for the Top-10 most innovative companies worldwide for the 5 years since strategy& started in 2010 from strategy& website[1]. We extracted the total number of US patents granted to each of the companies that made to the top-10 ranking during any of those 5 years, from the USPTO database[2]. Finally, we collected the R&D intensity and the market capitalization and other financial performance metrics from a professional database of financial markets[3]. To eliminate outliers introduced by "innovation bursts" from recent and young entrants, we eliminated from our statistical analysis any company that has less than 10 years of public trading. This resulted mainly in the elimination of Facebook and Tesla Motors.

We calculated the correlation function for each year from 2010 through 2014, between the Innovation Ranking for each of the top-10 innovative companies and each of the following three metrics:

(i) R&D intensity defined as R&D Spend/Annual Sales
(ii) Number of US patents granted
(iii) 4-year percent change in Market Capitalization

Key Findings

To summarize our findings in a concise manner, we plotted the correlation coefficient for each metric with the Innovation Rank on a yearly timeline from 2010 thru 2014.

In Figure 1, we plot Innovation Rank versus R&D intensity correlation coefficient for the 5 years during which the ranking is available. The reader will note with interest that there is actually little to negative correlation between the R&D intensity and innovation ranking for all years except for 2011, where the correlation coefficient is slightly positive. We remind here the reader that a correlation of 0.2 means that only 4% (the value R-square which is obtained by squaring the correlation coefficient) of the variance in the innovation ranking is accounted for by the R&D intensity, and hence is quite a weak correlation, especially given the small size of our samples.

In Figure 2, we show the correlation coefficient between the Innovation Ranking and the number of new US patents granted each year from 2010 thru 2014. Here, the results are even more dramatic in the sense that we find a consistently negative correlation, ranging from weak (-0.2) to significant (-0.6) for all the 5 years. This result flies against the conventional wisdom that patents are a reliable proxy for the innovativeness of a company.

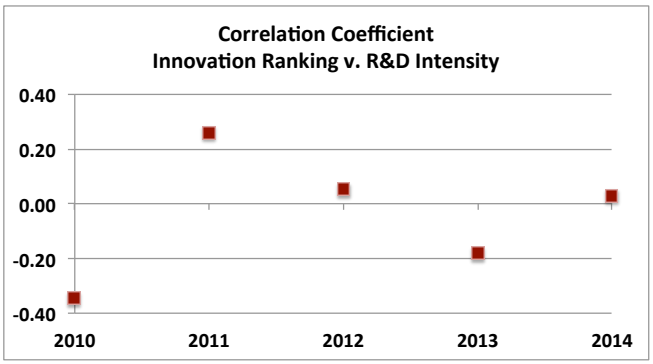

Figure 1: Plot of correlation coefficient between Innovation Rank and R&D intensity from 2010 thru 2014.

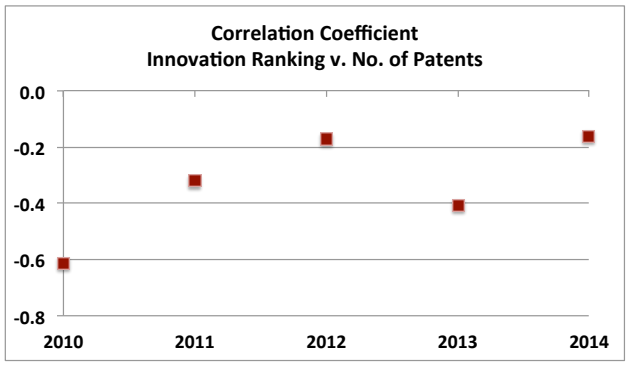

Figure 2: Across-industry 5-year cumulative change in CO_2 emission by non-GRI reporting companies.

Finally, we plot in Figure 3 the correlation coefficient between the Innovation Ranking and the 4-year % change in Market Capitalization during that same year. Unlike the previous results, we note in this case a strong positive correlation between the Innovation Ranking and the change in market capitalization, supporting the view that the market rewards true innovation, rather than R&D spending or technical inventions, as reflected by new patents granted. Note here that the only year where the correlation coefficient is quite weak is 2012, where the 4-year reference year corresponds to 2008, the year just before the 2009 US recession. We attribute this weak correlation function to the fact that many companies' capitalization was over-inflated and did not truly reflect the intrinsic value of the company.

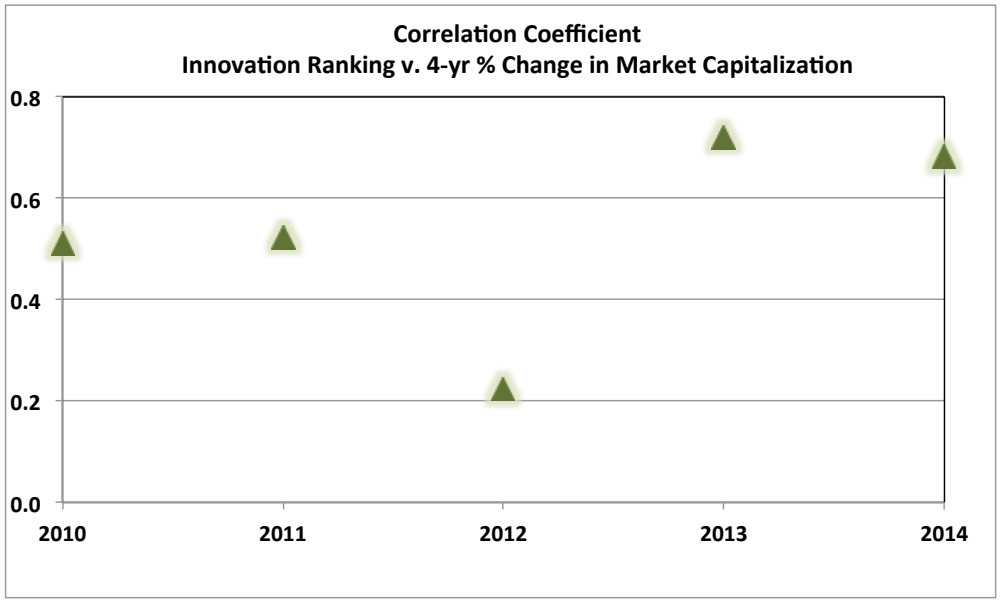

Figure 3: Correlation coefficient between Innovation Ranking and 4-year change in Market Capitalization

Discussion & Conclusion

In our assessment of the relevance of widely used innovation metrics, such as R&D intensity and number of new granted patents, we conducted a correlation analysis between those two metrics and the Innovation Ranking data obtained from strategy& Global Innovation 1000 surveys since 2010.

Not only have we not found any positive correlation between those two metrics and the innovation ranking, but we instead found some weakly negative correlation for the R&D intensity, and weak to significant negative correlation for the patents metric.

Moreover, we found a strong correlation between 4-year percent change in market capitalization and the Innovation Ranking, confirming on one hand that, although qualitative and somewhat subjective from one individual to another, the innovation ranking when aggregated across the entire population of executive surveyed by the Global Innovation 1000 provides a fairly objective and reliable measure of the innovation rank of the top-10 most innovative companies in the world. The strong correlation with the 4-year change in market capitalization also proves that the financial markets are smart enough to reward true innovation rather than R&D spending or inventions, as reflected by the newly granted patents.

This study remains however limited by the relatively small number (10) of companies subject to the innovation ranking. By removing companies with less than 10 years of public trading, we have had to further reduce that sample size to as low as 8 companies only. Furthermore, for our correlation analysis with change in market capitalization, we have had to contend with only 7 companies for the period of 2010-2013, because of the lack of financial data for Samsung prior to 2010. Also, we chose the 4-year period as somewhat arbitrary, and other period intervals, extending from 1 to 5 years would need to be explored to assess the if there is a particular interval that will maximize the overall correlation between innovation and change in Market Capitalization.

In conclusion, our study is the first of its kind at looking at statistical correlations between widely popular "innovation metrics", i.e. R&D intensity and newly granted patents, and a survey-based innovation ranking of the top-10 most innovative companies in the world. Somewhat surprisingly, and certainly going against conventional wisdom, we have found overall a weak to significantly *negative* correlation between those two "innovation metrics" and the innovation ranking. Furthermore, a correlation analysis between the innovation ranking and the 4-year % change in market capitalization shows a strong correlation between the two.

This study informs scholars and practitioners alike to the potential perils of continuing to use the R&D intensity and the number of newly granted patents as a measure of or an input enabler of innovation. It also suggests a new innovation indicator, albeit a lagging one, in the form of 4-year % change in a company's market capitalization, relative to the overall market.

Footnotes

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[1] Source: http://www.strategyand.pwc.com/global/home/what-we-think/innovation1000/top-innovators-spenders
[2] Source: http://www.uspto.gov/web/offices/ac/ido/oeip/taf/all_tech.htm#PartA1_1
[3] Source: https://www.ycharts.com