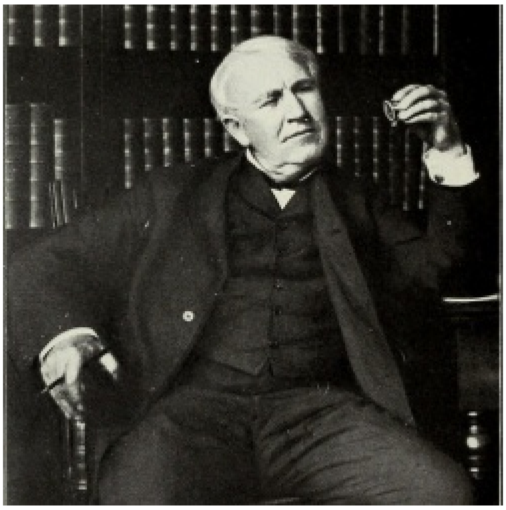
Is There A Magic Formula for Scientific Innovation?

By Chuck Dinerstein — March 2, 2018



Is there a formula for Edison? [1]

Innovation remains a “holy grail” for business where it may unlock new sources of income and in science where it increases our knowledge and promotes the careers and status of the innovators. The work produced in Bell Laboratories in the late 40’s through the 60’s, e.g., the transistor, is legendary for its innovative impact. Business has fruitlessly sought the pathway and circumstances for an environment fostering innovation since those times. Using big data about scientific publications a group of scientists has embarked on their quixotic quest hoping to use their characterization of scientific innovation to foster an environment, once again, more able to innovate.

The authors make use of private and publically available datasets of citations and impact, two metrics that serve as the coin of the realm in funding and tenure decisions and arguably reasonable measures of the usefulness and innovation of scientific reports. Citation of prior works is not evenly distributed; it is highly skewed; with many papers never cited, others, thousands of times. Citations have their own trajectory, an initial citation resulting in additional citations – a function of the works current impact. With time, a paper ages, the knowledge incorporated into the dogma, and citation fades. A small number of papers follow a different path. Referred to as “sleeping beauties” these are papers ignored in their youth and subsequently “discovered” by a later generation of scientists.

The volume of literature expands exponentially but the topics being addressed grow more slowly. The growth of new topics might be likened to our children moving away from home, but not too far, to set up their own lives. New research forms in clusters, supported by journals or editors, grouping around general problems or similar general views or hypothesis. While these networks promote within problem competition and growth, they have bounded silos of knowledge constraining cross-discipline discussion a known factor in innovation.

Innovation is often influenced by not merely the problem a scientist chooses to address, but by their approach. Scientists face a choice between issues previously identified, requiring further refinement or consideration of riskier untested hypotheticals. Scientists engaged in the more traditional investigation, and improvement produces a steady stream of reliable, moderately impactful research, based on an established agenda. They are rewarded by an increasing probability of tenure and funding – slow and steady wins the race. [1] Innovative research is more impactful, but comes at a higher cost to the scientist. Innovative research often results in unpublished, dead-ends, giving the appearance of less productivity and risking the loss of time and opportunity. The reward for successful innovators are mainly episodic, scientific awards and accolades – steady employment and funding follow for the lucky few. As the authors note, the choice of “traditional” research rewards the individual, “innovative” research rewards science.

Another way in which science and business find common ground is in the value of long-range planning. Research adopting a long-term outlook that is tolerant of error early on is far more likely to result in high impact innovative research when compared to research requiring reporting upon quarterly or annual goals.

The novelty of a scientific subject frequently accompanies interdisciplinary research that allows recombination of ideas from disconnected, disparate fields. Innovation takes what is known in a new or serendipitously encountered direction, extending the known through unique concepts outside the usual focus. Scientific investigation is no longer the work of isolated individuals it is the work of teams. In 1995 about 50% of papers had single authors, today that number had dropped to 10% - groups, not individuals are science’s workhorses.

Science, like business, has attempted to alter the characteristics of those teams, to enhance their productivity. Large teams, created to address a fixed research agenda, tend to produce more publications. Smaller teams, with a set core and ad hoc additions as the need arise, tend to be more disruptive or innovative – lean and mean. Paradoxically as teams have grown, the role of one or two key collaborators has also risen. An active collaborator may add up to 17% to a work’s citations; while their loss may result in a substantial loss of productivity.

It is evidently a generally held misbelief that a scientist’s best work occurs early in their career; for example, Einstein’s significant contributions were made when he was 26. The authors found that as long as scientists remain productively producing work innovation can occur at any point in the scientist's career. Unfortunately, for many scientists, as is equally true for many of us, productivity often declines over time, with or without the security of tenure and funding.

The authors did point out two significant consequences of the organization of work they characterize. First,

“Given that scientists fail more often than they succeed, knowing when, why and how an idea fails is essential in our attempts to understand and improve science. “

Feedback, especially regarding failure, is the hallmark of all learning enterprises; the publication of negative results is overlooked by the business of scientific publications and negatively impacts growing out scientific knowledge. Second, what you measure often shapes the manner organization evolves. Citation and impact, as THE metrics for advancement and funding results in a “hierarchical system, in which the “rich-get-richer dynamics suppress the spread of new ideas.” It is the business version of the Golden Rule; “He who has the gold, rules.”

The authors recognize that these identified characteristics are associative, not causative. Much of what the authors surmise about the roles of cross-discipline discussion, team structure, the function of long and short-term goals have been previously identified by knowledge and information companies. Countless hours and dollars have been spent in a vain effort to find that alchemist stone of innovation. While I applaud the effort again being made, I suspect that innovation will remain elusive, more serendipity and a prepared mind, than a formula based on teams, and workspace considerations.

[1] Studies demonstrate “that allocation of biomedical resources… is more strongly correlated to previous allocation and research than to the actual burden of disease.”

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Links

[1] https://www.flickr.com/photos/internetarchivebookimages/14757608976