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Small Business Research in a World of Skewed Returns

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Preface & Acknowledgements

Welcome to our Ninth Annual Acquisition Research Symposium! This event is the highlight of the year for the Acquisition Research Program (ARP) here at the Naval Postgraduate School (NPS) because it showcases the findings of recently completed research projects—and that research activity has been prolific! Since the ARP's founding in 2003, over 800 original research reports have been added to the acquisition body of knowledge. We continue to add to that library, located online at www.acquisitionresearch.net, at a rate of roughly 140 reports per year. This activity has engaged researchers at over 60 universities and other institutions, greatly enhancing the diversity of thought brought to bear on the business activities of the DoD.

We generate this level of activity in three ways. First, we solicit research topics from academia and other institutions through an annual Broad Agency Announcement, sponsored by the USD(AT&L). Second, we issue an annual internal call for proposals to seek NPS faculty research supporting the interests of our program sponsors. Finally, we serve as a "broker" to market specific research topics identified by our sponsors to NPS graduate students. This three-pronged approach provides for a rich and broad diversity of scholarly rigor mixed with a good blend of practitioner experience in the field of acquisition. We are grateful to those of you who have contributed to our research program in the past and hope this symposium will spark even more participation.

We encourage you to be active participants at the symposium. Indeed, active participation has been the hallmark of previous symposia. We purposely limit attendance to 350 people to encourage just that. In addition, this forum is unique in its effort to bring scholars and practitioners together around acquisition research that is both relevant in application and rigorous in method. Seldom will you get the opportunity to interact with so many top DoD acquisition officials and acquisition researchers. We encourage dialogue both in the formal panel sessions and in the many opportunities we make available at meals, breaks, and the day-ending socials. Many of our researchers use these occasions to establish new teaming arrangements for future research work. In the words of one senior government official, "I would not miss this symposium for the world as it is the best forum I've found for catching up on acquisition issues and learning from the great presenters."

We expect affordability to be a major focus at this year's event. It is a central tenet of the DoD's Better Buying Power initiatives, and budget projections indicate it will continue to be important as the nation works its way out of the recession. This suggests that research with a focus on affordability will be of great interest to the DoD leadership in the year to come. Whether you're a practitioner or scholar, we invite you to participate in that research.

We gratefully acknowledge the ongoing support and leadership of our sponsors, whose foresight and vision have assured the continuing success of the ARP:

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We also thank the Naval Postgraduate School Foundation and acknowledge its generous contributions in support of this symposium.

James B. Greene Jr.
Rear Admiral, U.S. Navy (Ret.)

Keith F. Snider, PhD
Associate Professor

Panel 5. Enablers for Growing Small Business Opportunities Within the DoD

Wednesday, May 16, 2012	
11:15 a.m. – 12:45 p.m.	**Chair: RADM Seán F. Crean,** USN, Director, Office of Small Business Programs, Department of the Navy ***Too Big Not to Bundle? Examining Drivers for Consolidation of Navy Contracts*** Max Kidalov, *Naval Postgraduate School* ***Improving the SBA's Methodology for Setting Small Business Size Thresholds*** Nancy Young Moore, Amy G. Cox, Lloyd Dixon, Clifford A. Grammich, and Judith Mele, *RAND Corporation* ***Small Business Research in a World of Skewed Returns*** Toby Edison, *Defense Acquisition University*

Seán F. Crean—Mr. Crean is the director of the Office of Small Business Programs for the Department of the Navy. He serves as chief advisor to the Secretary on all small business matters. He is responsible for small business acquisition policy and strategic initiatives.

Mr. Crean joined the Secretary of the Navy Staff as a member of the Senior Executive Service in January 2010 and has over 30 years of federal service. Prior to receiving this appointment, he served as Deputy Assistant Secretary of the Navy for Acquisition and Logistics Management during a two-year military recall to active duty as a rear admiral in support of Operation Iraqi Freedom.

Mr. Crean's previous experience includes serving as the senior procurement analyst for the U.S. Small Business Administration's Office of Government Contracting Area I (New England) for 19 years. In this role he was the principal advisor to the SBA's six regional district offices and congressional delegations on procurement issues. He provided acquisition strategy analysis for over 20 buying activities throughout the region, supporting both DoD and civilian federal agencies. He first entered federal civilian service as the deputy supply officer for Naval Air Station Brunswick, ME, where he was also appointed the activity small business specialist.

Mr. Crean's combined military and civil service careers have provided complimentary and extensive leadership responsibilities in service to the country. As a member of the reserve component, he has attained the grade of rear admiral (two-star) and is currently assigned as deputy commander, Naval Supply Systems Command. He holds a Bachelor of Science degree in business management and marine transportation from State University of New York Maritime College and a Master of Business Administration degree from New Hampshire College's Graduate School of Business.

He has a number of personal and command decorations, including two Legion of Merit awards. He is a member of the Defense Acquisition Corps and is DAWIA Level III Contracting certified.

Small Business Research in a World of Skewed Returns

Thomas Edison—Maj Toby Edison is a professor of program management for Defense Acquisition University (DAU), West Region, Los Angeles, CA. Edison received his doctorate at the RAND Graduate School. His thesis was an evaluation of the DoD Small Business Innovation Research (SBIR) program. While a program manager for Space Radar and Joint STARS, he initiated several acquisition innovations: the GMTI Community of Practice and the GMTI Characterization Lab. The GMTI Community of Practice brings together stakeholders to improve GMTI capabilities without an established program of record. This community provided guidance on GMTI for the ISR Task Force. The GMTI Characterization Lab demonstrated and fielded several novel GMTI applications and CONOPs. He is on active duty with the US Air Force and is currently deployed overseas. [toby.edison@dau.mil]

Abstract

This paper observes that outcomes from small business support programs are likely to have a small fraction of observations with extremely positive outcomes that may impact program evaluations and conclusions. Current evaluations of small business support programs generally estimate the efficacy of the program using an estimation of an average outcome or an average treatment effect. Because there are so few small business programs that have been designed for evaluation, researchers often report a simple average outcome based on a survey response of treated firms or, in very rare cases, report the effectiveness of the program as an average-treatment effect based on a quasi-experimental or experimental design. Unfortunately, presenting the small business programs' impact as an average might be understating the magnitude of the impact of the program because the actual distribution of the outcome of the program is probably not normally distributed and is probably skewed in the positive direction. In light of the possibility that small business programs produce skewed outcomes, this paper recommends that the small business evaluations include discussions on the distribution of outcomes to better inform policy makers, administrators, and participations on the nature of the outcomes.

Introduction

> *"Data analysis, like calculations, can profit from repeated starts and fresh approaches. … There is not just one analysis for a substantial problem"* (Tukey, n.d.).

This paper observes that outcomes from small business support programs are likely to have a small fraction of observations with extremely positive outcomes that may impact program evaluations and conclusions. Current evaluations of small business support programs generally estimate the efficacy of the program using an estimation of an average outcome or an average treatment effect. Because there are so few small business programs that have been designed for evaluation, researchers often report a simple average outcome based on a survey response of treated firms or, in very rare cases, report the effectiveness of the program as an average-treatment effect based on a quasi-experimental or experimental design. Unfortunately, presenting the small business programs' impact as an average might be understating the magnitude of the impact of the program because the actual distribution of the outcome of the program is probably not normally distributed and is probably skewed in the positive direction. In light of the possibility that small business programs produce skewed outcomes, this paper recommends that the small business evaluations include discussions on the distribution of outcomes to better inform policy makers, administrators, and participations on the nature of the outcomes.

This paper begins with a review of small business evaluations that highlight the universal presentation of small business support program effects as averages. Next, the paper focuses on observations of skewed returns in related research fields: technology policy and stock market returns. The paper then focuses on a body of small business

program evaluations that highlight the possibility that outcomes from small business support programs are skewed in a similar nature to stock market returns and technology investments. The paper concludes with empirical and non-empirical strategies for researchers to deal with the skewed nature of outcome observations to better craft policy recommendations.

If a Small Business Program Evaluation Reports an Outcome, It Is an Average

This section of the paper reviews the literature on small business support program evaluations, concluding that, generally, if an effect from program participation is estimated, that effect is presented as an average effect. The findings from two literature reviews on small business support programs are presented. The first, a 2008 working paper by Gu, Karoly and Zissimopoulos (2008), summarizes the then-current literature on small business support program evaluations, mostly in the United States. The second review, a dissertation literature review chapter from 2010 by Edison (2010), summarizes the then-current literature on the Small Business Innovation Research (SBIR) program. Both document that most program effects are presented as an average treatment effect or as an average of survey responses.

Small businesses are believed to play a vital role in the economy, generating new jobs and fueling innovation. Because of this, many local, state, and federal small business support programs have been created to finance, incubate, and educate entrepreneurs in the hopes that new firms will create new jobs and increase regional prosperity. Despite the strong support and billions of dollars in annual funding for set-aside contracts, subsidized financing, education, and business zones, there is relatively little rigorous research conducted on small businesses. Moreover, even when rigorous research is conducted, it often reveals very little information about how and why programs are effective (Gu et al., 2008).

Gu et al. (2008) review 22 small business support program evaluations that exclusively report program effects as averages of the outcomes observed. The researchers documented that, of the 22 studies, 20 of the studies use econometric analysis or means comparison methods, with two studies reporting descriptive summaries of surveys of the participants. The vast majority of the evaluations were published without comparing the average effect with treatment groups. Gu et al.'s (2008) review documented only two studies that employed experimental methods; Benus (1994) estimated a treatment effect from a randomized control trial that offered business training to randomly selected groups from a population of individuals interested in self-employment; and Bellotti (2006), which documented the experimental design Project Growing America Through Entrepreneurship (GATE), estimated a treatment effect. Furthermore, the Gu et al. (2008) literature review documented only two econometric quasi-experiments that used matched control groups Lerner (2006) and Sanders (2002), reinforcing the finding that very few small business support program evaluations use rigorous estimation models.

Edison (2010) reviewed the literature that documented the methods used in the 39 published reports that evaluated the SBIR program from 1996 to 2010. The SBIR is a federal research and development (R&D) program that mandates that large federal agencies set aside 2.5% of their external R&D budget to be awarded to small businesses through the SBIR program. The GAO, RAND, the Nation Academies of Sciences, and various academic researchers have extensively studied the program. Of the 39 published evaluations of the SBIR program, only six used quasi-experimental econometric methods to estimate an average treatment effect; the remainder of the reports presented the effects of the SBIR program with a simple mean, typically from a self-reported survey. A handful of the reports used other qualitative methods to describe the effects of the program, typically case

studies on a handful of participating firms, or of SBIR program administrators in the various federal agencies. Regardless of the level or rigor employed in the evaluations, researchers unanimously found a positive average (treatment) effect for firms that participate in the program. The conclusion to a 2005 GAO report summarized the state of SBIR program evaluations: "an issue that continues to remain somewhat unresolved after almost two decades of program implementation is how to assess the performance of the SBIR program" (p. 1).

Despite the preponderance of average effects published in the SBIR literature that Edison (2010) documented, the literature review documents a subset of analyses that document a phenomenon of extreme outliers in outcomes in Held (2006).[1] The most obvious documentation of extreme outliers is in the analysis of cohorts of first-time Department of Defense (DoD) contractors who won their first DoD contract through the SBIR program. For these cohorts of firms (256 in 1995 and 220 in 1999), non-SBIR defense contract awards for each firm were observed three years following their initial SBIR award. In each cohort, just three firms won more that 95% of the entire cohort's non-SBIR DoD contracts (see Figure 1). Edison (2010) observed that the extreme outlier phenomenon is consistent with the Scherer and Harhoff (2000) generalization that returns to innovation investment appear to be concentrated in a top few observations. Scherer and Harhoff (2000) observed the consistent pattern of 50–95% of returns from innovation are concentrated in the top 10% of study population observations; they further observe that this pattern is consistent in patents, Venture Capital investments, IPOs, startup firms, and pharmaceutical launches.

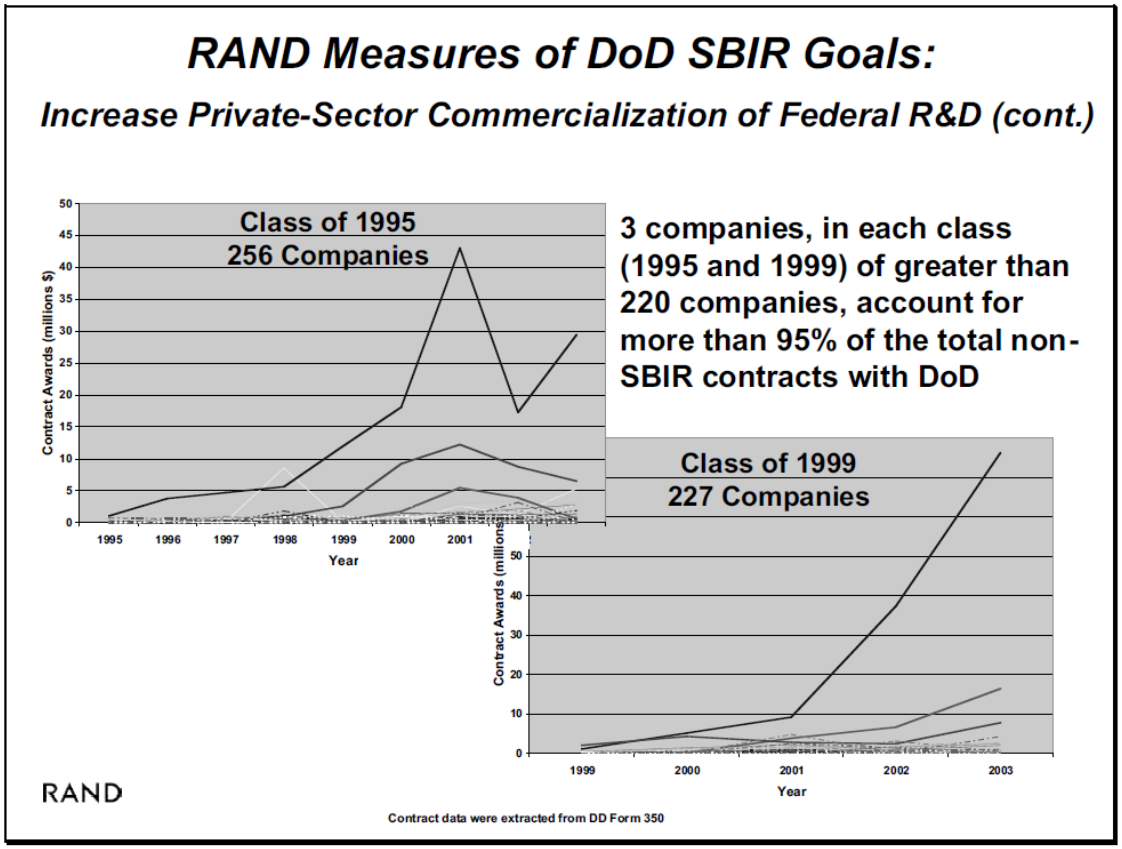

Figure 1. Graphical Analysis of SBIR "High Flyers"
(Held, 2006)

[1] The author of this article was also a member of the Held (2006) research team.

This section summarized the current paradigm of evaluating small business support programs using generally accepted econometric analysis and mean comparison methods. Both methods have strength in that informed laymen and advanced researchers easily understand them. Unfortunately, both methods rely on the assumption of normality or "approximate normality" to estimate average effects. The Edison (2010) observation that the rare analysis by Held (2006), which observed effects as containing a few high performing outliers (rather than an average), raised doubts about the "approximate normality" of the outcome variables, thus the validity of using averages to estimate program effects. The next section further discusses Scherer and Harhoff's (2000) seminal observations of skewed returns to innovation investments and presents related observations on skewed returns from the financial analysis research community and from the network traffic analysis community.

Exceptional Observations Literature Review

A paradigm of research agenda focusing on skewed returns is growing in the diverse fields of innovation policy, financial analysis, and network traffic analysis. This paradigm shift has been levered by simultaneous improvements in data collection and data processing that have enabled researchers to collect and analyze an entire census of population observations rather than samples of the population. The researchers analyzed the "skewed-distributed outcomes" (Scherer & Harhoff, 2002) or "heavy tailed" distributions (Mandelbrot, 2003; Resnick, 1997).

Peck and Scherer's (n.d.) research on skewed returns presented evidence from eight data sets (see Figure 1) that summarized the skewed-distributed outcome from a diverse range of innovation investments (e.g., patents, pharmaceutical introductions, initial public offerings [IPOs] of firms, and firm startups). In each of these populations, a small fraction of observations (~10%) contained a majority of the returns of the entire population. The authors documented implications that this generalization has for policy makers: to ensure success, a large variety of projects must be supported rather than a small number of national champions; and to measure success, policy makers must be able to support a program that might show a 90% failure rate. Scherer and Harhoff's (2002) observations appear to have been incorporated into some mainstream research and development policy evaluations (Roessner, 2002).

Scherer and Harhoff's (2002) conclusion that a small minority of innovations yields the lion's share of all innovations' total economic value also has implications for researchers, which I will elaborate:

- If researchers are using sampling methodology, there is a high probability that they will not sample some of the most significant observations, which will dramatically change the results of the evaluation.
- Standard econometric analysis and mean comparison methods, which rely on normality assumptions, might not be valid.
- Lag effects and spillover effect might be extremely large and potentially macro-economically disruptive.
- Standard sampling methods might miss the few most important observations in the population.
- Matching algorithms might drop key observations.
- Analysis of the returns from the top few performers might be sufficient to perform a cost benefit analysis. (Roessner, 2002)

Table 1. Scherer and Harhoff Returns to Innovation Portfolios
(Scherer & Harhoff, 2002)

Proportion of innovation samples' total value realized by the most valuable 10% of innovations

Data set	Number of observations	Percent of value in top 10%
German patents	772	84
US patents	222	81–85
Harvard patents	118	84
Six university patents		
1991 royalties	350	93
1992 royalties	408	92
1993 royalties	466	91.5
1994 royalties	411	92
Venture Economics startups	383	62
Horseley–Keogh startups	670	59
Initial public stock offerings (IPOs) — 1995 stock value	110	62
Grabowski–Vernon		
1970s drugs	98	55
1980s drugs	66	48

Limitations of Scherer and Harhoff's Skewed-Outcome Observations

In a real-world sense, Scherer and Harhoff's (2002) observations that the returns to innovation investments have a long skewed-outcome tail is fundamental for policy makers and analysts who need to understand the nature of the innovation process. Unfortunately, this real-world observation has a significant limitation when analyst are attempting to use standard quantitative tools to describe what they are seeing in the data. If what analyst are seeing can be characterized as having a finite "thin tail" that approximates a log-linear distribution, then researchers can use standard data analytic tools by transforming the outcome observations with a log function. The log-linear functions have the analytical strength of converging to stable means and variances with large numbers of observations. However, if what analysts are seeing is an infinite and or "fat tail" distribution, then this distribution is better described with a Pareto-Levy function, which has the analytically difficult challenges of having unstable means and variances, especially when larger numbers of observations are analyzed.

Another difficulty both log-normal and Pareto-Levy distributions have is that they are undefined for observations with zero or negative values. In many situations when analyzing

returns to innovation, this is not an issue, because some most innovations have some value greater than zero. For example, in the case of IPOs, the stock price of a firm represents an approximation of the value of assets of a company, which will probably have some non-negative worth. However, in the case of patents, some patents might not have any estimated commercial value. This limitation is even more worrisome when judging the impacts of small business support programs, because some interventions might possibly yield no increase in future sales, employment, or earnings, and other interventions could actually have a negative impact on business outcomes.

A careful reading of Scherer and Harhoff (2002) reveals a worrisome assumption: they postulate that the returns to innovation "most likely" adhere to a log-normal law (a long, thin tail) but open the possibility that their research "may not have captured the most extreme private values." The authors leave the door open to the possibilities of skewed-outcomes of a Pareto-Levy distribution. For most research applications with a small number of observations, narrowly defined outcome measures, and short-time horizons, the log-normal approximation provides researchers and policy makers with useful insights. Unfortunately, the models employing log-normal assumptions might not sufficiently represent the impacts of disruptive innovations, which have the potential to have significant macro-economic impacts. Disruptive innovations are actually, in many cases, what innovation and small business support programs are actually seeking.

In aggregate, the literature review on small business support evaluation in the previous section of this paper confirms that the prevailing paradigm is to assume normality and present an average effect; given this current paradigm it would be difficult for researchers to publish program evaluations that abandoned this paradigm to make it past a peer reviewer or bureaucratic sponsors with a report that presented their results as a distribution of outcomes, which was non-normal and skewed. To motivate a paradigm shift in small business research, a brief introduction to the current paradigms in financial research and network traffic analysis modeling is presented.

How Other Disciplines Embrace Non-Normality

Research in finance and telecommunications network modeling has long embraced the heavy-tailed, skewed distribution phenomenon. The stylized observations or non-normality stemming from heavy-tailed distributions, have caused significant re-examination of the analytical foundations of these disciplines.

The seminal paper on non-normality in network data analysis from these disciplines that might be useful for small business support policy analysis is a paper by Leland, Taqqu, Willinger, and Wilson (1994). Leland et al. (1994) described the research team's analysis of Ethernet LAN traffic as "self-similar" or fractal. This observation countered the then-prevailing paradigm of analyzing Ethernet traffic with "Poisson-like" models. The authors observed that, regardless of how small or large the time interval, Ethernet traffic reveals a pattern of "burstiness," which contained an extremely small percentages of extraordinarily large packages of information. The researchers then introduced several different advanced statistical methods to represent the behavior of the data. The roots of these analytical methods are found in the body of work by Mandelbrot (2003), which will be discussed shortly. What is more important to small business support program analysts is the three implications that the authors recommended for engineering on how to design systems.

The first implication, the self-similar nature that Ethernet data has for system design, is that the nature of the sources, destinations, and nature of the individual data packets needs to be analyzed. Small business policy researchers can certainly appropriate this observation by focusing inside the "black-box" of select firms in the population to discover

the nature of their founding story, the nature of the market they are selling to, and their internal structure. The second observation in Leland et al. (1994) was that researchers need to account for and describe the behavior of the variation in network traffic as longer and longer time intervals are observed. Because each population under analysis is necessarily a finite data-set, a mean and a variance can always be calculated; but when the time intervals are increased, the mean and variance might not converge to stable estimates. This observation can also be useful to small business policy researchers, who should describe the effect that increasing sample size or time intervals have on the mean and variance of the outcome of interest. Finally, Leland et al. (1994) detailed the implications that self-similar traffic pattern have for engineering predictive data traffic models. With better knowledge of the behavior of the traffic data, the engineers can build synthetic models of proposed Ethernet networks, which will experience better traffic flow, less congestion, and be optimally sized to reduce excess capacity. The observation that better system design is possible with a better understanding of the nature of the network traffic is directly applicable to small business policy researchers in better describing the nature of the observed outcomes resulting from program designs so that the delivery of the small business support can be more appropriately tailored to providing the right amount of support for small businesses.

This seminal paper by Leland et al. (1994) has many connections to Mandelbrot's (2003) research on non-normal behavior of stock market returns, portfolio risk, and optimal portfolio design. The *Handbook of Heavy Tailed Distributions in Finance* edited by Rachev (2003) contains a good summary of the research and theory that are the foundation of non-Gaussian (non-normal) financial analysis. Rachev (2003) offered these stylized facts regarding the distribution of financial data:

- non-Gaussian, heavy-tailed and skewed distributions,
- volatility clustering,
- temporal dependence of the tail behavior, and
- short- and long-range dependence.

These theories regarding the behavior of financial markets are directly applicable to small business policy researchers because small business support programs inherently involve financing business ventures with the hopes of those ventures increasing in value and improving the regional or national economy.

This section has some paradigm shifting observations regarding evaluations of small business support programs, specifically that skewed-outcome observations can invalidate normality assumptions and therefore call into question the recent advancements in small business policy research, which has made significant advances to estimate average effects. More research is needed to determine whether the log-normal assumption holds that extreme positive outcomes in small business performance can be characterized as a thin tail or a fat tail. It is the intention of this paper to motivate future researchers to detail the distribution of the outcomes (especially those skewed outcomes) in their evaluations, even if average effects are also presented.

A Deeper Example of Exceptional Outcome Data on Small Business Outcomes

Edison (2010) detailed the distributions of pre- and post-treatment outcomes for firms that applied for DoD SBIR contracts in 2003. The distributions for pre-treatment non-SBIR DoD contracts clearly adhere to the skewed-outcome distribution Scherer and Harhoff (2002) described (see Figure 3). Likewise, the post-treatment observations (see Table 2) illustrate another example of skewed, long-tail outcomes.

Given the previous presentation on the skewed nature of outcomes from innovation investments and financial markets, it seems plausible that the patterns presented from this evaluation of the DoD SBIR program would also be evident in other evaluations of small business programs. The only way to verify that this phenomenon is not just an anomaly is for researchers to include an analysis of the structure of the data sets in their publications. Additionally reviewers of research on small businesses should also request that their authors include graphical and statistical summaries of the skewed nature of the outcome variables. Through these subtle actions, a better understanding of the nature of the impacts from small business support programs can be characterized and help improve support programs.

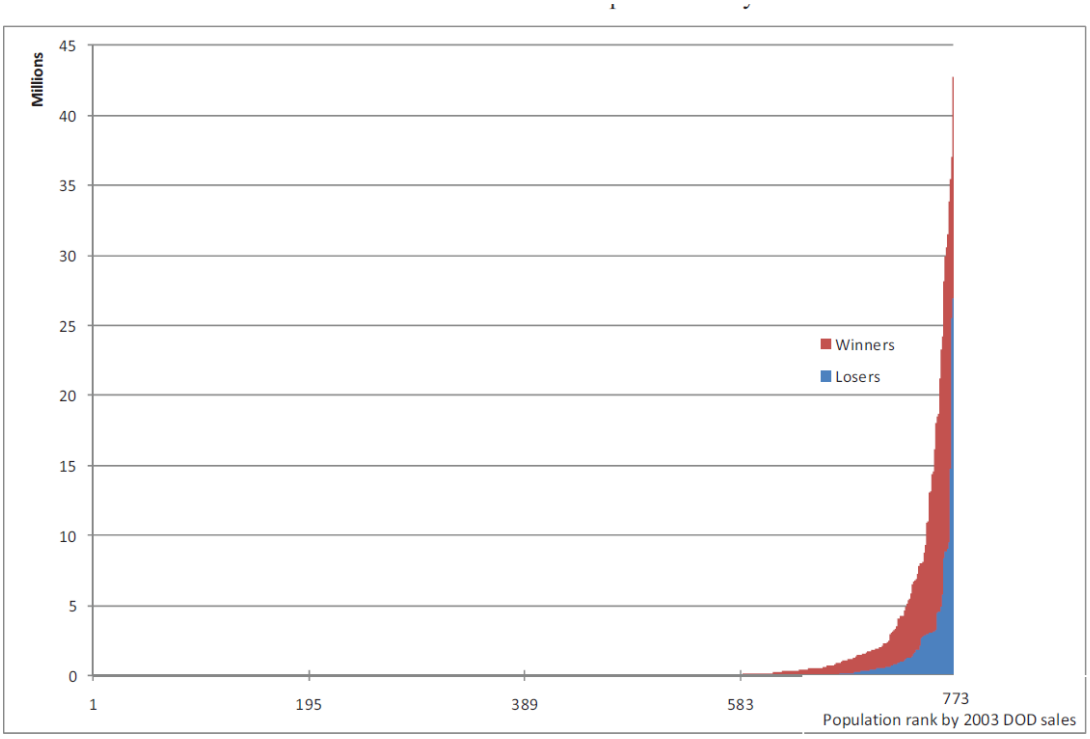

Figure 2. Pre-Treatment DoD Sales

Table 2. Post-Treatment Increase in DoD Sales (2003–2004)

	loser	winner
Observations	773	687
Mean	220,779	649,822
Stdev	2,121,602	4,468,850
Max	35,700,000	61,600,000
Min	(7,620,000)	(23,800,000)
% Negative	12%	18%
% Positive	15%	29%
% zero	73%	53%
% extreme neg (<2stdev)	0.39%	0.29%
% extreme pos (<2stdev)	1.29%	2.04%
% extreme	1.68%	2.33%

Recommendations for Researchers

1. Present the distribution of the outcome data with both normality (or log-normality) assumptions and non-normality assumption.
2. Present the average outcome (from the survey) or average treatment effect (from the experiment or quasi-experiment).
3. Do case studies on average firm, well-below-average firm, and exceptional firm.
4. Unleash the creative forces of policy researchers to invent a way to perform program evaluations in a world of skewed returns.

Peck and Scherer have noted in numerous studies that returns to innovation are highly skewed. This paper surveys literature on small business evaluation programs, finding that most researchers estimate an average treatment effect. This paper also reviews a subset of the small business literature on DoD small business programs to conclude that the returns to these programs appear to be skewed as well. Researchers and policy makers should consider the possibility that returns to small business support programs might be skewed; therefore, in evaluating the programs, a small average treatment effect might be hiding a large effect concentrated in a few high return successes.

Policy makers considering small business interventions should be aware of the phenomenon of skewed returns in building their support interventions; and in the rare instance that the policy makers choose to evaluate the intervention, they should consider augmenting average treatment effect with more focused case studies on the high flyers.

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