

Left-skewed Performance Distributions

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Document Version

Final published version

Publication date:

2023

License

Unspecified

Citation for published version (APA):

Andersen, T. J. (2023). Left-skewed Performance Distributions. Copenhagen Business School, CBS.

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RESEARCH NOTE

Left-Skewed Performance Distributions

The global economy and the organizations that operate within it to provide goods and services are exposed to a daunting array of risks, including financial crises, cyberattacks, social instability, governance failures, and extreme weather events. In addition, they face phenomena such as pandemics (e.g., Covid-19) and military conflict (e.g., Russia's invasion of Ukraine), which constitute unexpected developments that often evolve in unpredictable ways and yet have significant repercussions for global economic activity. Some organizations are able to adjust to these types of disruptive events and thrive despite the adverse odds they present, but many others fail. Hence, empirical evidence consistently shows that some firms outperform their industry peers in given time periods even though they are exposed to the same risk events, while a vast number of firms fall into a left-skewed tail of poor performers.

This phenomenon is a highly systematic and commonly observed empirical artefact. However, firms with extreme outcomes, especially negative outcomes, are typically not considered in mainstream management studies, even though their inclusion in such studies could provide interesting insights.² By studying the extreme exemplars, we might develop a better understanding of success and failure that could, in turn, help organizations better adapt to global economic turbulence. International businesses constantly face the potential for extreme future events—more so than we typically care to recognize even though such events can create disruptions and strategic discontinuities that may lead to extreme economic losses for society.³

Contemporary organizations are dealing with complex dynamic environmental contexts in which extreme events are difficult to predict, impossible to quantify and, hence notoriously hard to respond to or address. Studies of large, established firms suggest that they have a 10% chance of losing at least 25% of their total market value within a single month due to strategic risk events like falling sales, increased competition, or failing products, and that these firms

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We gratefully acknowledge support from Independent Research Fund Denmark for the project *Risky Business – Managing in a world with extreme exposures* (Grant 8019-00046B), which made this work possible.

² Boisot, M., & McKelvey, B. (2011). Connectivity, extremes, and adaptation: A power-law perspective of organizational effectiveness. *Journal of Management Inquiry*, 20(2), 119-133.

³ Taleb, N. N. (2007). *The Black Swan: The Impact of the Highly Improbable*, Random House.

would be unable to recover their losses.⁴ As a consequence, almost half of current Fortune 500 companies can be expected to disappear from the list within ten years.⁵ This attests to the difficulties otherwise successful firms may have in orchestrating effective responses to emergent changes in competitive market conditions.

These characteristics of realized performance data challenge conventional regression analyses of proposed cross-sectional relationships as well as advanced dynamic factor and vector-autoregressive models used for analyzing longitudinal risk-return relationships, as the assumed normality in the data (often) does not prevail (Figure 1).

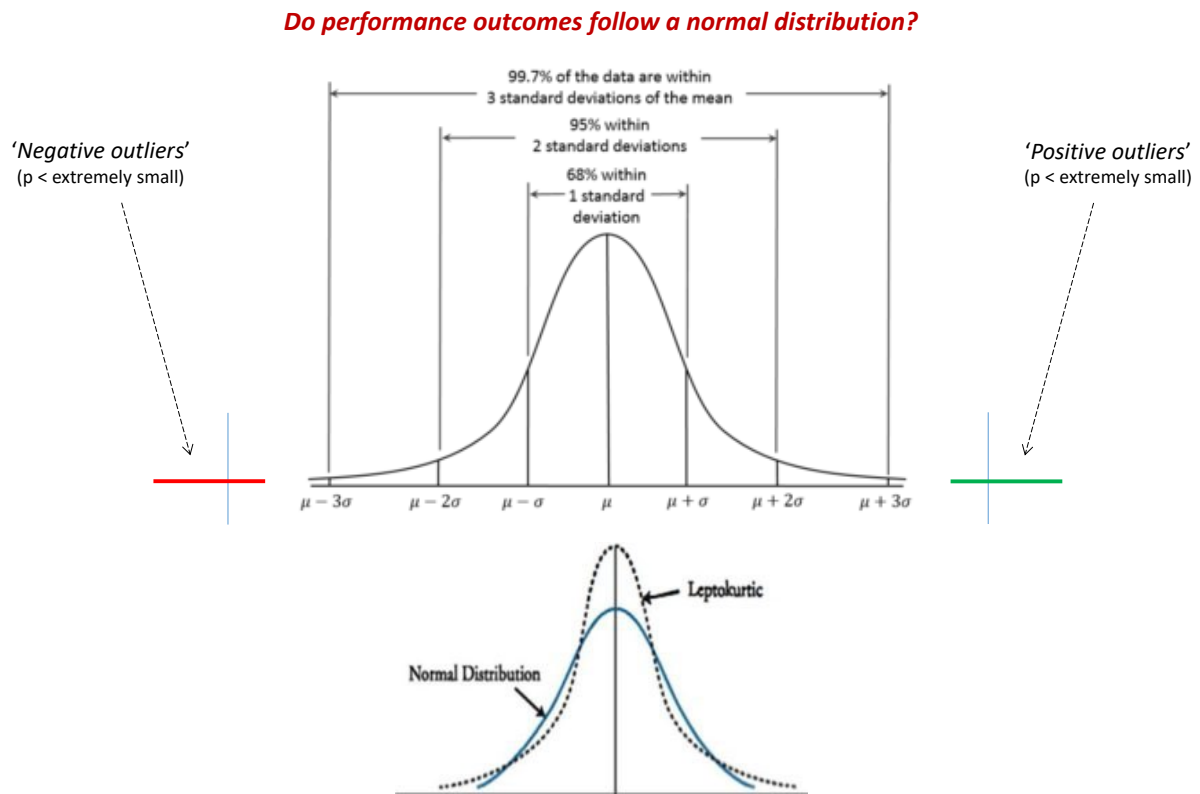


Figure 1. The assumed normal distribution with negative and positive outliers

When recording data on firms’ realized returns, we typically observe distributions with more *leptokurtic* characteristics of extreme outcomes.

Outliers

In statistical analyses, outliers—observations that exceed the acceptable limits of a normal (or Gaussian) distribution by wide margins—are considered a nuisance that should be eliminated to safeguard “sound” outcomes. Therefore, researchers tend to eliminate data points identified as outliers, at times almost by reflex, usually by following the common practice of automatically

⁴ Andersen, T. J., & Schröder, P. W. (2010). *Strategic Risk Management Practice: How to Deal Effectively with Major Corporate Exposures*. Cambridge University Press.

⁵ Goodburn, M. (2015). What is the life expectancy of your company? *World Economic Forum*.

removing “extreme” observations using, for instance, winzorising techniques that delete observations below the fifth and above the ninety-fifth percentiles. Nonetheless, some scholars argue that these outliers may be excellent case studies that can help us understand how extreme outcomes arise.⁶

To assess the observed extreme tail outcomes embedded in the distribution of realized firm performance, we identified a number of representative firms in the (often “fat”)⁷ negative and positive tails in a dataset extracted from Compustat of companies operating across industries identified by their four-digit SIC-codes. We looked at performance measured as *return on assets* (ROA = net income as a percentage of total assets) over the 25-year period from 1995 to 2019 and found many companies with returns more than four standard deviations below the mean but hardly any companies with returns more than four standard deviations above the mean (Figure 2).⁸ Hence, we typically observe extreme negatively skewed distributions across full samples of firms as well as in more confined industry subsamples.

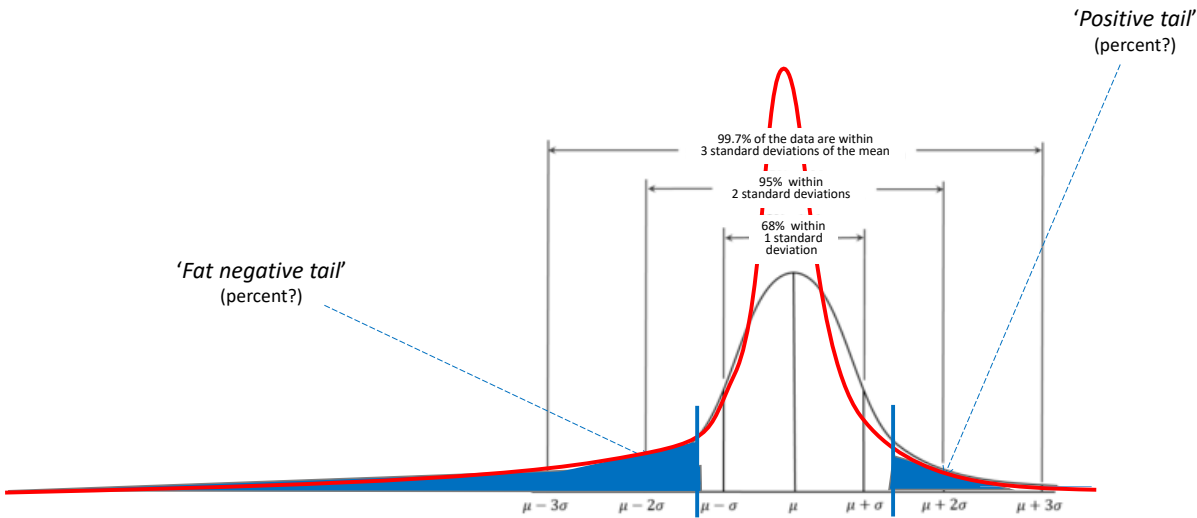


Figure 2. The distribution of realized returns (ROA) that typically display negative tails

We frequently observe extreme negative performance outcomes among firms that operate in industries where business activities are viewed as particularly “risky,”⁹ such as oil exploration, pharmaceutical drug discovery, and software development. These activities fall within certain four-digit SIC codes: drilling oil and gas (SIC 1381), pharmaceutical preparation (SIC 2834),

⁶ See, for example, Beamish, P. W., & Hasse, V. C. (2022). The importance of rare events and other outliers in global strategy research. *Global Strategy Journal*, 12(4), 697-713.

⁷ A “fat” tail in a distribution of returns exhibits high skewness with many extreme outcomes. A “fat” negative tail shows outcomes with extreme negative skewness.

⁸ Albæk, M., & Andersen, T. J. (2021). The distribution of performance data: Consistent evidence of (extreme) negative outcomes. In Andersen, T. J. (ed.), *Strategic responsiveness for a sustainable future: New research international management*, 147-174. Emerald Publishing, Bingley, UK.

⁹ By “risky,” we mean that the expected outcomes from these particular business activities and the capital investments made to pursue them are highly uncertain.

development of surgical and medical instruments (SIC 3841), semiconductors (SIC 3674), and prepackaged software (SIC 7372).¹⁰

In these commercial endeavors, which are rather capital intensive with uncertain business prospects, considerable resources are committed to exploratory development activities with highly uncertain outcomes. In the data sample, some companies only figure as extreme outliers in a single year, while others repeatedly exhibit negative extremes, some with several years between the adverse outcomes. The outliers may be explained as an effect of the risky nature of certain business activities, but the concrete circumstances around extreme outcomes appear to entail more complex conditions. In some cases, the phenomenon relates to erratic management behaviors involving mergers, takeovers, alliances, and restructuring activities aimed at accessing financial resources or preparing for future capital acquisition.

Some companies repeatedly modify their business focus, and change names through mergers and corporate restructurings, with a few ending up in bankruptcy. In these negative outcome tails, we also find some examples of misleading financial statements and failures to file periodic reports required by the SEC (the U.S. Security and Exchange Commission), leading to litigation against firms and their top managers. The fat negative tails also contain (some) young companies, including start-ups that are challenged in their business development and (often) rely on significant R&D investments. We also often observe power struggles among competing owners, with frequent restructuring, debt rescheduling, SEC reprimands, litigation, and eventual bankruptcies.

Performance outcomes

In terms of performance measured as *net income*, only a few companies are negative outliers with outcomes lower than four standard deviations below the mean. However, we find quite a few companies in the positive tail beyond four standard deviations above the mean. In terms of performance measured as *total assets*, which is a commonly used indicator of firm size, we obviously see no negative extremes more than four standard deviations below the mean, since assets are reported as positive numbers, while positive outliers more than four standard deviations above the mean typically are firms posting high net-income figures. They can maintain this position over extended time periods, often for several years, reflecting persistent or sustainable excess performance as measured by absolute net income.

These observations seem to indicate different individual and combined effects on net income and total assets. For example, when a firm is growing, it may have to borrow extensively, incurring high interest expenses and capital depreciation charges while total assets are high. This leads to low net income measured against high total assets, which results in lower relative performance, as indicated by ROA. Conversely, a firm that is (suddenly) hit by extraordinary losses may experience negative net income at lower total assets, as retained earnings are reduced by the loss, thereby possibly leading to a higher negative ROA. We should try to control for these extraordinary accounting-related effects when assessing the distribution of financial performance measured as ROA.

Among the positive extreme outcomes measured by net income, we see many large pharmaceutical companies dominating the high-end tail for extended periods of time. In some instances, this happens every year from 2000 to 2014 (e.g., for GlaxoSmithKline, Johnson & Johnson, Merck, Novartis, Pfizer, and Roche). In this tail, numerous large companies in a single industry (e.g., pharmaceuticals) post extremely high net-income figures that exceed four

¹⁰ SIC is the abbreviation for Standard Industrial Classification, which consists of four-digit codes that classify the industries in which various registered firms operate.

standard deviations above the mean. This reflects an industry context in which huge investments have been made to eventually realize revenues from successful drug-development processes pursued over longer periods. The associated patent-protected sales might not continue in perpetuity, as those patents eventually expire. At that point, new drugs must lead the way. This may also reflect a unique industry context characterized by many small, loss-ridden start-ups focused on R&D-intense drug development. Many such start-ups may initially be (partially) funded by venture capital and supported by big pharmaceutical companies that could eventually acquire them if they are successful.

We may discern similar business dynamics in other fields, like the technology-intense software and computer industries. For instance, Intel and Microsoft—both active in the prepackaged software industry—posted extreme positive net incomes each year from 1997 to 2014. This corresponds to the dominance of the “Wintel Standard” according to which computing is based on Intel’s micro-processors and Windows-based operating systems from Microsoft. We also find these firms in the extreme positive tail of R&D intensity (measured as R&D expenses as a percentage of sales), as they work to ensure a future earnings potential from successful technology-development processes.

In the total sample of firms, only one company figures on both the extreme positive and negative tails of net-income outcomes—Transocean Ltd., the large international offshore oil drilling contractor headquartered in Zug, Switzerland. The company posted superior net income in 2007, 2008, and 2009, but reported extreme negative net income in 2011 and 2014. *Deepwater Horizon*, the rig British Petroleum (BP) engaged to handle its deep-sea drilling at the Macondo field in the Gulf of Mexico, exploded in April 2010, killing 15 workers, and causing the largest environmental disaster in U.S. history. This deep-sea heavy-duty rig was owned by Transocean Ltd. and operated on behalf of BP. This shows how an abrupt adverse and unexpected incident can affect company performance and hurt its reputation. The observed performance effects can be linked to the left-skewed performance distribution (Figure 3).

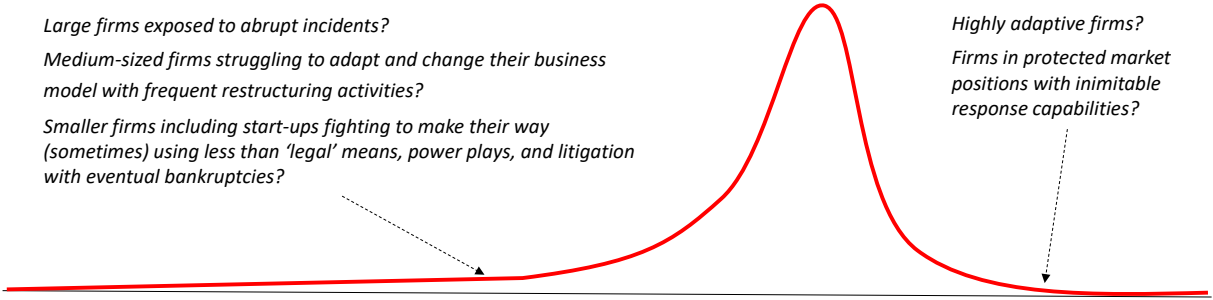


Figure 3. Distribution of realized returns and (possible) links to specific industry contexts

Successful sales efforts require commitments to increase operational capacity making substantial development investments in support of business expansion, which will generate depreciation expenses over multiple years. The investments in productive assets will grow the balance sheet and are expected to expand the future revenues. To the extent (positive) net income is reinvested in the corporate development efforts over time this will increase retained earnings and thereby boost the balance sheet. So, as successful firm generate positive and increasing net income figures, their total assets will increase as well. Hence, we see that the

outperforming companies are persistently located both in the extreme positive net income and total asset tails.

The negative outliers in the “fat” left tail represent a mixed group of firms: large, previously successful companies in decline; (younger) firms struggling to develop profitable business models; and firms exploring new businesses, forging their way with more or less rule-abiding behaviors. Some of these firms eventually end up in bankruptcy. Hence, the negative performance outliers include a diverse set of companies, where the largest firms only figure into the extreme negative tails when their businesses are in decline. Intermingled among such developments, we see patterns of ineffective leadership and risky strategic moves as precursors to negative performance outcomes.¹¹

¹¹ See, for example, Heracleous, L., & Werres, K. (2016). On the road to disaster: Strategic misalignments and corporate failure. *Long Range Planning*, 49, 491-506.

EXHIBIT 1

Distribution of ROA below and above four standard deviations from the mean

Firms with observed outcomes that are four standard deviations below the mean [year of observation]

[1997] Allis-Chalmers Energy Inc. (Houston, TX) was an oil-services and equipment company founded in 1913. The company reorganized in bankruptcy in 1988 and sold all of its major business lines. As of 2001, it had only one company, which was active in the equipment-repair business. Subsequently, it expanded by acquiring related oil-services and equipment companies. The company merged with Seawell in 2011 to form Archer, which was headquartered in Norway.

[2001, 2003, 2004, 2005] Matrixx Resource Holdings, Inc. (Los Angeles, CA) was founded in 2000 as Vinoble, Inc., a holding company seeking to identify long-term growth opportunities in the areas of homeland security, security information systems, and other security services. It acquired Ohana Enterprises, Inc.—a provider of video-streaming solutions for the assessment of candidates—in a reverse merger transaction in 2004. The merger included a 500-1 stock split in order to prepare for acquisitions and a listing on the national stock exchange. In 2005, rumors suggested that Vinoble was being investigated by the SEC. In 2005, it acquired new oil and gas prospects. The company changed its name to Matrixx Resource Holdings in 2006 to reflect its focus on exploration, drilling, and the development of oil and gas projects.

[2014] Intellect Neuro Sciences, Inc. (Englewood Cliffs, NJ) was founded as a biopharmaceutical company in 2005 with the aim of discovering and developing therapeutic agents for the treatment and prevention of neurodegenerative conditions, primarily proteinopathies.

[2008] MedGen, Inc. (Greensboro, NC) was founded in 1996 to produce and sell healthcare products. It was formerly known as Northstar Global Business Services, Inc. and changed its name to MedGen in 2015.

[2002] Skye International, Inc. (Scottsdale, AZ) was founded in 1993 to design, develop, and market water-heating appliances for consumers. It was formerly known as Tankless Systems Worldwide, Inc. and changed its name in 2005. It filed for Chapter 7 (liquidation bankruptcy) in 2015.

[2013] Solar3D, Inc. (Roseville, CA) was a provider of solar-power solutions. It was founded as a solar-cell technology company to commercialize a 3D solar cell technology but then morphed into a niche solar developer and installer through acquisitions, including the acquisitions of SunWorks in 2014, and MD Energy and Elite Solar in 2015. Its name was changed to Sunworks, Inc. in 2016.

[2008] Aethlon Medical, Inc. (San Diego, CA) was founded in 2009 to develop immunotherapeutic technologies focused on fighting infectious diseases.

[2010] Artossa Genetics, Inc. (Seattle, WA) developed and marketed pharmaceuticals for the treatment of breast conditions and breast cancer. It ran a phase 2 study of topical endoxifen.

[2011, 2014] Artventive Medical Group, Inc. (Carlsbad, CA) was a medical-device company that developed, manufactured, and marketed endoluminal occlusion devices (EOS) in Europe. It was founded as Uranium Plus Resources Inc. in 2007 and changed its name in 2010. It received EU approval for the EOS Plug in 2013 and FDA clearance in 2014, paving the way for expansion.

[2006, 2007, 2008] Revolutions Medical Corp. (Mount Pleasant, SC) was a developer of patented, disposable, safety syringes. In 2012, the SEC charged it with issuing fraudulent press releases on products and it was sentenced in 2018.

[2008, 2009] ComGuard.com, Inc. (Incinitas, CA/Dubai Internet City, UAE) was founded in 1998 as a developer of security applications for mobile and network markets.

[2013] eCrypt Technologies, Inc. (Austin, TX) was founded in 2006 as an encryption-software developer. It changed its name to Bravatek Solutions, Inc. in 2015 to reflect a focus on broader cybersecurity solutions.

[2012] Validian Corp. (Ottawa, Canada) was founded in 1989 as a developer of cybersecurity software.

Firms with observed outcomes that are four standard deviations above the mean

None

EXHIBIT 2

Distribution of net income (NI) below and above four standard deviations from the mean

Firms with observed outcomes that are four standard deviations below the mean [year of observation]

[2002, 2011, 2014] **Transocean Ltd.** (Zug, Switzerland) was the world's largest offshore drilling contractor with offices in 20 countries.

Firms with observed outcomes that are four standard deviations above the mean [year of observation]

[2006, 2011, 2014] Baker Hughes, Inc. (Houston, TX) was one of the world's largest oil field services companies. It was 50.4% owned by GE and 49.6% publicly traded.

[2007, 2008, 2009] **Transocean Ltd.** (Zug, Switzerland) was the world's largest offshore drilling contractor with offices in 20 countries.

[2008, 2009, 2012] Abbott Laboratories

[2006, 2007, 2008, 2009, 2010, 2011, 2012] Astra Zeneca

[2001, 2008, 2009] Bristol-Myers Squibb

[2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013] GlaxoSmithKline

[2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014] Johnson & Johnson

[1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2011, 2012, 2013, 2014] Merck & Co.

[2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014] Novartis AG

[2001, 2002, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014] Pfizer Inc.

[2000, 2004, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014] Roche Holding AG

[2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013] Sanofi

[1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014] Intel Corp.

[2008, 2009, 2010, 2012, 2013] Bard Inc.

[2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014] Becton Dickinson

[2007, 2008, 2009, 2014] Carefusion Corp.

[2001, 2002, 2004, 2005] Guidant Corp.

[1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014] Microsoft Corp.

[1999, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013] Oracle Corp.

[2007, 2011, 2012, 2013, 2014] SAP SE