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IS THERE A SINGULAR DRIVER OF ENTREPRENEURSHIP? POWER-LAW DYNAMICS OF ORGANIZATIONAL EMERGENCE AND GROWTH

G. CHRISTOPHER CRAWFORD
Ohio University, College of Business,
Athens, OH 45701

BENYAMIN LICHTENSTEIN
University of Massachusetts

ABSTRACT

Empirical findings show that power-law distributions most accurately characterize all revenue- and employee-based outcomes in entrepreneurship. We hypothesize that "opportunity tension" is the mechanism that initiates and perpetuates these distributions. Non-linear tests indicate significant support for our hypothesis, providing a solid foundation for a scale-free theory of new venture performance.

INTRODUCTION

What drives entrepreneurial activity? Answers to this question are as diverse as the study of entrepreneurship itself: Proposed drivers of entrepreneurship range from individual-level attributes to team-level resources to organizational-level actions to market- and industry-level characteristics–the entire array of human and social activity. Still, this search is useful, for finding a single driver of entrepreneurship could integrate findings across disciplines and, more importantly, generate very useful insights for entrepreneurs and policy-makers.

Complexity science offers a unique theory and method for asking whether a simple set of generating mechanisms can explain the creation and growth of entrepreneurial companies. These mechanisms are the *underlying dynamics* that give rise to the visually distinct, self-similar outcomes at multiple levels in a complex system (Gell-Mann, 1988; Sornette, 2006). These systems are composed of interdependent agents, each of which possesses adaptive mental blueprints—schemata— that drive how an agent interacts with other agents in the environment (Anderson, 1999; Simon, 1968). Over time, these interactions generate identifiable dynamics in the system that result in highly-skewed power-law distributions at all levels of analysis (Andriani & McKelvey, 2009; Winter, 2007); here, the slope of the power-law tail provides a measure of those dynamics. On this basis, we hypothesize that there is a singular value—the coefficient *alpha,* defining one specific slope—that reveals a single driver of entrepreneurship across the *entire range* of entrepreneurial outcomes. This applies to all ventures, regardless of scale: from non-growing lifestyle ventures, to growing SMEs, to VC-backed start-ups that generate the highest growth rates across all firms.

THEORETICAL BACKGROUND

Although most statistical analyses in organization science are based on a normal curve—the Gaussian distribution—an increasing number of papers argue that Pareto distributions are far more realistic and useful for management (O'Boyle & Aguinis, 2012). Pareto distributions of a

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phenomenon suggest that 80% of all instances have almost no influence on the rest of the system, while 20% of the instances yield the vast majority of its outcomes. In entrepreneurial terms, the outliers are the high-potential firms (Bhide, 2000)—the .03% of entrepreneurial start-ups that generate 60% of all new jobs—or the new ventures with radically new technology.

In mathematical terms, a power-law distribution exists when the frequency of an event of size x is proportional to the ratio of $1/x^{\alpha}$. Here, the exponent α is an indication of the dynamics in the population, ranging from 1 to 3, measuring the relative interdependence of the entire distribution on the observations in the tail. Like traditional statistics, the observations in the tail would be considered "outliers"—those outside the normal; in this case, when $\alpha \sim 3.0$, the population has relatively stable dynamics (looking somewhat bell-shaped with a very short tail), where outliers are random and do not significantly influence the overall properties of the system. When $\alpha \sim 1$, the dynamics are much more chaotic, and nearly all of the distribution's total outcomes lie in one outlier (as an example, consider if Bill Gates walked into a corner pub; on "average", everyone is a millionaire) and the tail of the distribution is extremely long. In contrast to traditional statistics, power-laws recognize that outliers have an inherently disproportionate influence on the rest of the system.

In theoretical terms, small differences in a system's initial conditions, iterated over time and amplified by continuous interactions with the environment, can result in extreme variations in individual outcomes (Bak & Chen, 1991; Bar-Yam, 1997). Most important to our argument, though, is that power-law distributions (and the outliers therein) are not random. Instead, power-laws result from a deep, underlying pattern of emergence (Bar-Yam, 1997). As Brock (2000: 29) describes, "Complexity considers whether these patterns have a property of *universality* about them." Such patterns are called scaling laws (Gell-Mann, 1988) because they are expressed as empirical regularities in *specific attributes that apply across many orders of magnitude of a phenomenon.* Such self-similar, fractal patterns across levels have been shown in multiple studies, across nearly all units of analysis in organizational studies and human interaction (see Andriani & McKelvey, 2009 and Barabási, et al., 2012). In all of these systems, the higher-level aggregate activity will exactly reflect the scaling pattern of the micro-level pattern; likewise, each higher level (order of magnitude) will have the same scaling dynamic (McKelvey et al., 2011). *Through this aggregation process, the entire scope of the phenomenon can be driven by the same generative mechanism.* Furthermore, due to its similarity, evidence of a power-law at one level is an indication that similar dynamics are evident at the preceding level.

In sum, power-laws can identify the presence of a single generative mechanism that drives the activity and outcomes of a given phenomenon. In such systems, a specific driver generates order at the most micro-levels; as this order is aggregated into higher levels the generative mechanism cascades 'upward' through the system, influencing all subsequent levels. The question we now ask is, what would such a generating mechanism be in entrepreneurship?

Schemata-and-Action as a Generative Mechanism

Complexity scholars have proposed that outcome patterns in social systems, including generative phenomena that display power-laws, are most likely the result of schemata because it drives how agents think, act, interact, and thus how they generate emergence (Anderson, 1999; Drazin & Sandelands, 1992; McKelvey, 2004). An entrepreneur's schemata allow them to identify salient opportunities (Shane & Venkataraman, 2000) and actively create potential markets for products that do not yet exist (Sarasvathy, 2001); schemata also provide the impetus

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and motivation to pursue and/or enact a new opportunity. Thus, schemata combine the internal desire to act with the directional pursuit of a specific opportunity.

Entrepreneurial schemata are also the basis for transforming opportunities into new companies, for they drive present and future interactions with customers, suppliers, investors and other stakeholders (DeKinder & Kohli, 2008). Further, customers use these interactions to construct expected value of the firm's offering and its potential outcomes (Gartner et al., 1992; Vargo & Lusch, 2008). Likewise, a founder's expectations about the venture's future growth, and the explicit or implicit expression of that intent to stakeholders, also influences the perceived value and potential of the firm (Wiklund & Shepherd, 2003). This connection between schemata (expectations) and entrepreneurial outcomes is underlined by researchers examining the link between individual-level processes and macro-level outcomes (e.g. Barnett & Sorenson, 2002; Lomi, Larsen, & Wezel, 2010). For example, Lomi et al.'s (2010) system dynamics model shows how small changes in micro-level expectations qualitatively (and non-linearly) influence macro-level outcomes, supporting our claim that schemata lead to organizational outcomes.

In sum, complexity science suggests that patterns of interaction are endogenously generated by the entrepreneur and at the same time the marketplace exogenously provides feedback as to the relative value of the new firm's offering. Together these interactions exhibit bottom-up and top-down causality, as originally envisioned for organization science by Lewin et al. (1999) and for entrepreneurship by McKelvey (2004). Further, entrepreneurs' expectations about future outcomes are highly skewed: most aim for 'normal' outcomes, whereas a small percentage hope for very high 'non-normal' growth rates, which are achieved by an even smaller number. Based on the complexity science analysis above, this combination of linearity and non-linearity across all companies may be recursive, leading to a power-law relationship of expectations and outcomes for the initial start-up as well as further growth of entrepreneurial firms. Thus, *the expected outcomes of entrepreneurial founders will be power-law distributed* and the *expected future outcomes of nascent entrepreneurs will be non-linearly associated with actual venture outcomes*.

Opportunity Tension as the Driver of Entrepreneurial Action

As mentioned above, entrepreneurial schemata revolve around a potential business opportunity, either recognized (Shane & Venkataraman, 2000) or created (Sarasvathy, 2001), *as well as* the motivation to capitalize on the opportunity to start a business. McKelvey (2004) used the term 'adaptive tension' to describe this duality of drivers in new venture creation—(a) the internal drivers of passion and need that are (b) externally induced by energy differentials in the system (i.e., opportunities). We adopt the more explicit term "opportunity tension" to capture this combination of external and internal drivers for action (Chiles et al., 2010; Lichtenstein, 2009), where 'opportunity' expresses the external driver and 'tension' refers to the *creative tension* of the entrepreneur (Fritz, 1989) that generates an intrinsic motivation to enact the opportunity. The higher the creative tension the more motivation to act, a theoretical link that has been born out in empirical studies of entrepreneurship (Cardon et al., 2009; Lichtenstein & colleagues, 2006, 2007). Although opportunity tension doesn't capture every possible driver, it does reflect a consensus around the agency that propels entrepreneurship (Delmar & Shane, 2004; Shane et al., 2003); it also reflects the micro + macro processes that are critical to understanding entrepreneurial outcomes (Barnett & Sorenson, 2002; Lomi et al., 2010).

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Opportunity tension can be operationalized in terms of the *expectations* an entrepreneur has about the potential growth of the company, and the *actions* s/he takes to achieve it. Theoretically and empirically these two elements are very hard to separate for new firms. In larger, fast-growth businesses, where causal complexity is much more difficult to assess (McKelvey, 2004), our measure of opportunity tension focuses on the actual outcomes of the organization. These outcomes still reflect an integration of micro- and macro- drivers for entrepreneurship, i.e. the continued realization of an opportunity through the committed action of the entrepreneur/ial team. Although internal motivations are opaque in external accomplishment, entrepreneurship researchers have shown that they are nonetheless present as key drivers of the process (Baker & Nelson, 2005). In considering outcomes, two of the most-used in the domain are annual revenues and number of employees. These are important across the entire range of entrepreneurial companies. Further, we measure growth in revenues and in employees because these two together present a relatively broad description of the scope of an organization, whereas separately they can present quite distinct outcomes for the same firm (Achtenhagen et al., 2010). Thus, taking these two measures together provides a realistic view of the firm: they reflect the actual scope of the opportunity and the motivation of the entrepreneurial team to capitalize on it.

We acknowledge that opportunity tension is moderated by a host of intervening factors – in the entrepreneur, the team, their network, the market, the technology, the economy, and so on. However, the beauty of power law mathematics is that it allows us to identify a generative mechanism within the entire range of data. Thus, our operationalization is particularly viable given the method we employ. As such, we use power-laws to see if we can identify a common dynamic—the distribution's exponent/ slope of the power-law tail, *alpha*—that explains an entire set of data according to a single generative mechanism or 'scaling dynamic.' In formal terms, *opportunity tension will lead to a universal scaling dynamic for a nascent founder's expectations for growth, and for the outcomes of both newly emerging firms and hyper-growth firms.*

METHOD

We pursue our hypotheses through an exploratory, quantitative research design, which is recommended for investigating scalability dynamics and extreme outcomes (Benbya and McKelvey 2011; Simon 1968). We use two theoretically relevant samples. The Panel Study of Entrepreneurial Dynamics II (PSED) tracks 1,214 subjects who are currently starting businesses; it is drawn from a random sample of Americans. The second sample is the Inc. 500® (INC) annual survey of the 5000 fastest-growing privately-held companies in the United States. These firms must have grown to at least $2M in revenue. Our measures of expected outcomes include: *PSED Expected Employees (Yr1); PSED Expected Revenue (Yr1); PSED Expected Employees (Yr5)*; and *PSED Expected Revenue Yr5;* our measures of actual outcomes are: *PSED Revenue* and *Employees (Yr1 & Yr5); INC Revenue, Revenue Growth,* and *Employees*.

To assess the data for power-laws we use MATLAB software (R2010a), and follow the techniques for calculating power-law model fit, as described by Clauset, et al. (2009). Using their framework, we estimate the parameters for the scaling exponent [α] *(alpha)* and calculate the Kolmogorov-Smirnov statistic (K-S) to assess goodness of fit with between the data and a pure power-law distribution. We examine whether the distribution exhibits a significant K-S statistic, and whether the estimated α exists across multiple units and levels of analysis. First, K-S values below 0.10 are considered significant for model fit (Newman, 2005). Second, if multiple distributions possess the same exponent, it suggests that the same underlying dynamic—the

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single generating mechanism—drives the outcomes at the next successive level of analysis. Finally, we use a nonparametric rank-order correlation statistic, Spearman's rho, to assess the significance of the long-range, non-linear association between expectations and outcomes.

RESULTS AND INTERPRETATION

Our analyses show that 20 of 22 variables are explained through a power-law distribution, i.e. they have K-S statistics below 0.10. Every revenue-related variable in the PSED and in the INC data sets is power-law distributed. Our second set of analyses tests for a universal scaling exponent; findings show a specific $\alpha \sim 1.75$ for a majority of variables. Specifically this *alpha* is found for PSED *Expected Employees Yr5, Expected Employee Gain, Expected Revenue Yr1, Expected Revenue Yr5, and Expected Revenue Gain.* The *same alpha* is found for PSED outcomes—*Employees Yr5, Employee Gain, Revenue Yr1, Revenue Yr5, Revenue Gain,* and *Revenue Growth.* Likewise it is found for INC 500 *Revenue* and *Revenue Growth.* Looking solely at the revenue variables across the two data sets, eight of eleven (72%) show an *alpha* of 1.75 ± 0.04, and 81% show a similar alpha ± 0.08. We hypothesize that this α, which represents an underlying dynamic across all firms, begins with expectations for future outcomes at the pre-organizing stage in the PSED, continues through realized outcomes in Yr1 and Yr5, and endures into the INC where most companies have been in operation for 10+ years. In support, we find that *PSED Expected Employees Yr5* is correlated with *Employees Yr5* (rho 0.345), and *PSED Expected Revenue Yr5* is correlated with *Revenue Yr5* (rho 0.622), with $p \leq 0.0001$ for both.

Is there a "Power Law of Entrepreneurship"? Our findings suggest that the answer may be yes, in two different ways. First, with limited exception, virtually all the data are distributed according to a power-law; that is, a K-S statistic ≤ 0.10 is confirmed for 91% of the variables. Second, we found a universal pattern of scalability ($\alpha \sim 1.75$) in 81% of all the revenue variables. This significance across multiple dimensions suggests, following Simon (1968: 443), that our findings, "…cannot be accidental, but must reveal underlying lawfulness." We therefore suggest that a simple set of generative mechanisms does indeed exist for entrepreneurship.

DISCUSSION AND CONCLUSIONS

What drives entrepreneurial activity? Our results suggests that the vast majority of entrepreneurial outcomes can be explained by the construct opportunity tension (Chiles et al., 2010; Lichtenstein, 2009), i.e. the entrepreneur's perception of an opportunity joined with their motivation and actions that capitalize on it. Whereas entrepreneurship research has shown that a venture's *endowments* (its human, social, intellectual, and financial capital) and *environments* (its resource munificence and competitive intensity) highly influence outcomes, we add empirical evidence that a founder's nascent *expectations* for future growth drive *engagement* (her activity dynamics) that generates those outcomes. In all four components—endowments, environments, expectations, and engagement—scholars have empirically identified power-law dynamics, and each is inherent in the domain of entrepreneurship. We propose that our construct encompasses all four components, whereby opportunity tension occurs when an observation exists in the tail of the distribution for any component. Thus, opportunities are most readily discovered and created—and ventures are most likely to emerge—when any of the four components exist

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outside the normal. Overall, our findings suggest that opportunity tension makes a significant contribution to both complexity science and entrepreneurship theory.

Contributions to Complexity Science

Complexity science has been used by entrepreneurship and management researches to uncover non-linear processes of new venture creation and growth (Lichtenstein et al., 2007) and dynamics of organizational innovation, leadership, adaptation and change (Levinthal, 1997; Plowman et al., 2007). However, this is one of the only studies to empirically explore for the presence of power laws in both individual- and organizational-level data, and it is the very first to apply power-law theory to entrepreneurship. Our results reveal that entrepreneurial outcomes can only be fully explained through the use of power-laws.

Further, ours is the first complexity science study to make hypothesis-driven tests across multiple data sets tracking the same outcomes; and, we provide one of the few confirmations of the recursive and aggregative nature of social action. Moreover, ours is the first that empirically identifies the ‘threshold’ or ‘tipping point’ in a data set, where observations transform from independent, linear, and additive, to interdependent, nonlinear, and multiplicative—details are presented in the full paper. The identification of this threshold significantly extends complexity theory by including all entrepreneurial outcomes into a single framework.

Contributions to Entrepreneurship Theory

Our findings can re-direct entrepreneurship research efforts: future theoretical development will need to account for power-laws in the data and explain the mechanisms that drive their emergence. Empirically, modeling emergent and non-linear processes using traditional linear statistics does not provide an adequate understanding of the phenomenon, with an associated detrimental effect on reliability, validity, and causality. The primary contribution of this paper is proposing opportunity tension as the basis for a generative mechanism in entrepreneurship. Our framework is scale-free: it is applicable to all entrepreneurial activity, regardless of the actual (or potential) scale of the venture. Theoretically, opportunity tension allows for an integration of discovery- and creation- theories of entrepreneurial opportunity (Alvarez & Barney, 2007), in part by shifting the frame from opportunity, per se, to its enactment in new and growing ventures (Gartner, 1993; 2001; Venkataraman, et al., 2012). The result is an integration of cognitive expectations, behavioral outcomes, and environmental responses, as well as a connection between micro- and macro-level influences.

This study also enhances our understanding of recursive and amplifying effects of opportunity tension. Specifically our data suggest that if a nascent founder *expects* to grow, s/he is more likely to *do* things that will facilitate growth. Perhaps most intriguing is the recognition that entrepreneurial expectations and outcomes are power-law distributed, suggesting that the drivers of entrepreneurship may be embedded in the dynamics of the individual interactions within the system, rather than in the content of each unique entrepreneurial venture. Although entrepreneurship scholars have made this argument in theoretical terms, our empirical confirmation makes this claim much harder to ignore, and highlights the value of pursuing a complexity science of entrepreneurship (Lichtenstein, 2011; McKelvey, 2004).

REFERENCES AVAILABLE FROM THE AUTHOR(S)