MANAGING IN A PARETO WORLD CALLS FOR NEW THINKING

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ABSTRACT

Increasingly, complexity science focuses on power laws, long tails, extreme events, fractals and other Pareto-related effects. New fields such as econophysics and sociophysics have arisen. These recognize the nonlinear interdependences among agents, where power laws are often signify scale-free dynamics. Findings showing the ubiquity of power laws in the social and organizational worlds underlie increasing calls for more applications of Pareto-driven ideas to organizational and management research. Given that the world of practicing managers is, then, quite likely Paretian rather than Gaussian, what to tell managers? Basic ideas highlighting key differences between Gaussian and Paretian approaches are first reviewed. Then, four specific cases highlighting the managerial tails of Pareto distributions are discussed. These illustrate how overall managerial effectiveness improves by managing the Pareto tails rather than relying on conventional wisdom to manage 'average' behaviour. Insights and effective strategies better tuned to Pareto-distributed managerial practice follow.

Key words: Extremes, Hollywood economics, long tails, Pareto, power laws, scale-free dynamics, UP gridlock.

In the past few years there has been an increasing attention in the complexity theory literature to power laws, long tails, extreme events, fractals and other Pareto-related effects (Schroeder, 1991; West and Deering, 1995; Iannaccone and Khokha, 1996; Newman, 2005; Barabási, 2002). Entirely new fields such as econophysics and sociophysics have arisen (Chatterjee et al. 2005, 2006, 2007; Mantegna et al., 2000) based on the recognition that the nonlinear interdependences among agents gives rise to a more complex world, where power laws are the signature of scale-free dynamics.

Aside from a few exceptions, (De Vany, 2003; Anderson, 2006; Taleb, 2007), the management, organizational theory and business literature is trailing behind, but at the same time it offers a very rich field of inquiry to the researchers who want to explain the origin and dynamics of the extreme diversity of business structures. On the one hand, we see extreme outliers at one end of a Pareto distribution – positive extremes such as GE, Microsoft, Wal-Mart and Google, and negative extremes such as the Challenger and Pioneer disasters, LTCM, Parmalat, Enron, CountryWide, IndiMac, Bear Sterns, Fanny Mae/Freddie Mac, and Lehman Brothers on the negative side. At the opposite end, we see the Pareto tail Chris Anderson writes about – a Pareto tail consisting, for example of Amazon's book sales or 17 million Pa& Pa stores – many of which are in idiosyncratic micro-niches.

In previous papers (Andriani and McKelvey, 2007, forthcoming) we have reviewed the literature on power laws, demonstrated the ubiquity of power laws in the social sciences and more in particularly in the organizational world, applied Pareto-driven ideas to methodology and research in organization science, and developed a framework to explain the emergence of power laws in the social sciences (which we call scale-free theory). In this paper we focus on a different aspect: Given that the world in which organizations live is frequently Paretian, what types of changes in thinking and practices are required of managers to successfully interact and prosper in a Paretian world? How to transform the new understanding of scalability and scale-free theories in tools useful to anticipate and govern the transformation of small initiating events into extreme events, either to favourably shape the emergence of new business market and/or organizational structures or to avoid their potentially lethal consequences? Can scale-free theories help identify the initiating stages of Holland's (2002) '*tiny initiating events*'?

These are big questions that require a reorientation of management and organization theory. In this paper we show how the practice of management changes when a practicing manager adopts a Paretian standpoint. We begin with a review of basic ideas that differ between the Gaussian and Paretian approaches. Then we discuss four specific cases in which the Paretian standpoint offers new insights and effective strategies. A conclusion follows.

1 PARETO VS GAUSS: WHY POWER LAWS MATTER

Abbott (2001, p. 7) discusses how the 'general linear model' from Newtonian mechanics came to shape social scientists' thinking. As Abbott writes:

> *The phrase 'general linear reality' denotes a way of thinking about how society works. This mentality arises through treating linear models as representations of the actual social world…. The social world consists of fixed entities (the units of analysis) that have attributes (the variables). These attributes interact…to create outcomes, themselves measurable as attributes of the fixed entities.*

The 'general linear reality' (GLR) model has influenced not only the way researchers build models and the philosophical assumptions they use but also directly the way we conceptualize the world. GLR, Abbott claims, has transformed normal distributions from a tool relevant under a set of specific circumstances into a representation of the world as it is. By stressing the centrality of fixed, independent entities, GLR fails to account for the emergent properties of systems that derive from connectivity within or among systems. The consequent interdependence among agents generates Paretian dynamics and power laws as its signature.

Power laws seem ubiquitous – they appear in leaves, coastlines, and music (Casti, 1994). Power laws characterize earthquakes and hurricanes. American, Japanese, Chinese, and Indian cities, among many others (but clearly not all), follow a power law when ranked by population (Auerbach, 1913; Zipf, 1949; McKelvey et al., forthcoming). The structure of the Internet follows a power law (Albert et al., 1999), as does the size of firms (Stanley et al., 1996; Axtell, 2001). We have collected 84 examples of power laws in the social and organizational world (Andriani and McKelvey, forthcoming). Brock (2000) says power laws are the fundamental feature of the Santa Fe Institute's (SFI) complexity science.

A Pareto distribution plotted as a double-log scale appears as a inverse power law – a negatively sloping straight line. Power laws are '…indicative of correlated, cooperative phenomena between groups of interacting agents…' (Cook et al., 2004, p. 3). Power laws often take the form of rank/frequency (or size) expressions such as $F \sim N^{-\beta}$, where F is frequency, N is rank and β, the exponent, is constant.[1] In 'exponential' functions the exponent is the variable and N is constant. Theories explaining power laws are also scale-free, i.e., the same explanation (theory) applies to several adjacent levels of analysis.

We argue that power law theories apply to management and organizations. There is good reason to believe that power-law effects are also ubiquitous in organizations and have far greater consequence than current management theories presume. Previously, we argue that any time there is the presence of tension and connectivity dynamics, the probability of power-law-distributed phenomena increases substantially. To the extent this is true, managers ignoring power-law effects risk missing an important part of the dynamics of business phenomena. Specifically, the extreme outcome at one end of the Pareto tail is typically N = 1. Extreme events and radical innovations fall into this group. At the opposite end the N can run into the millions and more. The mode, mean, and median do not overlap, as they do in a normal distribution. Moreover, in many power-law distributions the mean and the variance do not exist! There is no typical scale and therefore the use of averages and standard deviations to represent the phenomenon is misleading. Methods of good management at one extreme do not apply to the opposite extreme – managing a Ma& Pa store is not the same as managing Wal-Mart. As Axtell (2008) points out, 'the typical firm does not exist.' Managing the median firm is not the same as managing at either extreme.

Frequently, what is most important to managers are the extremes they face, not the averages. Yet, the research of most academics produces results based on averages in normal distributions and associated statistical significances (McKelvey and Benbya, 2007). We believe that research results stemming from Pareto-based science could be of more value to managers. But how? What can the study of Pareto-based science contribute to the practice of management?

We begin by highlighting the main areas that have been changed by the discovery of power-law phenomena. Then we apply these lessons to four specific fields and detail how Gaussian and Paretian approaches lead to entirely different conclusions.

1.1.1 Independence or Interdependence?

Power-law phenomena exhibit Paretian rather than Gaussian distributions – see Figure 1. The fundamental difference lies in assumptions about the correlations among events. In a Gaussian distribution the data points are assumed to be *independent-additive* (hereinafter simply 'independent'). Independent events generate normal distributions, which sit at the heart of modern statistics. When events are *independent-multiplicative* they produce a lognormal distribution. When events are *interdependent*, Paretian distributions dominate because positive feedback processes leading to extreme events occur more frequently than 'normal', bell-shaped Gaussian-based statistics lead us to expect; normality in distributions is *not* the norm.

>>>Insert Figure 1 about here<<<

Several theories explain power laws. They typically hinge on *interdependence* among data points and a possible ensuing positive feedback process. Herein lies the problem for 'normal' science: Most quantitative research involves the use of statistical methods presuming *independence* among data points and Gaussian 'normal' distributions. The many findings of natural and social power-law phenomena, however, indicate that *interdependence* is far more prevalent than 'normal' statistics assumes and the consequent extremes have far greater consequence than the 'averages' in between.

1.1.2 Heterogeneity and diversity

Linear science, GLR, and normal statistics assume that the world is complicated – but not complex. The distinction is about emergent properties. In a complicated world, the properties of systems can be derived from the properties of their constituent elements. For instance, in the Neo-Darwinian account of biology, the properties of an organism are set by the information in its genes. The causal chain is bottom-up, from genes to organisms. Ignoring emergent properties allows the radical simplification of reality.

[1] Note that though a power law exponent is constant in a particular function, the exponent may change for different settings, industries, times, etc. For example, Stanley et al. (1996) find slightly different scaling coefficients across a large sample of firms for sales, assets, number of employees, etc.

This assumption and the consequent methodology and methods have permeated entire disciplines within management and business studies, from decision-making to marketing, from logistic and supply chain management to strategy. If reductionism is a valid strategy, then the possible states of a system are finite and consequently both the heterogeneity of the agents of a social-economic system and its pattern of variability are finite, in principle and in practice. The purpose of the analyst is to identify the ‘atoms’ of the system. This can be a gene (Dawkins, 1989), meme (Dawkins, 1989), a rational optimizer (Nash, 1950), a technique (Mokyr, 2002), a way of making a living (Vermeij, 2006) or any fundamental units that can be aggregated to reconstruct a dynamical system.

This approach fails on two accounts: first, it ignores that emergent properties increase diversity and heterogeneity of agents at the specific level they operate. The emergence of company culture, or routines in social groups is a result of the connections within networks (connectionist property) and cannot be ‘reduced’ to the properties of the agents. Second, the focus of GLR-based sciences on discrete entities rather than on the connections among entities[2] allows the description of the entities and attributes via ‘normal’ bell-shaped statistics. This relies on the concept of the representative agent and assumes that the total diversity of the distribution is limited and mostly contained within two standard deviations from the mean. Armed with a Gaussian approach, the attention focuses on the centre of the distribution, where most of the data are expected to fall. The rare events that lurk in the tail of the distribution are treated as outliers and often discarded.

Linear sciences tend to ignore or underplay the true diversity of the systems they study, whereas power-law distributions reflect a dynamical range that is orders of magnitude wider than a normal distribution. The natural variability of most phenomena is practically unbounded and consequently, reliance on average/variance type of explanations is misleading. There is no typical firm, transaction, agent, consumer, voter, supplier, technology, etc.

1.1.3 Prediction and predictability

In the linear science paradigm, the evolution of a system follows a set of universal laws, time and space independent. The so-called initial conditions capture the settings of a specific system and consequently enable the resolution of the equations of motion of that system. In complicated systems, composed of multiple parts, the linearity assumption permits the simplification of a scientist’s task by breaking down the systems into its constituent parts. The task of predicting the evolution of a system can, therefore, be transformed into a modelling exercise of decomposing complicated systems down into individual parts, followed by the construction and testing of the relevant equations for the system’s parts, and finally by re-aggregation the reductionist findings.

At the opposite end of the spectrum, the prevailing view of complex systems stresses emergence, nonlinearity and the role of chance in the evolution of systems. This view stresses sensitivity to initial conditions, which leads to the idea that basically every aspect of complex systems is fundamentally chaotic, both at agent and aggregate levels. For instance, De Vany in his *Hollywood Economics* (2003) shows how every aspect of filmmaking is chaotic and sensitive to initial conditions. Consequently chance reigns supreme. We don’t dispute his conclusions but notice that complex systems and their statistical signature (power laws) result from the establishment of a collective system of interdependencies that give rise to a collectively critical system. The system self-organizes around some dynamical patterns that are amplified until they become a new form of collective order. This is something that science can study, model and try to anticipate and managers exploit. In general, the exact prediction of single events remains outside the capability of current science, but the possibility of anticipating major reversals in trends via the study of the build-up of interdependencies in the system becomes possible.

In conclusion, the emergent collective order of complex systems allows some limited forms of prediction. The tail and slope of power-law distribution give important information about the nature of the phenomenon under study and provide important information to the decision maker.

[2] Connections, and more in general the context within which the entities operate, are seen as forces that affect the variable attributes of the entities

1.1.4 Long Tail and Extreme Events

Life is inherently risky. Risk depends on the fundamental out-of-equilibrium dynamics of social and natural phenomena. As Nicolis and Prigogine (1989) write: *Non equilibrium reveals the potentialities hidden in the nonlinearities, potentialities that remain dormant at or near equilibrium.* Some of the self-organizing states of the out-of equilibrium dynamic lead to extreme events, that is, to bifurcating catastrophes that reshape the context in which 'normal' events take place. Eldredge and Gould (1972) found that biological evolution occurs in short bursts of frantic change followed by long periods of incremental change (Gould and Eldredge, 1977). The same view is now diffused in history (De Landa, 2000), history of technology (De Landa, 2000), economics and urban planning (Jacobs, 1969, 2000; Vermeij, 2004), business and management (Romanelli and Tushman, 1994), finance (Sornette, 2003; Mandelbrot and Hudson, 2004), and so on.

Risk in the punctuated equilibria model can be extreme. It is however difficult to account for this type of risk by using tools and models of traditional sciences. Traditional methods privilege the study of the average, the common and the variance around the representative scale. Risk is dealt with within this paradigm. Reliance on the fundamental assumptions of linearity, independence of events and continuity gives rise to theory that can only describe well-behaved distributions according to which extreme events should never happen.

Extreme events challenge the dominance of existing GLR-based theories. By definition extreme events are rare and difficult to describe via traditional statistics. They originate in the tail of distributions and grow around dynamical trajectories that are often unexpected and unprecedented. Extreme events tend to redraw the basic features of systems and therefore to give rise to new systems. The financial world after 1929 was different from the pre-crash one. Different rules applied and different regulations were needed. If the knowledge of the ordinary doesn't help, then it becomes necessary to pay attention to the tail of the distribution, to the outlier, and identify early on the expansionary self-organizing dynamics that trigger the emergence of a new system.

2 MANAGING IN A PARETO WORLD CALLS FOR NEW THINKING

> … much of the real world is controlled as much by the 'tails' of distributions as means or averages: by the exceptional, not the commonplace; by the catastrophe, not the steady drip…. We need to free ourselves from 'average' thinking. (Nobel Laureate P. W. Anderson, 1997, p. 566)

In the following we apply the Paretian framework to four specific areas to show how the change in paradigm from Gaussian to Paretian allows a better understanding of reality and helps formulate original and effective management strategies. We start by focusing on the emergence of *The Long Tail* and the consequent change of strategy; we then examine the business of an 'experience good' such as the movie industry and show how risk and prediction are redefined; next we show how concentrating on the tail suggests an alternative strategy to deal with the homeless problem. We turn to the collapse of UP Railroad to illustrate how a Paretian approach can help explain and potentially avoid major catastrophes.

2.1 Managing Extreme Uncertainty to Increase the Blockbuster Tail

The movie industry in the U.S. (i.e., Hollywood) is exposed to radical uncertainty and extreme events unlike most industries. Most movies are money-losers. A few blockbusters make huge profits and support the industry (De Vany, 2003). The Hollywood saying '*Nobody knows anything*' (Goldman, 1983) indicates that predictability of success (or failure) of movies has systematically escaped the efforts of analysts, academics, and practitioners. Extreme events such as '*The Blair Witch Project*,' which cost \$60,000 and brought \$140 million or the failure of '*Waterworld*,' which cost \$175 million but grossed only \$88 million at the U.S. box office are typical examples. The usual predictors of movies' success, such as budget, release date, variables related to actors, Academy Awards, critics' reviews, etc., do not seem to give any reliable predictions about the outcome of a movie.

Assuming that the movie world is Gaussian rather than Paretian is problematic on several counts.

First, it gives an unrealistic picture of risk. Assuming that the movie industry is Gaussian, the probability of a movie such as '*Home Alone*' (profit = \$93 million) is $2.97 * 10^{-16}$, a virtual impossibility. A stable Pareto gives the much more reasonable value of 0.83%. The '*Waterworld*' failure would never have been predicted by using Gaussian statistics ($-3.41 * 10^{-12}$), against a Pareto probability of 0.45% (De Vany 2003, pp. 219, 284). **Second**, it masks the importance of the rare events determining the success of the industry.

Third, if success is unpredictable, certain practices such as flat-fee distribution rights and contracts based on expected results are counter-productive and damaging to the industry. **Fourth**, in attempting to stabilize revenues and improve predictability, studios invest in sequels and make the plot of most movies follow a list of pre-determined and distilled ingredients. This is based on the '*minimum common denominator*' strategy described in our Long Tail section. Again, there is little evidence that these simple rules work.

Is the movie world Paretian? The typical distribution of budget, revenue and profit (movies released in 1999) is shown in Figure 2 (Longstaff et al., 2004) – the histograms show the typical signs of Pareto distributions. De Vany's (2003) research confirms the dominance of Pareto distributions in the industry.

>>>Insert Figure 2 about here<<<

How does management change if we assume a Pareto world? **First**, reliance on star power and following the star system doesn't produce consistent results. As De Vany points out, star, and in general movie contracting, should shift from expected results to outcome-based results. For instance, reward and contracting should be contingent to effective and not expected results.

Second, given radical uncertainty, it is unlikely that success will come from the application of some formulaic recipes (sequels are the perfect example of this approach) that appeal to the minimum common denominator of the potential audience, as opposed to the search of truly original plots. The Gaussian approach leads to homogeneity, the Paretian approach to heterogeneity.

Third, if movie success or failure is based on the 'epidemics' of scalable communications (large audiences emerge from the multiplicative spreading of rumours (communications) in heterogeneous networks, not from the additive aggregation of homogenous individuals), then promotion and marketing campaigns should target the mechanism of rumour-spreading in scale-free networks. *The Wisdom of Crowds* (Surowiecki, 2004) suggests that viral marketing, prediction markets, blogs, and communities may be more effective in advertising 'trailer' and movie design.

Fourth, if prediction is impossible, what type of assessment of future outcomes is possible? De Vany's description of the Pareto distribution as the universal attractor of the movie industry calls for the following approach: Movies are rated according to four categories: G, PG, PG13 and R. De Vany and Walls (2002) show that all four have a Pareto distribution with different exponents. Ranking the distributions according to their exponent, α (for revenues the values are: G=1.591; PG=1.814; PG13=1.661; R=2.274), shows that Hollywood invests disproportionably in R-rated films (about 52%), which is the group with the shortest revenue tail (highest α). Ironically, this is the only group with stable mean and finite variance ($2<\alpha<3$). As De Vany and Walls (2002, p. 450) write: 'a studio seeking to trim "down-side" risk and increase "upside" possibilities can do so by shifting production dollars out of R-rated movies into G-, PG- and PG13-rated movies'.

Fifth, another response is to learn how better to market films to more differentiated niches. Since movies are more and more digital from producer to theatre, films can be made in multiple forms aimed at proliferating niches. Films, like the proverbial Model T Ford, are all one colour (design). In the digital age producers can offer multiple movie designs for multiple tastes. For example, the profits of most movies mostly depend on the young female starlet; since they don't cost much (compared to well-known stars, it would be easy to cast an Asian, African-American, Hispanic, and Caucasian in the role; each would 'sell' better in each specific market; or let them compete! With digital filming and final editing, it is easy to insert each character into what is really just one movie.

A double-log graph of Hollywood box office revenues shows a heavily truncated Pareto distribution (De Vany, 2003). Near rank 100, the distribution shows a sharp drop off with profit quickly approaching zero around rank 500. Does the distribution reflect the inherent quality of the movies as perceived by the crowd? *No*! According to Anderson (2006), the truncation is simply a sign of bottlenecks in distribution. The carrying capacity of the theatre system is about 100 films. Lower ranked movies simply fail to be shown in theatres – from the point of box office revenues, they simply don't exist. A Pareto approach introduces an interesting twist in this story. If the natural form of diverse markets without bottlenecks is Pareto (as the music, book and other industries now show), then focus on theatre distribution blocks the emergence of the second tail of the Pareto distribution – the niche-proliferation tail with lots of small events. This 'missing' part is the space of potential demand that Hollywood leaves unexploited. How could Hollywood move into this space? As Anderson shows in his book, *The Long Tail* (2006), this requires moving from an economy of consumerism to an economy of 'producerism', which correspond to a shift from an economy of hits to an economy of some big hits and many micro-niches. Interestingly, and almost by default, the industry now makes only ~14% of its gross revenue from theatres (Epstein, 2005).

2.2 Managing Chris Anderson's High-frequency, Low Cost 'Long Tail' for Profit

The ICT revolution over the past 20 years has created the conditions for the emergence of a profitable complement to the traditional economy of high-volume sales off store shelves, that is, the 'long tail' of business micro-niches (Anderson, 2006). The traditional economy based on high volume 'hits' is a consequence of the limited carrying capacity of conventional markets: products and services have to compete for scarce distribution channels, shelf space, advertising dollars, etc. The tyranny of 'shelf space' associated with the cost of production creates a minimum-cost barrier below which it is unproductive to carry products. The allocation of scarce resources, therefore, becomes one of the main tasks of managers. Since the ICT revolution allows managers to get out from under these effects, traditional market assumptions and behaviours are being transformed.

First, when products are limited, each is designed to maximize potential sales by appealing to the largest possible consumer base within a designated segment – the 20%. This base is built by taking the minimum common denominator across heterogeneous classes of customers, in effect, treating a population as a sum of homogeneous entities (i.e., presuming limited variance). In a world of scarce resources, exploiting what the average consumer wants works. This leads intuitively to concentrating management effort on the profitable 20% of products and ignoring the remaining 80% – the 80/20 rule. Second, the profitability threshold leads to the definition of failure and success. Products exceeding the profitability threshold by the largest possible amount define success. Conversely, failure signals lack of high sales. The mentality of high-volume hits comes to dominate marketing. Third, the 80/20 rule, which is another way to express scarcity and asymmetry of distribution, leads intuitively to concentrating management effort on the profitable 20% of products and essentially discarding the remaining 80%.

When distribution, marketing, and search become cheap and easily available, markets develop a long tail of proliferating niches containing fewer and fewer customers. This alters the balance between hits and micro-niches, thereby causing the emergence of 'unconstrained' markets which show both tails of a Pareto distribution: the long tail of the 'hit' product niches and the long tail of diversified micro-niches that appeal only to a few consumers. The meaning of the 80/20 rule is also transformed. In the traditional economy, a minority of products (the 20%) generates the majority of revenues (~80%) and virtually all of the profits. In an economy of many micro-niches, every product generates profits even if sold only once. Assuming that the new Internet-based markets with physical plus virtual distribution channels carry 10 times as many products as the physical distribution chain, (so the former 100% becomes 10% in the new markets), the hits (now 2% of the products) still account for a disproportionate amount of revenues and profits, but now the previous unprofitable 80% and the new tail both generate profits in approximately equal fractions. The result is the transformation of the 80/20 rule. The basis of competition shifts from 'average-based' minimum common denominator management searching for 'hits' to business that caters for the long tail of niche products.

This is what Eric Schmidt, CEO of Google says about the Long Tail (from Anderson, 2006, p. 214):

> *'The recognition that businesses such as ours show a Pareto distribution appears to be a much deeper insight than anyone realized…. When we looked at our business, we concluded that we built a model that works particularly well in the middle of the curve. After reading the article* [Anderson, 2004]*, we looked at the Tail and asked ourselves: 'How are we doing against this opportunity*'?
>
> *Take a Pareto curve of the world's businesses, ranked by revenue. Number one is Wal-Mart. So what is the last entry? It turns out it's a person in India with a basket selling something they made. The area under that curve, which includes about a billion people, is essentially the world's GDP. So start at the bottom and move up the curve until you've got people with an Internet connection. They're reasonably educated, they're a small business, and they want to market their goods. And we ask ourselves, 'what benefit can our model bring them to increase their revenues?' And the answer is that if we let them do business outside their own villages, they're reaching a larger market, have got more suppliers, better price competition, and so on.*
>
> *There are a lot of reasons why this is slow to happen, mostly having to do with infrastructure. So let's say for the purpose of argument that we don't focus on 90 percent of the people. That still leaves 100 million people. The numbers are so large that you lap off a large chunk and it's still a huge market'.*

What do we conclude from the analysis above? First, the natural shape of unconstrained markets is Paretian with two fat tails: (a) high-volume hits comprising one extreme; and (b) a long tail of heterogeneous micro-niches at the other extreme. The fact that distributions of commodities are power-law shaped is not particularly new. What is new – in Anderson's analysis – is the argument that the emergence of virtual Internet-based markets makes the distribution of markets fully Paretian.[3] Second, business models appropriate for opposite ends are very different. The most successful cases of the past 10 years – the Googles, eBays, and Amazons – are extreme events that have developed business models appropriate for the other 80% of the Paretian world. The quote by Google CEO Schmidt (above) shows that full appreciation of the transition to Paretian markets is still ongoing. Third, Anderson shows that the double-tailed distribution of niches and hits holds across sectors (music), genre (classical music), sub-genre (chamber music), and so on. In other words, nested Pareto distributions give rise to self-similar markets, which are expressed by the statistical regularity of power-law distributions.

>>>Insert Figure 3 about here<<<

2.3 Managing to Lower the Cost of the 10% Chronic Homeless Tail

Nowhere is what is important to manage better illustrated than in Gladwell's recent article for *The New Yorker* (2006). We start with his data and stories about the cost of trying to solve the 'homeless problem,' where 'what is important' is so obviously different. Gladwell gives various homeless numbers for Philadelphia, New York, Boston, Denver, and San Diego – and one in Nevada (*Million Dollar Murray*). In Table 1 we use the 80%/20% ratio found in Philadelphia[4] with New York's cost of housing and treating the homeless.

>>>Insert Table 1 about here<<<

We don't take space to show the graph, but Gladwell notes that the cost of housing and treating the homeless in several cities is Pareto distributed and if graphed on double-log scales shows a power law.

After his discussion from which we generate the numbers in Table 3, Gladwell shifts his focus to how the city of Denver decided to deal with the very expensive 'tail' of its Pareto distribution of homeless costs. The city has 1000 'chronic' homeless. The cost 'on the street' of their current method of housing and treating the tail of the distribution – the 1000 – averages $45,000 per person per year.

They got their new approach from Philip Mangano, currently the Executive Director of the U.S. Interagency Council on Homelessness, which oversees twenty Federal Agencies. The basic idea is simple; it is cheaper to give a person like 'Million Dollar Murray' his own room and nurse than treat him in the prevailing fashion. Denver now 'recruits' its chronically homeless to take up residence in rooms it provides for free. The cost of a city-paid room plus a staff of ten people to manage the homeless adds up to $15,000 per person and is expected to reduce to some $6000 in the near future – this compared to the $45,000/person using the traditional approach. The lesson is that it is cheaper to take a radically different approach to manage the tail of the distribution as opposed to the traditional method of doing what seems reasonable for the 80% who stay in shelters for a day or two and don't run up incredible medical costs.

2.4 Managing Scalability – Seeing Butterfly-events in Time to Do Something

In their book, *Managing the Unexpected*, Weick and Sutcliff (WS) (2001: pp. 3–4) say that '…people often take too long to recognize that their expectations are being violated and that a problem is growing more severe... Managing the unexpected often occurs in the earliest stages, when the unexpected may give off only weak signals'. Their book is about how '*high-reliability firms*' such as aircraft carriers and nuclear power plants have learned to pay more attention to what Holland (2002) calls '*tiny initiating events*' – what we will call '*butterfly-events*' in honour of Lorenz's classic paper of 1972. The management problem is: How to transform butterfly-events into 'butterfly-levers' (see Holland, 2002) that may be used to *stop* bad butterfly-events from spiralling into negative extreme events like Chernobyl, the Challenger disaster or Enron, *or* enable good butterfly-events to spiral up into positive extremes like Microsoft, Wal-Mart, Google, Intel's processor chip and the Internet (initiating butterfly-event was a computer-to-computer communication between UCLA and University of Illinois). We now focus on the failure to see butterfly events and levers in the UP's (Union Pacific) acquisition of the SP (Southern Pacific) railroad. We begin with a short description.

[3] Brynjolfsson, Hu, & Smith (2006) show that the micro-niche long tail is explicitly due to Internet marketing.

[4] Gladwell reports on Dennis Culhane's database on Philadelphia's distribution of homeless people.

Nearly total deregulation of American railroads in 1980 reduced them from forty to ten. The UP's acquisition of the SP left the American West serviced by only two giant railroads – the UP being the largest in the nation with 30,000+ miles of track (Union Pacific, 2008). Even before the merger, the risk of future operational problems was readily apparent. For example, most of the SP track (which was the primary route between the LA ship port and Houston), was single tracked, which meant trains could not pass each other, which then made it the primary source of congestion, delay, and increased customer shipping costs – all of which started the gridlock on the UP after the merger. In addition, the UP cut many SP jobs outright. When the remaining SP employees, who had a long history of gridlock on the SP, told their new UP bosses about the SP problems and solutions that worked, they were ignored. In their book, WS make special mention of the arrogance of UP managers toward 'expendable' former SP employees. The acquisition occurred in July 1996. UP claimed it would save $627 million. In fact, 'by March 1998 delays in shipments had cost rail customers approximately $1 billion in curtailed production, reduced sales, and higher shipping costs' (Union Pacific, 2008).

To begin, we highlight some of the butterfly-events on the Union Pacific railroad (UP) that WS describe (2001, pp. 4–10) in Table 2 below. Here we try to mention only incidents that are at the level of initial clues – they are seemingly random events that are essentially trivial and occur now and then under normal circumstances; no obvious reasons to assume scalability.

>>>Insert Table 2 about here<<<

The foregoing are examples of Holland's 'tiny initiating events,' our butterfly-events. In Table 3 we now paraphrase a number of higher-impact events that are set off by the butterfly-events. These are evidence of scalability. The small events (above) spiralled up into scalable events (below) that eventually led to system-wide gridlock – the ultimate extreme outcome. None of these events could result from a single isolated butterfly-event. The latter have to scale up – spiral up – via some causal process such that they have broader impact.

>>>Insert Table 3 & 4 about here<<<

Having described what we have reduced to brief descriptions in the foregoing tables, WS then describe some of UP's managerial response. We paraphrase these in Table 4.

WS's identifications of UP management's failures are right on target and, in fact, could be broadly applied to almost any kind organizational failure seemingly due to apparent management failures. In particular, WS mention:

- 'early and ample signs that the UP did not understand… (p. 8), and failures to detect that allow '…unexpected events to spin out of control.' (p. 9)
- They suggest that managers need to '…treat any lapse as a symptom that something is wrong…that could have severe consequences if separate small errors happen to coincide at one awful moment….' (p. 10)
- They say 'resilience is a combination of keeping errors small….' (p. 14)

Management scholars worry about case writers who are 'theory laden' – they see what their theories tell them to look for (Kuhn, 1970; Franklin et al., 1989; Guba and Lincoln, 1994). But the opposite may be true as well: *One can't see what one isn't looking for*. For us, scalability dynamics and their causes are what one may not see unless one is better trained to see them. Elsewhere (Andriani & McKelvey, forthcoming) we describe fifteen theories about why scalability dynamics occur. But it is not just about 'seeing' butterfly-events. As Holland (2002) observes, it is about managers learning to think about 'tiny initiating events' as '*levers*' by which to either shut down negative scalability dynamics or enable and speed up positive scalability dynamics. In Table 2 we list a few '*butterfly-levers*' that most obviously apply to the UP circumstances, to high-reliability firms more broadly, and to organizations in general. We describe their applicability to management in more detail in Andriani and McKelvey (forthcoming).

In what follows, we briefly discuss how several causal dynamics at the butterfly-event level at UP scale up into negative extreme outcomes that managers could/should gain leverage over.

1. ***Square-Cube Law:*** In organisms, surfaces absorbing energy grow by the square but the organism grows by the cube, resulting in an imbalance; fractals emerge to bring surface/volume back into balance. (Carneiro 1987). This scalability law was brought into organization theory by Haire (1959). Stephan (1983) translated it into '*surface*' and '*volume*' employees. Surface employees deal with customers and bring in business and revenues. Volume employees are those who administer and produce products and services. In the UP, then, surface employees connect

to customers; volume employees fix tracks, sort trains in yards, dispatch and run trains, manage things, etc. The '*¼ power law,*' initially applied to blood flows in a body can also restrict surface or volume growth. Here, it applies to flows of trains and goods over the tracks. From the merger with SP (Southern Pacific railroad), customers were about doubled; trackage was roughly doubled – but train flows along any single track had to stay about the same; for the merger to be approved they had to allow the BNSF railroad rights to run on ~3000 miles of track. Just from knowing the surface-volume law, one can easily see that the railroad is immediately out of balance. Even though 'surface' was roughly doubled, single-track flows remained unchanged. Worse, volume employees were cut when, in fact, the law calls for increases in either efficiency or number of employees. Knowing the surface-volume law, one could easily predict the extreme outcome and then try to manage it away.

2. ***Combination/Breakage Laws:*** Normal distributions of different variables remain normally distributed if they are combined (even becoming *more* normally distributed, in fact). But if somewhat skewed distributions are combined (even just added together in terms of impact), they become more skewed. If several are combined, the result is a Pareto distribution. Let's suppose that before the merger UP activities were normally distributed – mostly things worked as expected but with some random deviations because of events like the flu or storms. Thus, *normally*, train crews are on time; trains are on time; locomotives are at the right location on time; repair and dispatch crews are on time; locomotives and crews and other railroaders function effectively most of the time, etc. Then comes the merger. Now each of the foregoing normal distributions become skewed. Since there are several, and since they interact with combined effects, we see scalability with the result that the entire system becomes gridlocked rather quickly. Because of the cumulative skewing, one could easily predict the extreme outcome and then try to manage against it.
3. ***Preferential Attachment:*** Given newly arriving agents into a system, larger nodes with an enhanced propensity to attract agents will become disproportionately even larger, resulting in the power law signature (Yule 1925, Barabási 2002). This theory suggests that as the UP and SP social and work-related networks merged, some individuals would emerge as more 'connectively' important in getting the new system and new ways of doing things up and running. Prior dominant nodes could reasonably be expected to be replaced by new 'stars'. Instead, the old-guard railroaders kept themselves dominant and kept the old separate-railroad networks dominant – the old UP network trying for dominance over both railroads; the old SP network in rebellion, passive resistance, and slow-downs. Instead, both could have joined in a collective reframing of a new combined network. Managers aware of this theory would expect network dynamics to change dramatically with the merger and would 'manage' toward this end.

3 CONCLUSION

We started the paper stressing Abbott's claim that many disciplines in the social sciences are subtly influenced by the General Reality Model, which has reified the Gaussian view and given Gaussian methods a certification of nearly universal validity and applicability. We claim that the alternative Paretian view gives a more realistic representation of the social dynamics. In particular, it affects the way we look and conceptualize the following general questions:

>>>Insert Table 5 about here<<<

How does this change in perspective impact on the practice of management? This is a big problem that involves a paradigm change in a Kunhian sense. In this paper the impact of the Gauss-to-Pareto transition is shown by means of four paradigmatic examples that serve to illustrate the four aspects of (a) perception and management of risk in the movie business; (b) the change in strategy and business practices resulting from the emergence of a constellation of profit-making micro-niches in industries based on intangible products and internet distribution channels; (c) management of an apparently intractable social problem such as the homeless in a modern city; and (d) lessons from 'smouldering' crisis and what can we learn about the early perception and scalability of '*tiny initiating events*' in the prevention of disruptive crises.

>>>Insert Figure 4 about here<<<

Figure 4 illustrates graphically the change in perspective. In the first case, managers that adopt the Paretian view can easily notice that the world they live in is not the dominated by the well-behaved Gaussian means and deviance but is instead dominated by the radical uncertainty that characterize the tail of the Pareto distribution. Once the Gauss-to-Pareto transition has taken place, the unbounded nature of risk is immediately recognized, the lack of correlation between main variables and box office results become evident and all management practices based on predictions of single events are rejected, including contracting based on expected results.

The emergence of the *Long Tail* of micro niches is something that appears mysterious to a Gaussian trained manager. They look at changes that happen within a few standard deviations from the mean and expect those changes to emerge via a shift of the mean. Reliance on the idea of the mean as a correct representation of reality pushes them to develop minimum common denominator strategies to maximize profits around average consumers. Unconstrained by diversity-limiting paradigm, Pareto managers instead realise that change happens in the tails and that the non-existence of a representative scale (or agent) creates a condition for the emergence of strategies that rely on the aggregation of the niches rather than the aggregation of customers around homogenous products. As Anderson (2006) points out, latent markets exist every time that the rank-frequency curve looks truncated or, in other words, commodity distributions look 'normal' only because the long tail of micro niches has been ignored.

Management by averaging can be misleadingly simple and dramatically ineffective as the homeless case illustrates. When dealing with social issues Gaussian managers apply one-size-fits-all approach. The size is determined by the average of the phenomenon. For instance, dealing with an epidemic Gaussian managers assume constant contagion probability and adopt blanket vaccination policy. Dealing with homeless, they reduce the diversity of homeless to a non-existing average homeless and provide an homogenous solution to this non existing entity. Managers wanting to shift perspective discover that addressing the extreme cases in the tail may be cheaper and more effective.

Finally, Toyota has long been known for wanting its assembly line workers to shut down the entire line if they see something that is not right. Rochlin (1989, p. 167) notes that on the aircraft carrier, *Carl Vinson*, '…any critical element that is out of pace will be discovered or noticed by someone before it causes problems'. Of course, not every random error or event scales up into extreme outcomes. But as Andriani and McKelvey (forthcoming) show, scalability is much more prevalent than most people are willing to realize but we see no evidence that scalability has seeped into management or organization theory textbooks. The UP Railroad shows that the adoption of a Paretian approach help to manage scalability and consequently reveal the connection between '*tiny initiating events'* and extreme events.

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Figure 1. Gaussian vs Power-law distributions

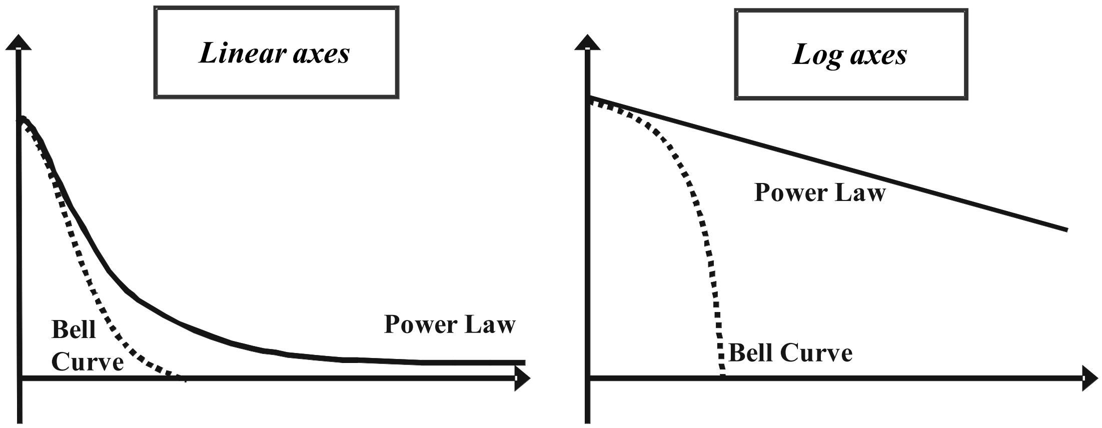
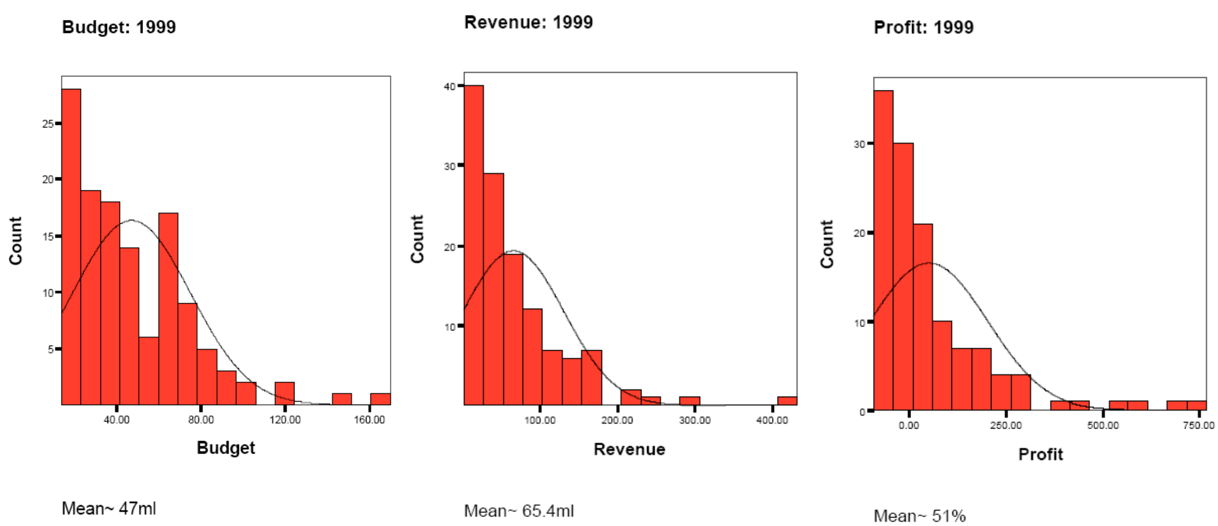
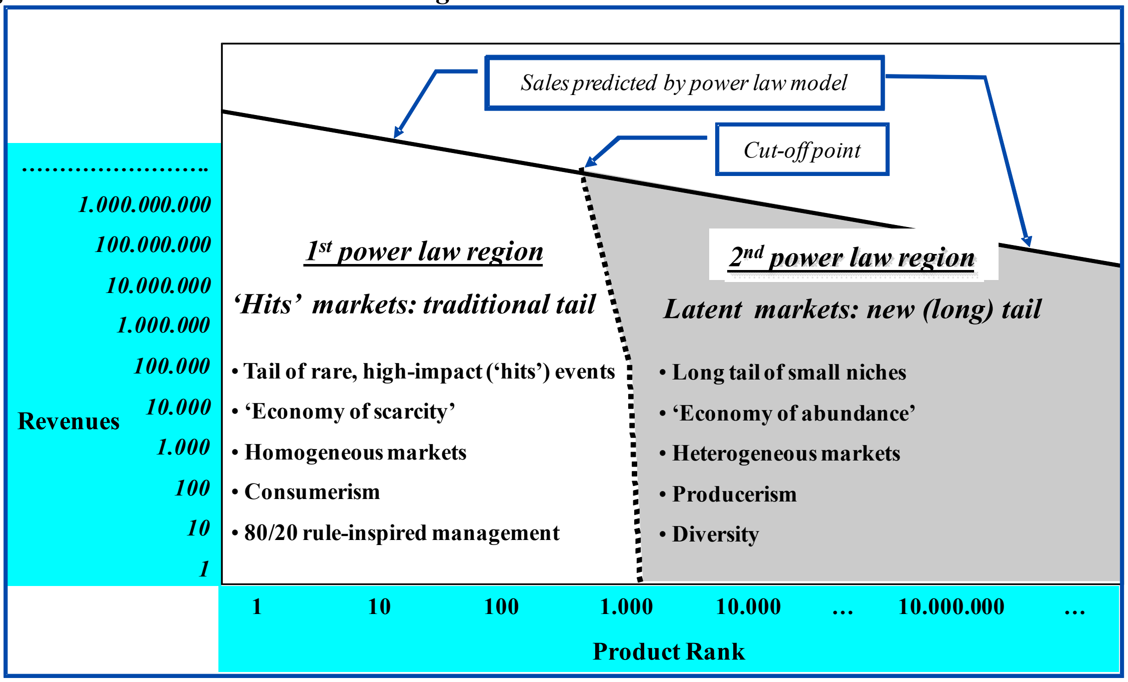


Figure 2: Budget, Revenue, & Profit in the US Movie Industry in 1999*



* (Longstaff et al. 2004).

Figure 3: The *Tail* of Hits and the *Long Tail* of Micro-niches.



Traditional markets ('hits' markets) show a truncated distribution of goods, that is, goods that fall in the 1st power law region. The characteristics of the markets in this region are illustrated in the Figure under the title: 1st power law region. Long-tailed markets develop in the region of latent demand space beyond the cut-off point that constrains 'hits' markets. The features of the long-tailed markets are shown in the Figure under the title: 2nd power law region.

Figure 4. The transition from Gauss to Pareto in the four case studies of section 2

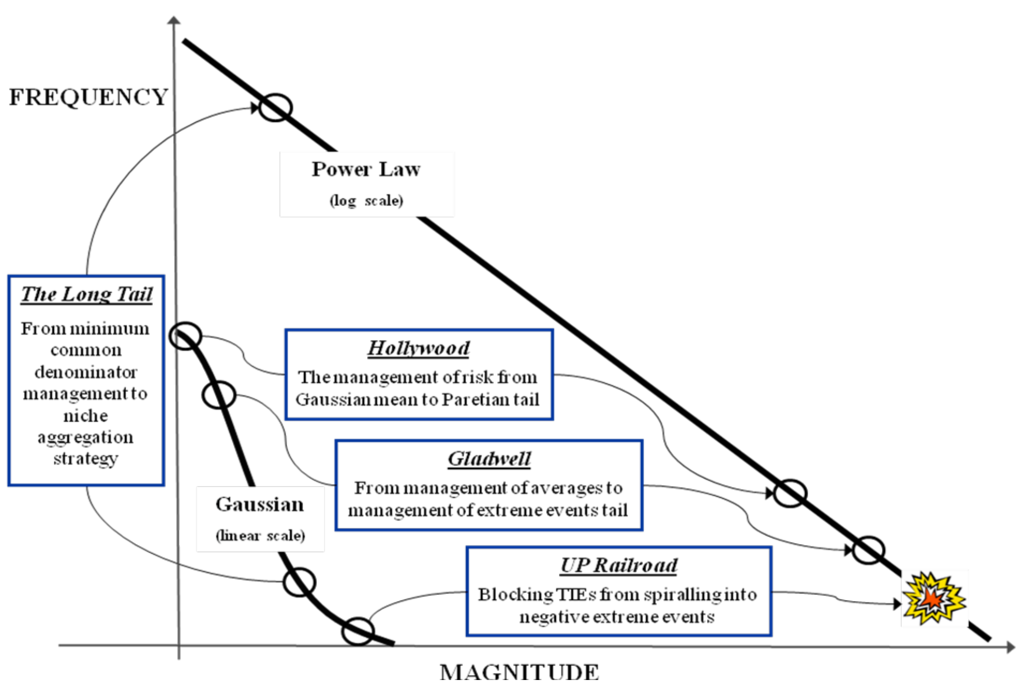


Table 1: Distribution and Cost of Homeless‡

	New York City≠				Boston	Denver	S. D.	Nevada	S.D.
Distribution by persons using the services	147k 1 night	98k 2 nights	2500 Periodic*	2500 Chronic†	119 people	1000 people	15 people	1 person§	1 person
Cost/group/year	50% for $9,702	30% for $12,936	10% for $13.86 million	10% for $62 million	$18.834 million	$45 million	$1.5 million		
Cost/person/year	$66	$132	$4,158	$24,800	$31,650	$45,000	$66,700	$100,000	$312,950

‡ Constructed from data supplied by Gladwell (2006).

≠ We apply Gladwell's numbers on homeless distribution in Philadelphia to NYC and its costs.

* Periodic = a 3-week stay periodically, with more in Winter; we estimate a total of four.

† Chronic = staying in a homeless shelter most of the time and running up huge medical costs.

§ *Million Dollar Murray* is the name given to a drug and alcohol addict who cost Nevada $100,000 for each of 10 years before he died.

Table 2: Butterfly-Event-Level Clues

1. Large cuts in personnel	2. Crews on duty longer than the law allowed
3. Fatigued crews	4. Equipment not maintained
5. Dispatchers unfamiliar with assigned territory	6. Shipments lost; can't be traced
7. Speed of trains drops from 19 to 12 mph	8. Crews falling asleep while running trains
9. Four employees killed in yard accidents	10. Not enough locomotives

Table 3: Evidence of Scalability

1. Shippers upset by delays getting worse & worse	2. Trains stuck on sidings without locomotives
3. Oct. 8; 550 freights standing still	4. Stalled trains meant crews' duty time expired
5. Trains going in opposite directions couldn't pass each other on a single mainline because sidings were filled with backed-up trains	6. Since most stalled trains were pointed toward the Englewood yard in Huston, no trains could leave Englewood because of the blocked mainlines
9. 1800 locomotives unavailable because they were stuck in the wrong place	10. Sorting of cars into trains by destination was centralized, thereby exacerbating the delays
11. More engines sent to Englewood to unblock system; but they just added to the blockage	12. Denial of failures repeated at all levels of the hierarchy
13. 'The system was gridlocked as far away as Chicago'. (WS, 2001, p. 6)	

Table 4: Evidence of Management Failures

1. Old-line operations guys were running the railroad; CEO started as a brakeman	2. Blamed blizzards, track work, flash floods, derailments, Hurricane Danny, poor maintenance
3. Ignored early warning signs	4 Failure to articulate important mistakes
5. Didn't organize to detect them	6. Allowed events to spin out of control
7. Mentality: UP is the victim not the culprit	8. 'Crisis times treated just like normal times' (p. 17)
10. 'Preoccupation with success and its denial of failures…repeated at all levels of the hierarchy' (p. 11)	11. 'UP executives neither looked for failures nor believed that they would find many if they did' (p. 11)
12. 'Slowdowns were underreported and allowed to incubate until they were undeniable &…irreversible' (p. 11)	
13. 'People keep mentioning intimidation, a militaristic culture, hollow promises to customers, abandonment of workarounds, production pressure on train crews….' (p. 14)	
14. 'The UP…favoured centralization and formalization and treated improvisation as insubordination' (p. 15)	

Table 5: Gaussian vs. Paretian Responses to Key Questions

	Gaussian Manager	**Paretian Manager**
What is the probability of occurrence of extreme events and how important are they in shaping the basic features of social systems?	*Extreme events a few standard deviations away from the average are so rare that it is safe to ignore them. Also social systems evolve by slow accumulation of small changes (gradualism).*	*Extreme events are much more likely to occur and with bigger magnitude than linear science wants to think. Also the basic features of social systems emerge quickly during so-called punctuation periods (radical change periods).*
What is the role of 'tiny initiating events' (TIEs) in the development of extreme events?	*Big changes must be caused by big causes. Big disasters by big shocks. Causality matters. TIEs are irrelevant!*	*Life is inherently nonlinear. Google didn't exist 10 years ago. It started with better search software. From there it invented a brave new world. Spotting TIEs early can facilitate new Googles and/or prevent new Enrons.*
Is the diversity of social systems and business phenomena bounded or unbounded?	*The diversity of social business phenomena is captured by normal statistics. It is usually possible to represent the diversity by means of a mean and the variance around the mean.*	*Diversity is unbounded. Most often means are unstable and variance is practically infinite. This results in long tails. The centre of a Pareto distribution can at best capture the past. The tails of the distribution are where innovations occur.*
Can we predict business and social transformations?	*Yes! The number of outcomes of a business initiative is finite. The tails of a Gaussian distribution are fundamentally finite. Therefore, given enough knowledge and the availability of relevant frameworks, prediction is possible. Statistics and probability theory are the tools to use.*	*Given the nonlinearities and emergent properties prediction of single events is impossible. Quantitative methods are to be complemented by qualitative/intuitive approaches.*