

Centre for Technology Management

FIRM GROWTH AND THE ILLUSION OF RANDOMNESS

James Derbyshire, Elizabeth Garnsey and

Garry Haywood

No: 2013/02, July 2013



Centre for Technology Management Working Paper Series

These papers are produced by the Institute for Manufacturing, at the University of Cambridge. They are circulated for discussion purposes and authors would benefit from a copy of work citing them. Your comments and suggestions are welcome and should be directed to the first named author.

Firm growth and the illusion of randomness

James Derbyshire*, Elizabeth Garnsey**,

Garry Haywood***

No: 2013/02, July 2013

*Institute for International Management Practice, Anglia Ruskin University, Email:

james.derbyshire@anglia.ac.uk

**Institute for Manufacturing, University of Cambridge, Email: e.garnsey@eng.cam.ac.uk

*** So-mo, Liverpool, Email: garry@so-mo.co

Keywords: firm growth; growth paths; randomness, agency, enterprise policy

JEL classification: L25; L26

Abstract

This paper explores the distinction between ontological and epistemological perspectives on randomness with reference to theories of the growth of firms. Random outcomes can be attributed to irreducible chance and indeterminacy or classed as random because their causes are too complex to unravel. A recent example of random growth theorising, Gambler's Ruin Theory (GRT), adopts an ontological approach that excludes entrepreneurial agency. In our analysis of a comparable data set, outcomes are not found to be random. However, the exploration of GRT opens up interesting issues relating to research design, the nature of randomness and the potential for agency. The interplay between epistemological randomness and agency is advocated as a more promising avenue for future research than the gambling analogy.

1. Introduction

Theories of the growth of the firm are among many areas of inquiry that draw on the concept of randomness, but analysts seldom make explicit the assumptions underlying their use of this notion. In this paper we explore randomness as it has been applied in recent work on the growth of the firm in order to unravel the implications of these assumptions for research design and the interpretation of findings.

There are two major interpretations of randomness. The first is the 'ontological randomness' associated with early 20th century quantum mechanics. This is the view that randomness is an inherent feature of the universe and entities within it. This means there are phenomena subject to an irreducible and absolute form of chance, as in Brownian motion in physics (von Plato, 1994). Hacking (1990, p.1) has commented that this interpretation meant that 'Causality, long the bastion of metaphysics, was toppled, or at least tilted'. This toppling was achieved specifically in relation to phenomena at the quantum scale, but is often taken to apply more generally.

The second interpretation of randomness is 'epistemological randomness' applied to phenomena that operate above the quantum scale. This is a view of randomness as a reflection of the infeasibility of identifying and measuring causes and does not imply that causes do not exist or the absence of agency. This view of randomness originated with the scientific determinism of Laplace (1951) in 1814, much discussed, e.g. by Jevons (1958) and McShane (1970, p.37).

If, for example it were possible to identify and model the conditions under which the flip of a coin took place - such as the force applied to the coin, its exact trajectory, the effect of air currents, the exact moment the coin is caught in the coin-flipper's hand etc. - then it would be possible to know the causes of the outcome. Coin-flipping seen in this light is not random although it is not feasible to identify and measure the relevant causes. There is determinacy because the outcome of the coin-flip has cause.

However, there are important features of randomness that apply whether an ontological or epistemological interpretation is adopted. Under both it is important to distinguish between randomness as a characteristic of a sequence and randomness as characteristic of the process that

has produced that sequence. We show in this paper that the former does not necessarily imply the latter. Under both approaches, among a number of characteristics a sequence must exhibit in order to be random is the absence of any ‘special attribute’ or ‘typicality’ (Dasgupta, 2011, p.6). Under neither interpretation does randomness imply an equally-distributed outcome – for example, an equally-distributed occurrence of heads and tails from a sequence of coin flips. These issues are relevant to the attempt to benchmark randomness in the design of research and apply the chosen interpretation of randomness. Under both interpretations, probability and random outcomes apply at the collective level, not at the individual level, so it is necessary to select the appropriate level of analysis.

In this paper we explore the implications of these features of randomness and of the assumptions underlying the concept. While randomness has certain attributes that are similar under either perspective, in other respects, the perspective adopted has different implications for the design of research and the interpretation of results - as explored in this paper in the context of theories of the growth of the firm.

2. The Firm Growth Debate

Whether firm growth can be characterised as random is the subject of a long-running debate in the economic literature. Initiated by Gibrat (1931), this debate encompasses contributions from a diverse set of luminaries including Ijiri and Simon (1964, 1967 and 1974), Mansfield (1962), Dosi (2007), Kalecki (1945), Axtell (2001), Geroski (2000) and Ashton (1926).

This debate is of considerable importance among other reasons because if firm growth is predominantly random in the ontological sense, entrepreneurs cannot influence outcomes for

start up firms, there is little scope for policy in stimulating firm growth and a considerable part of the scholarly literature is of limited value. A prominent recent contribution to this debate is the application of ‘Gambler’s Ruin Theory’ (GRT) to firm growth by Coad et al. (2013). We examine this paper with three aims in mind: firstly, to make explicit some of the implications of the authors’ underlying assumptions about randomness; secondly, to explore aspects of research design and ontological issues related to randomness; thirdly, to contribute to an emerging approach that emphasises the interplay between causality, agency and chance in firm growth. We point to the need to investigate further entrepreneurs’ creative responses as they change course on detecting unanticipated opportunities, gain leverage from and hedge their resources in order to take advantage of unexpected events.

More specifically, our critique of GRT has three themes. (1) The integrating theme concerns the ontological and epistemological issues raised by the topic of randomness. (2) The methodological theme relates to why quasi-randomness may be an artefact of the methodological procedures used. (3) In this connection we examine in more detail the methodology that excludes periods of stability from the analysis of firm growth paths. To substantiate our argument that this is unjustified we provide empirical evidence on the relative frequency of growth and stability in a comparable data set on firm growth. Thus our main interest is in the conceptual issues raised by the gambling analogy applied to firm growth. But before the wider issues of randomness and agency are addressed, some empirical ground clearing is required. Accordingly, we present evidence on the employment change over a four-year period of the cohort of 79,427 firms created in the fourth quarter of 2005 in the UK. This reveals that the typical state for a firm is neither growth nor decline, but stability or stasis. That research design influences the appearance of randomness is shown by use of methodologies different from those used in the GRT study.

The remainder of the paper is organised as follows. Section three reviews the history of research on firm growth to situate the subsequent discussion in the broader evolution of firm-growth theorising. Section four provides a brief description of Gambler's Ruin Theory (GRT) as applied by Coad et al. (2013). Section five analyses their application of this theory. Section six presents evidence from our empirical study of firm growth, the findings of which we show are supported by other evidence. Section seven provides a summarising discussion and explores implications for firm-growth theorising and policy stemming from the issues around randomness raised in this paper.

3. Literature review - the development of firm-growth theory

The debate about random firm growth is long running and its literature extensive in nature. Even more so is the set of literature not confined to randomness that examines firm performance more broadly. In this paper we do not attempt exhaustive coverage of this literature but refer the reader to the comprehensive review by Coad (2009).

This section highlights a number of features of the evolution of the firm-growth literature relevant to the argument subsequently developed. This serves to provide the reader with the context in which to situate both the analysis of Gambler's Ruin Theory and our analysis of a different dataset on firm growth that follows.

3.1 The shift to dynamism

Early theorising on firm growth was conducted under the comparative statics framework in which firms were simply seen as expanding to their optimal size (Coad, 2009). In effect, this explained away firm growth in a tautology in which firms grow because they are not yet at their

optimal size - because they have not yet grown sufficiently. This placed the emphasis on firm size rather than firm growth as the unit of observation in studies of the firm.

Dissatisfaction with the conventional static approach to economic theory, including its failure to explain firm growth, led to the emergence of dynamic theorising emphasising uncertainty, change and turbulence in the economy (Coad, 2009; Boschma and Frenken, 2006). The dynamic approach emphasises uncertainty, which, unlike risk, is not calculable (Knight, 1921). Dynamic theorising in economic analysis makes growth the important unit of observation in firm studies, relegating firm size to a status of secondary importance (Marris, 1999). This shift to an emphasis on turbulence and change takes an extreme form in GRT that explicitly excludes firm stability or stasis from the analysis.

3.2 Gibrat's Law

The shift in focus from firm size to firm growth as the unit of observation, along with the move from the comparative statics framework to the dynamic approach, is evident in the work of Gibrat. Essentially, Gibrat's Law implies the absence of a relationship between size and growth. 'Gibrat's law of proportionate effect' as a heuristic for firm growth has been expressed as follows: 'the probability of a given proportionate change in size during a specified period is the same for all firms in a given industry – regardless of their size at the beginning of the period' (Mansfield, 1962, p.1030-1031).

A number of studies have disputed this alleged independence as they have found that the growth rates of new and small firms tend to be negatively related to start-up size (Audretsch et al., 1999, p.976; Dunne et al., 1988, 1989; Wagner, 1992; Cabral, 1995; Mata et al., 1995). Delmar et al. (2003, p.196) show that several other studies (Dunne and Hughes, 1996; Evans, 1987; Storey,

1995; Sutton, 1997) suggest that growth rates diminish with increasing firm size, a result that conflicts with the independence between size and growth rate suggested by Gibrat's Law. The present paper does not examine the issue of the relationship between firm size and growth directly, but its findings contradict the view of firm growth as random that has been based on Gibrat's law.

A distinction has been drawn between the purely 'stochastic' view of firm growth incorporated in Gibrat's law and the determinist or empiricist approach to understanding firm growth associated in particular with Penrose (1959). Coad et al. (2013, p.616) present the latter approach as emphasising the firm's endowment of resources as the 'cause' of its growth and refer to it as 'Resource Theory'.¹

Storey has pointed out (2011, p.309-310) that attempts to identify the resource factors associated with growth have not been successful. A review by Coad (2009, p.97-98) of regression models that attempt to identify these factors has shown that their explanatory power is rarely sufficient to explain more than 15 per cent of firm performance.

The opposing stochastic and resource-based views reflect a long-established division between competing explanations of firm growth, as explained by Audretsch et al. (1999, p.967). Sutton (1995) suggested that a useful theory of firm growth would incorporate the strategic aspects, or deterministic and resource-based view, while taking into account what would happen when such strategic factors are absent (i.e. if firm growth were entirely random). The summarising

¹ It is a misunderstanding of the work of Penrose to suppose that she attributes growth to the firms' resources alone. She wrote of firm growth as the outcome of a continual interplay between the 'market opportunities of the firm and the productive services available from its own resources' (Penrose, 1971, p.14). She also referred to 'The continual change in the productive services and knowledge within a firm along with the continual change in external circumstances that present the firm with a continually changing productive opportunity' (Penrose, 1995, p. 150). She implied that as markets change the firm must aim at '....building up an experienced managerial and technical team in new fields of activity' (Penrose, 1971, p. 14), again emphasising the match between resources and market opportunities, rather than resources alone. She further emphasised that 'Knowledge of markets, of technology being developed by other firms, and of the tastes and attitudes of consumers are of particular importance'

discussion of the present paper contributes to the emergence of such a theory by suggesting that the random and resource views are not competing but complementary if an epistemological approach to randomness is adopted and agency is attributed to the entrepreneur who systematically turns unexpected events to advantage.

3.3 Theorising on firm development

The distinction between random and resource-based views of firm growth is important to the subsequent argument in this paper. The ‘resource view’ of firm performance would tend to promote a view of firm growth as episodic in nature since resource building is often a discontinuous process (Penrose, 1959; Audretsch et al., 1999, p.969). Because it sees growth as episodic and occurring in spurts, this view recognises the importance of what are sometimes referred to as ‘growth plateaux’ or periods of stability (Garnsey and Heffernan, 2005). Coad et al. (2013) adopt a growth path analysis but do not take on board the associate idea of plateau periods in firms’ growth paths.

4. Gambler’s Ruin Theory

This section provides a brief review of GRT, as described in Coad et al. (2013), prior to analysing their paper in terms of the distinction between the ontological and epistemological theories of randomness as set out in the introduction to the present paper.

4.1 Comparison against the random benchmark of coin-flipping

When setting out GRT, Coad et al. (2013) examine data for 2,184 firms started in the same quarter of 2004 and surviving for four subsequent years. They compare the performance of these firms against what they consider to be the random benchmark of coin-flipping. The flip of a fair

(Penrose, 1959, p. 79). Nevertheless, while acknowledging that Penrose emphasised both resources and the fit between those resources and market

coin can only have two possible outcomes - either heads or tails - so in order to facilitate this comparison firm performance must similarly be reduced to just two categories. In order to carry out a binary analysis, they use growth of sales turnover above and below that of the median firm. Firms exhibiting growth of sales turnover greater than that of the median firm are considered to be ‘growing’ in the year in question, and those with sales turnover growth below that of the median firm ‘declining’. This methodology together with use of a volatile indicator, sales turnover, means that they have a sample in which almost no firms appear to be static over time, as they recognise,.

When flipping a fair coin the probability of landing on heads or tails is exactly equal. For four consecutive flips of a fair coin there are therefore sixteen different possible sequences of outcomes (Fig.1).

Figure 1: Possible outcomes from a sequence of four tosses of a fair coin

H-H-H-H					
T-H-H-H	T-H-T-T	T-T-H-T	T-T-T-H		
T-T-H-H	T-H-H-T	T-T-H-H	H-T-H-T	T-H-T-H	T-H-H-T
T-T-T-H	H-H-T-H	H-T-H-H	T-H-H-H		
T-T-T-T					

H=Heads T=Tails

Following this analogy, if the performance of firms is reduced to the two categories of ‘growth’ or ‘decline’ then over a period of four years there are also sixteen possible firm ‘growth paths’ (Fig. 2), each of them occurring 6.25% of the time if firm growth is random. The occurrence of the growth paths in Coad et al.’s (2013) analysis is sufficiently close to the coin-flipping benchmark of 6.25% for the authors to conclude that growth occurs in an approximately random fashion and that firm growth is therefore analogous to gambling as reflected in the name given to

opportunities, as shown above, as a shorthand we refer here to Penrose’s explanation of firm growth as the ‘resource view’.

GRT. Under this theory firms accumulate resources from a win (a year of growth) and dissipate resources from a loss (a year of decline). They continue in business until their resources are exhausted, just as a gambler remains at the table until his funds run out.

Figure 2: Possible outcomes from a sequence of four years of firm growth or decline

G-G-G-G					
D-G-G-G	D-G-D-D	D-D-G-D	D-D-D-G		
D-D-G-G	D-G-G-D	D-D-G-G	G-D-G-D	D-G-D-G	D-G-G-D
D-D-D-G	G-G-D-G	G-D-G-G	D-G-G-G		
D-D-D-D					

G=Growth D=Decline

The continued existence (or otherwise) of the firm is therefore explained by how ‘lucky’ it is in terms of whether it has a sufficient number of wins to build the resources needed to see it through the inevitable losses (periods of decline) that it will incur, and which may occur in a series of successive periods if the firm is unlucky. Large firms are better able to survive as they have built up sufficient resources to survive longer periods of successive decline.

4.2 Optimism and Chance model

Closely related to GRT is Storey’s (2011) Optimism and Chance (OC) model of entrepreneurship, which can be considered a forerunner to it. Storey (2011, p.313) explicitly states that the OC model is ‘closely aligned’ to GRT. This closeness is evident in that the OC model also uses the analogy of gambling, albeit at a roulette wheel, to explain a number of stylized facts about firm performance.

Storey (2011, p.313) states that the OC model can be used to explain why modest winners stay at the table, thereby explaining the existence of the large number of ‘small-scale businesses – often

referred to as a ‘lifestyler’, ‘trundler’ or ‘economic core’ business – which numerically dominate enterprise numbers in every economy in the world’. The OC model is also used to explain how some individuals have no wins but continue to have sufficient resources to cover their stake – implying that it can be used to explain firms that do not grow but continue to exist. However, the predominance of such cases is not addressed in the application of GRT to firm growth.

5. The Methodology of Gambler’s Ruin Theory

Coad et al. (2013) provide in GRT a clear, elegant and simple model of firm growth. However, in order to do so they have to use procedures to ensure that firm performance is reduced to just two categories, growth and decline in relation to median performance, as required to benchmark performance against coin-flipping. We find below that it is the imposition of these and other procedures that leads them to conclude that firm growth is random.

Certain requirements must hold if outcomes are to be classed as random under both the ontological or epistemological views, as summarised in the introduction. These are not met in the GRT paper perhaps because there is an exploratory or “what if” element to their use of the gambling analogy; this they treat as a ‘first approximation’ to an explanation of firm growth. The authors play with the idea that randomness should result in an equally-distributed outcome as if to say, ‘what would happen if this were the case?’ More worryingly, in interpreting their findings they make inferences at the firm/entrepreneur level from findings of randomness at firm population level. And as we explore in more detail below, they neglect the issue of typicality in the evidence (Dasgupta, 2011).

Our critique of GRT in this section is organised as follows. The integrating conceptual theme is treated next. Other methodological issues are then examined, after which we turn to the empirical

evidence that raises questions about the justification for the methodology used in the GRT paper.

5.1 Randomness and an equally-distributed outcome

We saw in setting out the two main interpretations of randomness in the introduction that for neither of these perspectives are equally-distributed outcomes to be expected. A coin-flipping analogy does not imply an equally-distributed outcome (von Mises, 1957; 1964). Instead the occurrence of heads or tails will approach the limiting value of 0.5 as the sequence of observations is indefinitely continued (Schield and Burnham, 2008), but any individual part of this indefinitely continued sequence will deviate from this characteristic. The probability of a given size of deviation is dependent on the number of observations. This is relevant to attempts to benchmark randomness in the design of research whichever theory of randomness is adopted. The equally-distributed probability of approximately 6.25% per ‘growth path’ at the population level is introduced as a methodological procedure in Coad et al. (2013) but it is this procedure that produces the outcome of firm-level probability of growth or decline of 50%.

A common misunderstanding of randomness, highlighted by Taleb (2007, p.169-170), is the expectation that it manifests itself in an equally-distributed outcome. Taleb (2007, p.169-170) shows this intuitive understanding of randomness to be mistaken, using the example of sixteen darts thrown at sixteen squares. Rarely if ever would this result in the equal distribution of one dart per square. Even the outcome from a sequence of $2,184^2$ sequences of sixteen darts would not result in an equal distribution. Coad et al. (2013) expect just such an equally-distributed outcome to result from random firm growth.

² The sample size in Coad et al.’s (2012) analysis.

A more appropriate test for randomness than comparison against an equally-distributed outcome around the median would be to examine firms in terms of the change in their ranked performance over time. Henderson et al. (2012) carry out such an analysis and argue that their results support the view that some firms are endowed with greater/better resources and as a result of these resources achieve better performance beyond what may be achieved simply through randomness. This is the view referred to by Coad et al. (2013) as ‘Resource Theory’, in contradiction to a view of performance as largely random.

5.2 The appropriate level of analysis

Coad et al. (2013, p.623) see the outcome of their coin-flipping analogy as corroborating the usefulness of Gibrat’s Law as a heuristic for explaining firm growth. However, as shown above, Gibrat’s law implies that ‘the probability of a given proportionate change in size during a specified period is the same for all firms *in a given industry* – regardless of their size at the beginning of the period’ (Mansfield, 1962, p.1030-1031, emphasis added). This implies that the correct unit of analysis is a collective such as the industry.

In the GRT analysis the macro-level probabilities of growing and declining across a population of 2,184 firms are examined but there is also reference to the individual entrepreneur or ‘gambler’, as reflected in the theory’s name. However, ‘probability’ has no meaning at the level of the individual case (Schield and Burnham, 2008). It was shown by von Mises (1957, p.104-134) that it only makes sense to think of ‘probability’ as applying to a ‘collective’ (or population). What matters to the individual entrepreneur is what he/she can do in order to improve the performance of his/her individual firm, not whether the aggregate level sequence of firm performance is random (This issue is taken up below in our discussion of agency).

Conclusions drawn at the level of the firm in GRT actually apply at the level of the population of firms or industry.

5.3 Assigning firms to growth or decline categories based on median firm's sales

5.3.1 Negligible differences between firms categorised 'growing' and 'declining'

As a feature of exploring the gambling analogy, GRT uses growth of sales turnover above and below that of the median firm to reduce firm performance to the two categories of 'growth' and 'decline' required to compare against the random benchmark of coin-flipping. Using the median sales turnover in this way, however, can result in negligible differences between the firms categorised as 'growing' and 'declining'.

In the first year of the analysis by Coad et al. (2013) the median sales turnover is just £39,276 and between year 1 and year 2 the median growth of sales turnover is just 6%. Therefore, if the firm with the median sales turnover in year 1 grew at the median growth rate between year 1 and year 2 its sales turnover in year 2 would be £41,633 and it would be considered a 'growing' firm in year 2. However, if instead the firm only grows its sales turnover by 5.9% between year 1 and year 2, or from £39,276 to £41,593, the firm would instead be considered to be a 'declining' firm in year 2 – yet the difference between the two is just £40. A very minor difference in sales turnover over the period of a year, which here separates firms categorised as 'growing' from those categorised as 'declining', will not reflect a genuine difference in firm performance. If we instead apply this approach to the sales turnover at the 90th percentile in year 1, which is £261,042, the difference between a firm classified as 'growing' and one considered 'declining' between year 1 and year 2 is still under a week's wages for an employee, at £261³.

³ A firm starting at £261,042 in year 1 and growing at 6% grows to £276,704.52, whereas one growing at 5.9% grows to £276,443.48.

5.3.2 Firms with negative growth categorised as 'growing'

Another implication of the use of the median firm to reduce firm performance to the two categories of 'growth' and 'decline' is that the rates of growth required if a firm is to be considered 'growing' rather than 'declining' under Coad et al.'s (2013, p.622) approach are very variable. Between year 1 and year 2 the rate of growth required is 6% as shown above. However, between year 2 and year 3 it is less than half of this at 2.6%. Then it drops to 1.6% between year 3 and 4. Finally, between years 4 and 5 and 5 and 6 a firm can be considered as 'growing' even if its sales turnover has actually declined. For example, between year 4 and 5 any firm with a growth rate of *minus* 6.5% or higher is considered to be 'growing'. GRT theory as explicated in Coad et al. (2013) therefore contains the perverse implication that firms whose sales turnover is declining are 'growing' firms as long as it is declining more slowly than the median firm, which between year 4 and 5 of their analysis can mean that it declines at greater than 6% in a 'growing' firm.

In summary, a measure of firm performance such as sales growth above and below that of the median firm reduces firm performance to the two categories of 'growth' or 'decline' required by a comparison with the random benchmark of coin-flipping. However, this results in negligible differences between those firms categorised as 'growing' and those categorised as 'declining', and, for some years of the analysis, results in firms whose turnover grows negatively being categorised as 'growing'.

6. A contrasting empirical study

Our critique calls for empirical evidence to back our argument that randomness in the GRT study is an artefact of the methodology used and that it is not justifiable to exclude stable periods in analysing firms' growth paths. Accordingly we present evidence on the 'growth paths' taken by

39,825 firms created in 2005 across the UK. We contrast our results with those of Coad et al. (2013). We do not obtain results showing firm growth to be predominantly random, leading to further discussion on the theme of randomness. Space does not allow us to exploit the further potential of the data set to reveal growth patterns; our aim is specifically to show that methodology and measurement impact on the appearance of randomness in firm growth.

6.1 Data

The dataset used in the following analysis is from The Beta Model (TBM). TBM is a database comprising 2.6m UK firms whose establishment, performance (change in employee numbers) and survival have been tracked over a period of ten years.⁴ It is a cohort for which there are four subsequent years of data and is close to 2004, the time of the creation of Coad et al.'s (2013) cohort of firms. In the fourth quarter of 2005 there were 79,427 created across the UK. A total of 39,825 of these survive for four subsequent years and are included in this analysis of employment 'growth paths'.

Any single measure of firm growth has drawbacks (Shepherd and Wiklund, 2009). However, changes in employee numbers represent a more standard and comparable unit of observation than does sales turnover. For this reason it has recently been used by Hamilton (2010) in an analysis of firm growth paths similar to that in this paper. Employment figures are more comparable because they avoid such problems as inflation, changes in currency value and in international outsourcing arrangements that can make sales figures invalid measures of

⁴ The TBM database registers the establishment of a firm through its inclusion in one of two (or both) major UK directories, The Yellow Pages or Thomson Local (Derbyshire and Haywood, 2009, p.315). This method of data capture ensures the firm's existence is registered much closer to its actual creation than in the official VAT data in which 'new' firms tend to be an average of three years old (Johnson and Conway, 1997). For this reason, the problem of 'left truncation' (Yang and Aldrich, 2012) is reduced and, as a result, in 2010 TBM had 2.6m firms registered on it whereas the UK government's VAT dataset had just 1.5m. In 2004 new data from Thomson Local was merged with the original data from Yellow Pages, resulting in a more extensive and robust dataset. The merging process was completed by 2005. The cohort examined in the analysis in this paper is for the fourth quarter of 2005 when this merging process had been completed.

performance. Change in employee numbers is the measure we used in the contrasting empirical analysis offered in the next section of this paper.

6.2 New study of growth paths of 39,825 UK firms

That stasis is the most common outcome for firm growth becomes clear from our study when we replicate the approach designed to eliminate (or exclude as much as possible) stasis from the analysis (Coad et al., 2013, p.621). If we exclude from the 39,825 firms any firm with a period of stasis (no change in employment) in any of the four years of analysis, we are left with just 187 firms. Out of 39,825 firms 39,638, or 99.5%, have at least one period of stasis over the period of four years under analysis.

If instead we include stasis, or no change, as an additional category, the number of possible ‘growth paths’ increases from sixteen to eighty-one (3^4). The new analysis of growth paths for the cohort of 39,825 firms started in the fourth quarter of 2005 and surviving for the four subsequent years is shown in Table 1.

Table 1: Growth paths for 39,825 firms started in 2005 and surviving four years

Growth Path	No. of firms	% of firms	Growth Path	No. of firms	% of firms
D-D-D-D	1	0.00%	G-G-D-S	40	0.10%
D-D-S-D	1	0.00%	S-D-G-D	44	0.11%
D-D-D-G	2	0.01%	D-S-S-D	60	0.15%
S-D-D-D	2	0.01%	G-S-D-G	65	0.16%
G-G-G-G	3	0.01%	S-G-S-G	66	0.17%
G-D-D-D	3	0.01%	D-S-G-G	68	0.17%
D-G-G-G	3	0.01%	D-G-S-D	69	0.17%
D-S-D-D	5	0.01%	G-D-S-G	79	0.20%
D-G-D-D	5	0.01%	D-D-G-S	80	0.20%
S-G-G-G	5	0.01%	D-S-D-S	83	0.21%
G-G-D-D	5	0.01%	D-G-D-S	86	0.22%
G-G-G-D	7	0.02%	S-G-G-S	94	0.24%
G-D-D-G	8	0.02%	G-S-S-G	106	0.27%
G-G-S-G	8	0.02%	G-D-G-S	110	0.28%
S-D-D-G	9	0.02%	D-S-G-D	112	0.28%
S-G-D-D	12	0.03%	S-S-D-G	123	0.31%
G-G-D-G	13	0.03%	D-D-S-S	129	0.32%
G-D-G-G	14	0.04%	S-D-S-G	130	0.33%
D-D-D-S	14	0.04%	G-G-S-S	148	0.37%

G-G-G-S	18	0.05%	G-S-G-S	156	0.39%
D-G-G-D	18	0.05%	S-S-G-G	157	0.39%
D-G-D-G	18	0.05%	S-G-S-D	172	0.43%
G-S-G-G	19	0.05%	G-S-S-D	246	0.62%
D-S-D-G	19	0.05%	D-S-S-G	253	0.64%
G-S-D-D	21	0.05%	S-D-G-S	263	0.66%
D-G-S-G	23	0.06%	S-G-D-S	277	0.70%
D-D-S-G	25	0.06%	S-S-G-D	341	0.86%
G-D-G-D	26	0.07%	G-S-D-S	385	0.97%
D-G-G-S	26	0.07%	D-G-S-S	413	1.04%
S-S-D-D	26	0.07%	G-D-S-S	432	1.08%
S-G-G-D	26	0.07%	D-S-G-S	614	1.54%
G-D-D-S	27	0.07%	S-S-S-D	780	1.96%
S-D-G-G	28	0.07%	S-S-D-S	845	2.12%
D-D-G-D	29	0.07%	S-D-S-S	887	2.23%
G-D-S-D	29	0.07%	S-S-S-G	1162	2.92%
D-D-G-G	32	0.08%	S-G-S-S	1254	3.15%
G-G-S-D	33	0.08%	S-S-G-S	1960	4.92%
S-D-S-D	33	0.08%	D-S-S-S	2161	5.43%
S-D-D-S	38	0.10%	G-S-S-S	2199	5.52%
S-G-D-G	39	0.10%	S-S-S-S	22463	56.40%
G-S-G-D	40	0.10%	Grand Total	39825	100%

G=Growth; S=Stasis (no change); D=Decline

When using change in employee numbers as the measure of firm performance, and including stasis as a specific category of growth outcome, Table 1 shows that 56% of firms have a growth path comprised of four consecutive periods of stasis. Other growth paths dominated by stasis (i.e. those including three periods of stasis or more) are the paths followed by a somewhat larger percentage of firms than those dominated by either growth or decline.

The proportions of firms growing, declining or static for each of the four years individually confirm the importance of stasis as a separate category of firm performance. In year 1 11% of firms grow, 11% decline and 78% are static; in year 2 7% grow, 6% decline and 87% are static; in year 3 11% grow, 5% decline and 84% are static; and in year 4 6% grow, 5% decline and 89% are static. This is similar to Hamilton's (2010) recent finding that even growing firms spend 65-

75% of their time in stasis. As would be expected, across all firms (including those that never grow) in this analysis the figure is even higher.

We saw in the discussion of randomness in the introduction that to be random a sequence should not exhibit any 'special attribute' or 'typicality'. (Dasgupta, 2011, p.6). The evidence presented here indicates that firm growth performance does have a special attribute or 'typical' outcome: stasis or no change. In each of the four years of analysis between close to 80% and 90% of firms are static, and across all four years a growth path characterised by four years of stasis is followed by 56% of firms. This contrasts with the findings of the GRT in which growth and decline occur 50% of the time and stasis is explicitly excluded from the analysis.

Results showing the importance of stasis are consistent with Storey's (2011, p.313) finding that firms exhibiting little or no growth dominate the economy and Coad's statement to the same effect (2009, p.6). The exclusion of periods of stability in firms' growth paths in Coad et al. (2013) contrasts with the separate category assigned to stability in Blackburn and Brush's (2009) typology of firm growth and in Garnsey and Heffernan's (2005) discussion of the growth of high tech firms. Several other studies show that a large number of firms start small and remain that way throughout their existence (McKelvie and Wiklund, 2010, p.266; Birley and Westhead, 1990; Davidsson et al., 1998). It is therefore a feature of the thought experiment approach to the gambling analogy that procedures were used in Coad et al. (2013) to exclude stasis as a feature of firm performance. This and small differences in sales turnover are needed to facilitate the mapping of coin-flipping patterns onto the data. A clear set of results are obtained by an elegant modelling process, but the randomness found in the results reflects the procedures used.

7. The ontology of randomness and the problem of agency

In this concluding section we touch on two of the three themes that arise from our critique of GRT: firstly, the conceptual aspect related to the ontology and epistemology of randomness and secondly the scope for entrepreneurial agency, a question so important as to call for fuller treatment elsewhere (Hugo and Garnsey, 2004).

7.1 Randomness and agency

The question arises as to why the authors find the Gambler's Ruin Theory a compelling way of modelling the growth of new and small firms. The authors have made an outstanding contribution to the study of firm growth in their prior work. From their investigations and knowledge of the firm-growth literature both Storey and Coad concluded that there is no evidence from regression analysis of a clear association of firm growth with specific causal factors. One conclusion that could be drawn from this is that regression analysis does not have the functionality to identify, for a population of firms, the determinants of attributes that are causally ambiguous. Where there are complex causal paths, causes can become effects as path dependent sequences play out and intertwined feedback effects are difficult for regression analysis to unravel. However, the conclusion reached in Coad et al. (2013) is that if discrete causes of firm growth have not yet been identified, firm growth is indeterminate and hence the outcome of randomness. In choosing to explore this notion by applying a gambling analogy to firm growth they opt for an ontological theory of randomness: leaders of resource-constrained enterprises have no ability to influence outcomes, their enterprises are as 'corks in a sea driven by a range of factors beyond their control' (Coad et al., 2013, p.7).

Their interest in exploring the gambling analogy and the attraction of an elegant model appear to have diverted the authors of the GRT paper from examining the conceptual implications of the coin-flipping analogy. The authors adopt an ontological perspective in assuming that a sequence of coin flips reflects sheer chance. As we have seen, any such sequence can also be viewed from the epistemological perspective as reflecting specific though unknown physical conditions, including the dimensions of the coin, any distortions in its symmetry, the trajectory in a given instance, the force of the action, etc. An epistemological perspective applied to runs of firm growth would suggest that these too are the result of specific causes, including the actions of the entrepreneurs concerned. Not all unrevealed causal factors in an epistemological approach to randomness are attributed to agency; other hard-to-isolate factors (market shifts etc.) are at work, but nor is agency excluded as it is by the assumption of random indeterminacy.

The attraction of GRT to Coad et al. (2013) is that it appears to provide a compelling account of the experience of young firms; these are viewed as able to remain in the game of growth by accumulating resources, just as a gambler can stay longer at the table if he accumulates a stash of tokens from winning runs. The authors of the GRT study maintain that firm survival is enhanced (though not guaranteed) as firms accumulate more resources; survival then provides such firms with growth prospects greater than those of smaller, newer firms. This is a plausible contention but it does not require a gambling analogy that rules out agency as an explanation. It is well established that resource-constrained new firms are vulnerable to uncertainty because they are unlikely to have reserves to protect them against even short-term blockages to the flow of resources (or returns) needed to keep them in business. Such problems are all the more likely for firms with an immature production and customer base. Some firms overcome such difficulties; appropriate responses by their managers cannot be ruled out as among the reasons why they do so.

As to which of the early stage resource-constrained firms achieve growth, the subsequent performance of firms may be affected by factors that include the legacy of entrepreneurs' actions that took place earlier while the firm was small, though the benefits of such agency may not have been detectable at that time. An evolutionary perspective (in which the firm itself is a complex adaptive system) could view the large firm's survival and growth as a reflection of the extent to which its routines conferred fitness in its business environment (Nelson and Winter, 1982); many such routines will have been established in the firm's infancy.⁵ The evolutionary perspective holds that benefits of action to set up effective routines when the firm is small do not necessarily become visible until later on, once selection conditions have operated as sorting processes through which certain firms grow and achieve scale.⁶

The researchers applying GRT to the issue of firm growth explicitly conclude that growth performance is not open to influence by entrepreneurs and managers of resource-constrained new firms: 'we need to understand that growth is largely random, whether we try to explain growth in one particular year, or whether we try to explain the longer-term growth path that unfolds over several years' (Coad et al., 2013, p.628). But the gambling analogy is presented as only a 'first approximation' in their explanation of firm growth. An interesting feature of their paper is the reintroduction of determinacy and agency into the analysis to explain growth in the better-resourced larger firm. They infer that growth resulting purely from luck has the effect of helping the lucky firm to access further resources because there are further benefits from the appearance of success: 'Growing firms may believe they are superior to their rivals – and convince others too – which may give them an advantage over their slower-growth counterparts'

⁵ For relevant evidence on the longer term impact of early routines see: 'Organizational Blueprints for Success in High-Tech Start-Ups: Lessons from the Stanford Project on Emerging Companies' (Baron and Hannan, 2002).

(Coad et al., 2013, p.628). That credibility enhances resource-access for a young firm is a valid point but is not consistent with the gambling analogy, since the appearance of success does not alter the odds in the gambler's favour. However, knock-on or 'reinforcement effects' are an intrinsic feature of complex adaptive systems and provide support for a complexity approach. To view a firm as a complex adaptive system makes it unnecessary to invoke a different theoretical approach for start up as opposed to established firms; a coherent conceptualisation is available that applies to both sets of firms.

One of the suggestions made in the conclusion to the present paper is similar to that advocated by Coad et al. (2013): research should focus on the interplay between randomness, resources and agency. For this purpose a different approach is required, as described in relation to the 'edge of agency' below.

7.2 The Operation of Complex Dynamic Processes and the Edge of Agency

Instead of viewing resource-constrained young firms as corks bobbing on a sea of chance, transformed into active agents if they accumulate an unspecified store of resources, we can view new enterprises as complex adaptive systems (Garnsey and McGlade, 2006): '[a complex system]...is any system that has within itself a capacity to respond to its environment in more than one way. This essentially means that it is not a mechanical system with a single trajectory, but has some internal possibilities of choice or response that it can bring into play' (Allen, 2001, p.150). In other words, there is scope for agency whether or not it is a challenge to identify its impact.

⁶ This argument holds even if some firms that introduce effective routines are eliminated by other unfavourable selection forces. It is an error to equate 'epistemological randomness' with undetected agency, since this approach sees other hard-to-isolate factors beyond behavioural factors as also affecting outcomes.

Thus, beyond the limitations of regression analysis, possibilities other than indeterminacy arise. The complexity approach has established that phenomena subject to complex dynamic processes are difficult or impossible to predict.⁷ We see firm growth as one such phenomenon. It is not specific firm attributes or discrete facilitating conditions in themselves, but rather the cumulative interactions between them that give rise to firm growth and the feedback effects that sustain growth. Penrose who was an implicit systems thinker wrote: 'Growth is governed by a creative and dynamic interaction between a firm's productive resources and its market opportunities (as perceived by its entrepreneurs)' (Penrose, 1960, p. 1). It is not enough, therefore, to limit analysis to the firm's resources. The causes at work are multiple and subject to complex feedback effects. But outcomes that result from hard-to-identify causes are not random in the ontological sense associated with gambling.

The continual iteration and matching efforts in entrepreneurial firms between internal resources and evolving external opportunities explain the prevalence of 'improvisation' 'adaptation' and 'effectuation' strategies found in recent studies of entrepreneurial managers (Brown and Eisenhardt, 1998, p. 33; Bhidé, 2000, p. 61; Sarasvathy, 2001). Skill and agency are embodied in the measures the entrepreneur undertakes, the choices they exercise to improve prospects for survival and growth in a world where unexpected developments are the norm. Many consistently seek ways to take advantage of uncertainty and the unexpected. Policies could be devised to assist entrepreneurs in this process.

Rich case studies can isolate and examine how entrepreneurs respond to occurrences that were unexpected though not retrospectively inexplicable. Repetitive learning is not the only way of improving performance as Coad et al. (2013) assume. Even in conditions of continual change, entrepreneurs develop such skills as building alliances and scanning for new opportunities that

⁷ Boulding argued that when we are dealing with disequilibrium systems (a firm is one such system) our power of prediction is very limited, though not zero (Boulding 1987).

can be pursued with limited means; they develop new ways to access and create resources. Of particular interest are firms where a series of unexpected occurrences are turned to advantage despite initially appearing to be adverse (Hugo and Garnsey 2005)⁸. Other revealing firms include those where a change of approach by new leadership turns a company around without a favourable change in other circumstances. These and other studies can increase understanding of firm growth despite limits to prediction, just as understanding in meteorology outpaces the ability to predict.

7.3 Concluding comments

The exploration of the gambling analogy in the context of firm growth by Coad et al. (2013) is a useful exercise for a number of reasons. Their conception of firm growth as episodic is an advance on previous work analysing growth as though it were continuous. Their study confronts fundamental issues in identifying causes of firm growth and highlights the problem of agency. The paper also provides insight for unintended reasons by boldly addressing controversial issues. It brings to the fore the difference between ontological and epistemological approaches to randomness. It shows how randomness can be an artefact of methodological procedures. And it points to the neglect of demand in much modern 'resource theory' and the need to recognise that: 'In a firm where there is an entrepreneurial outlook, there is a continual interplay between the 'market opportunities' of the firm and the productive services available from its own resources' (Penrose, 1971, p.14). Their study shows that complexity theory has not reached mainstream economics to bring home the difference between the unpredictability of complex dynamic processes and indeterminacy (Brown and Eisenhardt, 1998; Garnsey and McGlade, 2006). Firm growth, as a complex dynamic process, is subject to further complex dynamic processes such as

⁸ Effectuation processes involve shifts to new opportunities effected by entrepreneurs on the basis of given means at their disposal (Sarasvathy 2001). Resource shortfalls and other apparently adverse occurrences can promote ingenuity in the way resources are used and created as well as

market and technological shifts; the consequent difficulty of identifying causes means that an epistemological approach to randomness is called for. Attention can focus on the uncertain and unexpected factors that constrain predictability without implying indeterminacy.

It is well known that spurious theories may be developed to account for chance or unrelated associations (Denrell, 2004, p.923). The reverse also happens. Randomness that is the artefact of measurement procedures may be attributed to outcomes of highly complex but partly non-random phenomena that are difficult to explain with precision. Firm growth is one such phenomenon.

We recognise the difficulty of identifying specific causes of firm growth but this is not because running a new firm is directly analogous to gambling. It is because firms are subject to complex dynamic processes that are inherently unpredictable. This feature of the world does not rule out scope for agency. There is no doubt that unpredictable developments are at work influencing the conditions in which entrepreneurs operate, but they respond to these conditions as proactive agents, not as passive corks on a conditioned sea.

References

Allen, P., 2001, A Complex Systems Approach to Learning in Adaptive Networks. *International Journal of Innovation Management* 5 (2), 149–180.

Ashton, T. S., 1926. The growth of textile businesses in the Oldham district, 1884–1924. *Journal of the Royal Statistical Society* 89 (3), 567–83.

Audretsch, D. B., Santarelli, E., Vivarelli, M., 1999. Start-up size and industrial dynamics: some evidence from Italian manufacturing. *International Journal of Industrial Organization* 17 (7), 965-983.

Axtell, R. L., 2001. Zipf distribution of US firm size. *Science* 293 (5536), 1818–20.

Baron, J., Hannan, M., 2002. Organizational Blueprints for Success in High-Tech Start-Ups: Lessons from the Stanford Project on Emerging Companies. *California Management Review* 44 (3), 8-36.

Bhidé, A. V., 2000. *The Origin and Evolution of New Businesses*. Oxford University Press, Oxford.

Birley, S., Westhead, P., 1990. Growth and performance contrasts between types of small firms. *Strategic Management Journal* 11 (7), 535-557.

Blackburn, R. A. Brush, C. G., 2009. Understanding the challenges to growth in entrepreneurial firms: cases from the UK and USA. Paper to the XXIII RENT conference, Budapest, 19-20 November.

Boschma, R. A., Frenken, K., 2006. Why is economic geography not an evolutionary science? Towards an evolutionary economic geography. *Journal of Economic Geography* 6 (3), 273-302.

Boulding, K. E., 1987. The Epistemology of Complex Systems. *European Journal of Operational Research* 30 (2), 110-16.

Brown S., Eisenhardt K., 1998, *Competing on the Edge: Strategy As Structured Chaos*. Harvard Business School Press, Boston, Mass.

Cabral, L., 1995. Sunk costs, firm size and firm growth. *Journal of Industrial Economics* 43 (2), 161-172.

Coad, A., 2009. *The Growth of Firms: A Survey of Theories and Empirical Evidence*. Edward Elgar, Cheltenham, UK.

Coad, A., Frankish, J., Roberts, R. G., Storey, D. J., 2013. Growth paths and survival chances: An application of Gambler's Ruin theory. *Journal of Business Venturing* 28 (5), 615-632.

Dasgupta, A., 2011. Mathematical foundations of randomness. In: Bandyopadhyay, P. S., Fraser, M. R. (Eds.), *Handbook of the Philosophy of Science, Volume 7: Philosophy of statistics*. Elsevir, London.

Davidsson, P., Lindmark, L., Olafsson, C., 1998. The extent of overestimation of small firm job creation: An empirical examination of the regression bias. *Small Business Economics* 11 (1), 87-100.

Delmar, F., Davidsson, P., Gartner, W. B., 2003. Arriving at the high-growth firm. *Journal of Business Venturing* 18 (2), 189-216.

Denrell, J., 2004. Random walks and sustained competitive advantage. *Management Science* 50 (7), 922-934.

Derbyshire, J., Haywood, G., 2009. Uncovering creative destruction brought about by new firm formation: A new method and data source. *Local Economy* 24 (4), 310–322.

Dosi, G., 2007. Statistical regularities in the evolution of industries: a guide through some evidence and challenges for the theory. In: Malerba, F., Brusoni, S. (Eds.), *Perspectives on innovation*. Cambridge University Press, Cambridge, UK.

Dunne, P., Hughes, A., 1996. Age, size, growth and survival: UK companies in the 1980s. *Journal of Industrial Economics* 42 (2), 115-140.

Dunne, T., Roberts, M. J., Samuelson, L., 1988. Patterns of firm entry and exit in US manufacturing industries. *Rand Journal of Economics* 19 (4), 495-515.

Dunne, T., Roberts, M., J., Samuelson, L., 1989. The growth and failure of US manufacturing plants. *Quarterly Journal of Economics* 104 (4), 671-698.

Evans, D. S., 1987. Test of alternative theories of firm growth. *Journal of Political Economy* 95 (4), 657-674.

Garnsey, E., Heffernan, P., 2005. Growth setbacks in new firms. *Futures* 37 (7), 675-697.

Garnsey, E., McGlade, J., (eds), 2006. Complexity and Co-evolution; continuity and change in socio-economic systems. Edward Elgar, Cheltenham.

Geroski, P. A., 2000. The growth of firms in theory and practice. In: Foss, F., Mahneke, V. (Eds.), Competence, governance and entrepreneurship. Oxford University Press, Oxford, UK.

Gibrat, R., 1931. Les Inégalités Economiques: Applications aux Inégalités des Richesses, à la Concentration des Entreprises, aux Populations des Villes, aux Statistiques des Familles, etc.: d'une Loi Nouvelle: la Loi del'effet Proportionnel. Recueil Sirey, Paris.

Hacking, I., 1990. The Taming of Chance. Cambridge University Press, Cambridge, UK.

Hamilton, R. T., 2010. How firms grow and the influence of size and age. International Small Business Journal 30 (6), 611-621.

Henderson, A. D., Raynor, M. E., Mumtaz, A., 2012. How long must a firm be great to rule out chance? Benchmarking sustained superior performance without being fooled by randomness. Strategic Management Journal 33, 387-406.

Hugo, O., Garnsey, E., 2004. From obstacle to opportunity: Problem-solving and competence creation in new firms. Centre for Technology Management, Working Paper Series, No. 2004/03, August 2004. University of Cambridge, UK.

Ijiri, Y., Simon, H. A., 1964. Business firm growth and size. American Economic Review 54 (2), 77-89.

Ijiri, Y., Simon, H. A., 1967. A model of business firm growth. *Econometrica* 35 (2), 348–55.

Ijiri, Y., Simon, H. A., 1974. Interpretations of departures from the Pareto curve firm-size distributions. *Journal of Political Economy* 82 (2), 315–31.

Jevons, W. S., 1958. *The Principles of Science: A treatise on logic and scientific method*. Dover Publications, New York.

Johnson, P., Conway, C., 1997. How good are the UK VAT registration data at measuring firm births? *Small Business Economics* 9 (5), 403-409.

Kalecki, M., 1945. On the Gibrat distribution. *Econometrica* 13 (2), 161–70.

Knight, F., 1921. *Risk, uncertainty and profit*. Harper and Row, New York.

Laplace, P. S., 1951. *A Philosophical Essay on Probabilities*. Translated by Truscott, F.W. and Emory, F.L. Dover Publications, New York.

Mansfield, E., 1962. Entry, Gibrat's law, innovation, and the growth of firms. *American Economic Review* 52 (5), 1023–51.

Marris, R., 1999. Edith Penrose and economics. *Contributions to political economy* 18 (1), 47-65.

Mata, J., Portugal, P., Guimaraes, P., 1995. The survival of new plants: start-up conditions and post-entry evolution. *International Journal of Industrial Organization* 13 (4), 459-482.

McKelvie, A., Wiklund, J., 2010. Advancing firm growth research: A focus on growth mode instead of growth rate. *Entrepreneurship Theory and Practice* 34 (2), 261-288.

McShane, P., 1970. *Randomness, Statistics, and Emergence*. University of Notre Dame Press, Notre Dame, Indiana.

Nelson, R. R., Winter, S. G., 1982. *An evolutionary theory of economic change*. Harvard University Press, Cambridge, Mass.

Penrose, E. T., 1955 (1971). Limits to the Size and Growth of Firms. *American Economic Review* 45 (2), 531-543. Reprinted in Penrose, E. T., 1971. *The Growth of Firms, Middle East Oil and Other Essays*. Frank Cass, London.

Penrose, E. T., 1959. *The theory of the growth of the firm*. Basil Blackwell: Oxford.

Penrose, E. T., 1960. *The Growth of the Firm - a Case Study: The Hercules Powder Company*. *Business History Review* 34 (1), 1-23.

Penrose, E.T., 1995. *The Theory of the Growth of the Firm*. Oxford University Press, Oxford. (First published 1959).

Sarasvathy, S. D., 2001. Causation and effectuation: Toward a theoretical shift from economic inevitability to entrepreneurial contingency. *Academy of Management Review* 26 (2), 243-263.

Schild, M., Burnham, V., 2008. Von Mises' frequentist approach to probability. *Joint Statistical Meetings*, Denver, 2008.

Shepherd, D., Wiklund, J., 2009. Are we comparing apples with apples or apples with oranges? Appropriateness of knowledge accumulation across growth studies. *Entrepreneurship Theory and Practice* 33 (1), 105-123.

Storey, D. J., 1995. Symposium on Harrison's 'Lean and mean': a job generation perspective. *Small Business Economics* 7 (5), 5-8.

Storey, D. J., 2011. Optimism and chance: the elephants in the entrepreneurship room. *International Small Business Journal* 29 (4), 303-321.

Sutton, J., 1995. The size distribution of business part I: A benchmark case. *London School of Economics, The Economics of Industry Group, Discussion Paper Series, No.EI/9*.

Sutton, J., 1997. Gibrat's legacy. *Journal of Economic Literature* 35 (1), pp.40-59.

Taleb, N. N., 2007. *Fooled by randomness*. Penguin, London.

von Mises, R., 1957. *Probability, statistics, and truth*. Allen & Unwin, London.

von Mises, R., 1964. *Mathematical theory of probability and statistics*. Academic Press: New York.

von Plato, J., 1994. *Creating Modern Probability: Its Mathematics, Physics, and Philosophy in Historical Perspective*. Cambridge University Press, Cambridge, UK.

Wagner, J., 1992. Firm size, firm growth, and persistence of chance: testing Gibrat's law with establishment data from Lower Saxony. *Small Business Economics* 4 (2), 125-131.

Yang, T., Aldrich, H. E., 2012. Out of sight but not out of mind: Why failure to account for left truncation biases research on failure rates. *Journal of Business Venturing* 27 (4), 477-492.