

# **Marshall's 'Trees' and the 'Global Forest': the Extinction Patterns of Capitalism's Largest Firms**

**Paul Ormerod** ([pormerod@volterra.co.uk](mailto:pormerod@volterra.co.uk))\*

**Helen Johns** ([hjohns@volterra.co.uk](mailto:hjohns@volterra.co.uk))

**Laurence Smith** ([lsmith@volterra.co.uk](mailto:lsmith@volterra.co.uk))

**Volterra Consulting Ltd**

**The Old Power Station  
121 Mortlake High Street  
London SW14 8SN**

**October 2001**

\* Corresponding author

We are grateful to the Institute for Complex Additive Systems Analysis of the New Mexico Institute of Mining and Technology for financial support towards this research

## ***Abstract***

*We analyse in this paper information on the evolution of the largest firms which existed in the opening decades of the 20th century.*

*We show that the relationship between the frequency and size of the extinctions is approximated well by a power law relationship. Further, the intervals of time between extinction events can also be described by such a relationship.*

*Analysis of the most informative data set available suggests that the exponent of the fitted power law is very similar to that reported in the literature on the extinction of biological species in the fossil record.*

## 1. Introduction

At the turn of the nineteenth century, large corporations were being built on an unprecedented scale, mainly due to a massive wave of mergers and acquisitions. Hannah (1999) notes how this altered the judgement of Marshall, the leading economist of his day, on the life spans of corporations. In the first edition of his *Principles of Economics*, published in 1890, Marshall suggested that, like trees in the forest, there would be large and small firms, but 'sooner or later age tells on them all'.

As Hannah notes, Marshall was an acute observer of the contemporary economy in the UK, Germany and the US, and by the sixth edition of his book published in 1910, his views had changed. Marshall then held the opinion that 'vast joint stock companies ... often stagnate but do not readily die'. Much more recent work by business historians (e.g. Chandler (1990)) has generally been supportive of Marshall's latter view. By the start of the twentieth century, an entirely new phenomenon of the firm with global reach had been created, and these firms in general still dominate markets.

Hannah constructed a data set of the 100 largest industrial companies in the world in 1912. These are firms which had survived the merger boom at the turn of the century, and were large even by the standards of today. US Steel employed 221,000 workers, and most of the others employed more than 10,000.

By 1995, only 52 of these firms survived in any independent form. Nineteen of the survivors remained in the top 100 industrial companies in 1995, but 24 of them were smaller than they were in 1912. Hannah argues that this evidence suggests that, on balance, Marshall's earlier view is more consistent with the evidence than his later one. Very large firms do in fact die. Further, only a distinct minority retained their position in the top 100 companies.

The purpose of this paper is to examine the evidence on firm extinction for the existence of any particular patterns. There is a growing literature on extinction patterns in the fossil record of biological species (see Drossel (2001) for a detailed survey). An important

aspect of this is the relationship between the number of species which become extinct in an given year, and the frequency with which the different numbers are observed. Section 2 carries out this analysis.

A further point of interest is the distribution of the timing of extinction events. In particular, we examine the distribution of the gaps between extinction events in the firm data set. In other words, the distribution of the successive number of years in which no extinction is observed. This is examined in section 3. Section 4 provides a brief conclusion.

## **2. Frequency and size of firm extinctions**

The standard approach in the analysis of the extinction patterns of biological species (Drossel op.cit.) is to fit a relationship between the number of agents which become extinct in any given year, and the frequency with which these are observed.. In other words, no attempt is made to replicate the actual time-series observed for extinctions. Instead, the focus is on the properties of the underlying distribution which could give rise to the historical realisation which is actually observed.

Figure 1 plots the frequency of annual rates of extinction, which varies substantially. In most years, no single giant firm became extinct, but four firms became extinct in the year 1919, and no fewer than six in 1968.

Frequency of annual extinction rates 1912-1995  
World's largest 100 companies in 1912

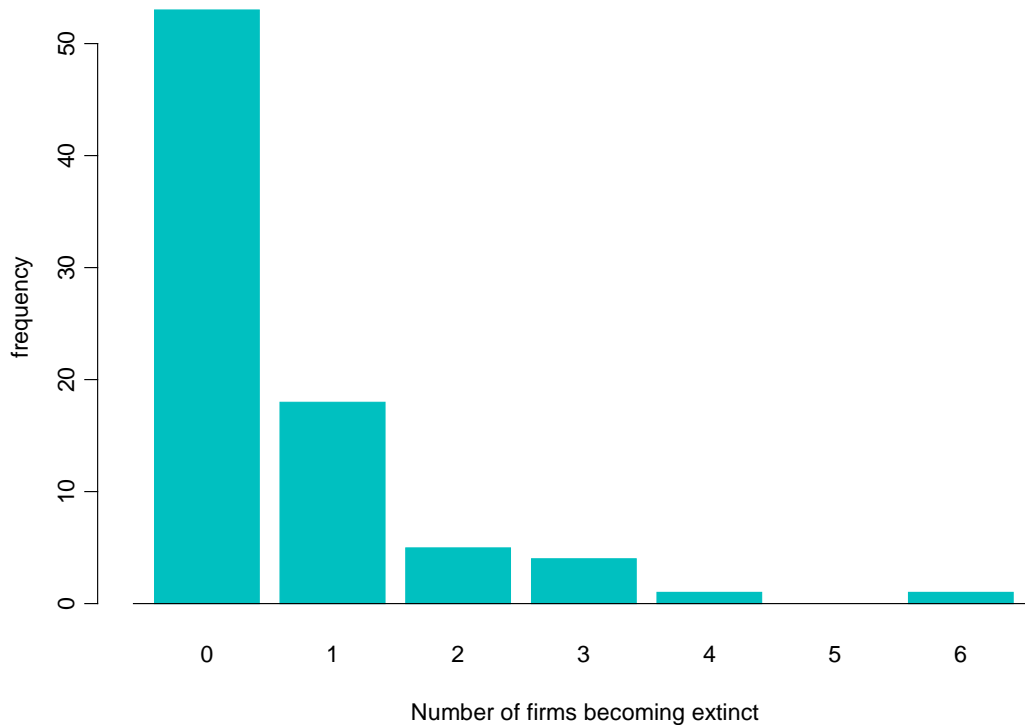


Figure 1

A power law of the form

$$F = \alpha \cdot N^\beta \quad (1)$$

describes the data well, where  $F$  is the frequency with which the annual number of extinctions is observed over the 1912-1995 period, and  $N$  is the annual number of extinctions.

A least squares<sup>1</sup> fit of (1) to the data (for  $N > 0$ ) gives estimated values of  $\alpha$  of 18.0 and of  $\beta$  of -1.76, the latter with a standard error of 0.18. The standard error of the equation

---

<sup>1</sup> using a non-linear least squares algorithm in S-Plus rather than the conventional log-log least squares fit, because there are no examples in the data of 5 firms becoming extinct in any single year and hence the dependent variable takes the value zero for this observation

is 0.94. Comparing this latter to the standard error of the data, 6.75, the equation fits the data well.

The actual values and those fitted by (1) are set out in Table 1. For comparison, the fitted values of an exponential relationship of the form  $F = \alpha \exp(\beta(N-1))$  are also shown. This alternative form is frequently used for comparison with a power law in the biological literature.

**Table 1. Frequency of annual extinction rates: Actual and fitted<sup>2</sup>**

	Number of extinctions					
	1	2	3	4	5	6
<b>Frequency</b>						
Actual	18	5	4	1	0	1
Power law fit	18.0	5.3	2.6	1.6	1.1	0.8
Exponential fit	17.8	6.3	2.3	0.8	0.3	0.1

Just as in the description of biological extinctions (Drossel, op.cit.), the shortage of data points means that we cannot be too dogmatic about the precise nature of the functional form. However, a power law relationship in this case provides a better description of the data than does an exponential distribution.

---

<sup>2</sup> the fitted values are rounded to 1 decimal place

The evidence for biological extinctions suggests, intriguingly, that a power law with an exponent of -2 provides a good description of the data. This is very close to the -1.76 fitted with the large firm data set.

An important implication of this kind of relationship between frequency and size of extinctions is that extinctions on any scale can happen at any time. The probability of a very large extinction is very small, but it is greater than zero.

A further data set is given by Fligstein (1990). This reports the membership of the 100 largest firms in the US, selected on the basis of asset size, at the end of each decade from 1919 through 1979. Altogether, 216 firms appear in the data set. Fligstein reports whether a firm was in the top 100, and does not give information on whether a firm ceased to exist as an independent entity. Exact years of entry and exit from the top 100 are not reported, but the status of each firm at the end of each decade.

There is one direct comparison which can, however, be made between the Fligstein and Hannah data sets. In the Fligstein US data, only 34 out of the top 100 in 1919 survived in the top 100 in 1979. Hannah's data set is the world top 100 in 1912, and by 1995 19 were still in the world's top 100 industrial companies. So the 'extinction' rate defined as exit from the top 100 is very similar in the two data sets. In Fligstein, 66 of the original top 100 in 1919 dropped out by 1979, and 81 of Hannah's 1912 firms dropped out by 1995. The annual average 'loss rate' from the top 100 is therefore very similar: 1.10 in Fligstein and 0.98 in Hannah. Of course, there is overlap between the data sets, with 42 of Hannah's 1912 companies being in the 1919 Fligstein data, but it is far from being complete.

Given that 'extinction' in the Fligstein data is defined as being exit from the top 100 and that this data is aggregated over time into periods of a decade, a direct comparison with the results from Hannah is not possible. However, a power law between frequency and size of 'extinction events' also fits the Fligstein data extremely well. Comparing 1919 and 1929, 31 firms exited from the US top 100, the largest number in any decade 1919-79.

The lowest observed number of exits was 14 in the 1939-49 period. Fitting a least squares regression between the number of firms exiting in any given decade, and the overall rank of that number<sup>3</sup>, the estimated value of the exponent of the power law is -0.397 with a standard error of 0.054. The fitted values, rounded to the nearest whole number, are very similar to those of the actual data.

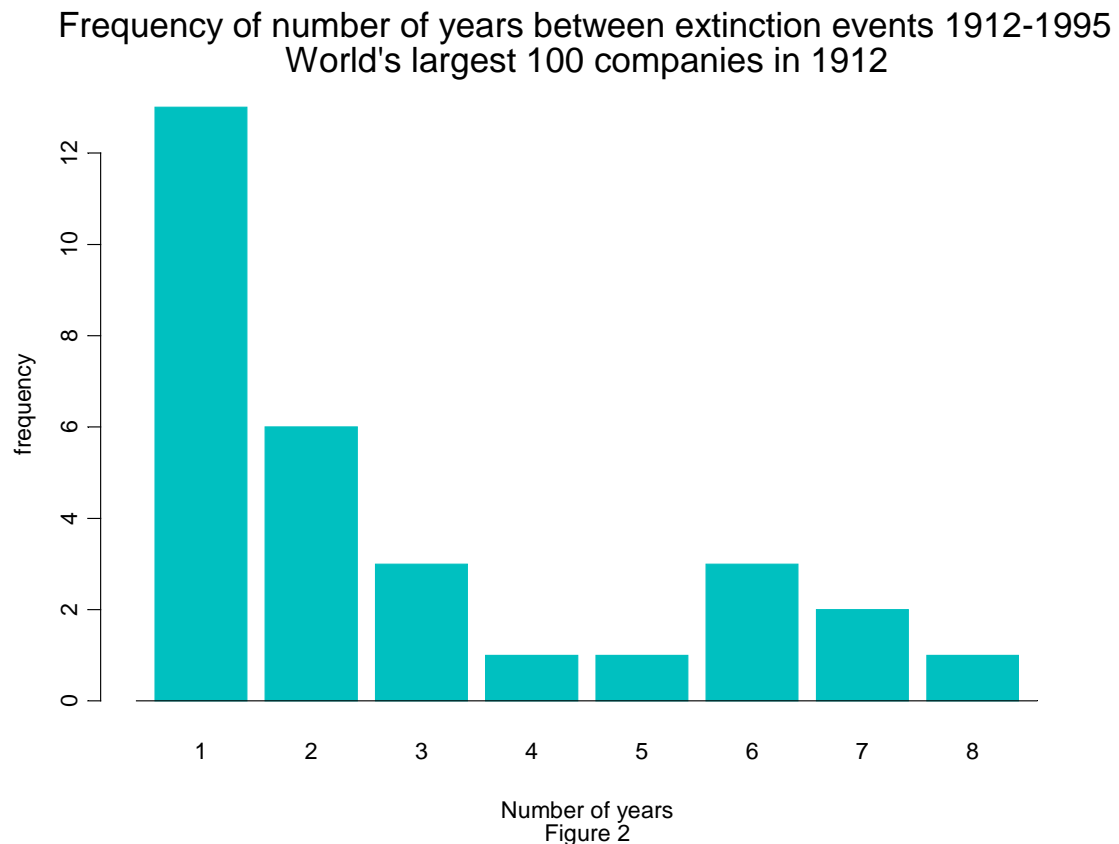
To emphasise again, the Fligstein data set cannot be compared directly with the Hannah one for a number of reasons, but power laws give good descriptions of both data sets.

---

<sup>3</sup> In other words, the highest number of exits (31 during 1919-29) is given rank of 1, through to the lowest (1939-49) which is ranked 6.

### 3. The distribution of the periods of years between extinction events

Figure 2 plots the information in the Hannah data set relating to the number of years between an extinction of at least one of the top 100 industrial firms in 1912. The most frequent observation is one year, which means that in this case extinctions took place in successive years, as for example in 1931 and 1932 and 1968 and 1969.



A power law provides a reasonable fit to the data and, again, this is somewhat better than that given by an exponential distribution. The estimated exponent in the power law least squares fit is  $-1.18$  with a standard error of  $0.22$ . The overall fit, however, is not quite as good as that of the frequency data reported in section 2. Table 2 shows the actual and fitted values.

**Table 2. Number of years between extinction events: Actual and fitted**

	Number of years							
	1	2	3	4	5	6	7	8
<b>Frequency</b>								
Actual	13	6	3	1	1	3	2	1
Power law fit	12.0	5.3	3.3	2.3	1.8	1.5	1.2	1.0
Exponential fit	12.7	6.5	3.3	1.7	0.9	0.5	0.2	0.1

#### **4. Conclusion**

In this paper, we have examined patterns of extinction amongst capitalism's largest companies. The main focus of the analysis is a data set constructed by Hannah (1999) of the top 100 industrial companies in the world in 1912, which provides information on the year in which individual members of this group ceased to exist as independent entities over the 1912-95 period. A related data set is provided by Fligstein (1990) of the top 100 US companies 1919-79. For a variety of reasons the analyses of the two data sets are not in general comparable in a quantitative sense, but qualitatively the results using the two sets are very similar.

We find that power law relationships offer good descriptions of the extinction patterns of very large companies. In particular, the frequency with which a given number of extinctions in any time period is observed depends upon the inverse of the number raised to a power of itself. This is identical to the empirical relationships which have been used to describe the relationship between the frequency and size of extinctions of biological species. In addition, the distribution of the number of years between years in which extinctions occur also follows a power law.

Power law relationships imply that events on any scale can occur at any time. The probability of a large extinction happening in any particular period is much less than that of a small one, but such events are an intrinsic part of the survival/extinction patterns of very large firms.

## References

A.D.Chandler (1990), *Scale and Scope: the Dynamics of Industrial Capitalism*, Harvard University Press

B.Drossell (2001), 'Biological evolution and statistical physics', cond.mat/ 0101409, forthcoming in *Advances in Physics*

L.Hannah (1999) 'Marshall's "Trees" and the Global "Forest": Were "Giant Redwoods" Different?' in N.R.Lamoreaux, D.M.G.Raff and P.Temin, eds., *Learning by doing in markets, firms and countries*, National Bureau of Economic Research

N.Fligstein (1990), *The Transformation of Corporate Control*, Harvard University Press