Historical Methods: A Journal of Quantitative and Interdisciplinary History
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/vhim20

The Life-Spans of Empires

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Version of record first published: 28 Jul 2011.

Scholarly Incursions
HISTORICAL METHODS, July–September 2011, Volume 44, Number 3

The Life-Spans of Empires

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Abstract. The collapse of empires is exceedingly difficult to understand. The author examined the distribution of imperial lifetimes using a data set that spans more than three millennia and found that it conforms to a memoryless exponential distribution in which the rate of collapse of an empire is independent of its age. Comparing this distribution to similar lifetime distributions of other complex systems—specifically, biological species and corporate firms—the author explores the reasons behind their lifetime distributions and how this approach can yield insights into empires.

Keywords: empires, exponential, lifetime, longevity, species

The rise and fall of empires is a complicated affair. Empires fall for many reasons. Some have argued that the increased complexity of a society causes it to collapse on itself (Tainter 1988), whereas others have argued that the fundamental reason for societal collapse is how it responds to environmental stresses, both endogenous and exogenous to the system (Diamond 2005). However, there are many other reasons for collapse, among them economic and geopolitical causes.

In addition, much work has quantitatively examined the rise and fall of states (Turchin 2003). However, despite the rich literature on the causes of the growth and collapse of societies, empires, and civilizations, no one has mathematically examined the aggregate lifetime distribution of these systems. Furthermore, understanding the lifetime distribution of empires within the larger context of complex systems—systems that have large numbers of interacting components that give rise to emergent properties—is of great importance.

For example, similar to societies, other types of complex systems have lifetimes that are determined by a complexity of variables. The mass extinction at the Cretaceous-Paleogene boundary (when the dinosaurs died) would not have occurred without a massive meteor impact (Schulte, Alegret, Arenillas, Arz, Barton, Bown et al. 2010). The Japanese family-owned company Kongo Gumi, which existed for more than 1,400 years until being absorbed by a large construction firm, would have survived if they had perhaps not invested as heavily in real estate (Hutcheson 2007). Each system's survival is often remarkably idiosyncratic and distinct. Surprisingly however, by examining the distribution of lifetimes of corporate firms and biological species, a researcher can learn about their behaviors in aggregate.

It is well known that the extinction rate of a species is independent of its age (Van Valen 1973). This means that no matter how long-lived a species already is, its extinction rate is nonetheless the same as a much newer species. Ever since Leigh Van Valen's seminal paper (ibid.), the Red Queen effect—the presence of constant rates of extinction due to evolution in the face of a changing environment—has been used to explain the constant rate of extinction of biological species. More recent research has sought to explain why species lifetimes adhere to exponential distributions, while the lifetimes of larger taxa, such as genera, adhere to power-law distributions (Pigolotti et al. 2005).

These exponential distributions are not unique to biological systems. In addition, it has been found that corporate firm lifetimes also conform to a memoryless exponential distribution (Fujiwara 2004). Guided by this work, I examined the extinction rate of long-lived empires, or civilizations. Here I found that this property of complex systems is also present in the distribution of lifetimes for empires, using a data set that spans over three millennia.

Materials and Methods

In two studies, Rein Taagepera (1978, 1979) compiled the lifetimes of 41 empires, which spanned from 3,000 BCE to 600 CE. Surprisingly, as far as can be determined, Taagepera did not analyze the lifetime distribution of these empires. Therefore, I derived the lifetimes of 41 empires from Taagepera's work, as measured in centuries. When a range was given in the data set, the midpoint of the range is used for the imperial lifetime. The exponential distribution was then fit by a maximum-likelihood model.

To evaluate the appropriateness of the exponential distribution, several other distributions were attempted for comparison: normal, log-normal, geometric, and gamma ones. For each of these, the log-likelihoods were compared with

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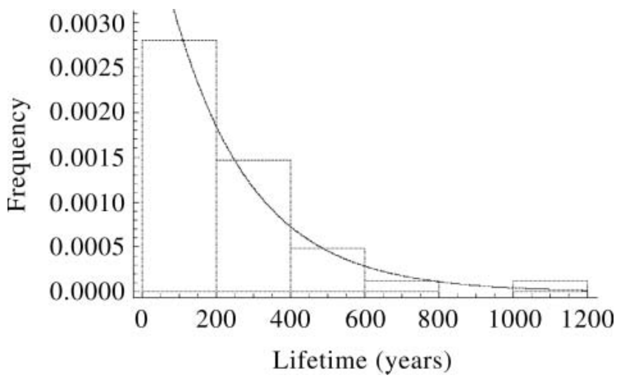

FIGURE 1. Lifetime distribution of empires. The best-fit line for the exponential distribution is overlaid on the lifetime distribution of 41 empires. The bin height is the frequency of empires in each bin, divided by the bin width, to arrive at a probability density.

that for the exponential fit, and the only distributions that had better likelihoods were the gamma distribution (which the exponential distribution is a subset of) and the log-normal distribution, which for certain parameter values can appear similar to the exponential distribution. However, the exponential distribution uses only a single parameter value, unlike the others. Without an empirically validated mechanistic model, it therefore seems the most reasonable to use.

Results

Using the data set of lifetimes of 41 empires from 3,000 BCE to 600 CE (see Appendix), I found that imperial lifetimes can be fit to an exponential distribution, $\lambda = e^{-\lambda t}$, with a parameter value of $\lambda = 0.46$ and an expected mean imperial lifetime of approximately 220 years (see figure 1).

Discussion

It is striking that all three of these complex systems—species, firms, and empires—have lifetimes that can be fit to exponential distributions. While the exponential distribution is the only distribution that is memoryless, it is clear that these systems' fitnesses are not inherently time-independent—especially the fitness of species, which undergo natural selection. The Red Queen effect has been posited to explain this distribution (Van Valen 1973) and why the lifetime appears to be memoryless, when in fact it can be due to a variety of exceedingly complex factors.

Recently, it has been argued that speciation and the Red Queen effect more generally are not due to adaptation to a changing environment (Venditti, Meade, and Pagel 2010). Rather, Chris Venditti, Andrew Meade, and Mark Pagel found that speciation is primarily caused by rare stochastic events. Their results raise the question of whether similar processes contribute to new empires and firms, as well as to the failure of existing ones, or whether more traditional competition against the environment is the cause of the same lifetime distribution found in these complex social systems as in species. It is reasonable to assume that empires are subject to a similar traditional Red Queen effect, where the exponential distribution is the result of a civilization's constant adaptation to a changing environment, which includes competition with neighboring civilizations, as well as changing circumstances, such as resource use and depletion (Diamond 2005).

Bolstering this, there is little evidence that rare stochastic events are the single cause of the fall of certain empires. For example, it has long been posited that the reasons for the fall of the Roman Empire were multifarious and complex (Gibbon 1994). Further research will be necessary to determine the nature of the Red Queen effect on the lifespans of empires and their characteristic exponential distribution.

In addition, in the realm of prediction, previous research has used the Copernican principle to determine the expected lifetime of a complex system (Gott 1993). This method uses the present age of the system to calculate confidence intervals for future longevity. However, more recent work has shown that this method is dependent on many implicit assumptions about the lifetime probability distribution (Ledford, Marriott, and Crowder 2001). In addition, as previously shown, the longevity of an empire is independent of its current age, rendering the Copernican principle inappropriate for this system.

Further work in understanding the lifetime of empires is necessary. Specifically, as there are a couple other functional forms that might be fit to our small data set, expanding the data set can be useful for determining how robust the fit actually is. Furthermore, constructing models that incorporate mechanisms for imperial growth and decay will better allow for understanding these fits. Specifically, if a mechanism can be developed that allows for the exponential distribution, the fit measured here will be on firmer ground. Several models of empires have been developed that incorporate physical location (Turchin 2009), population size and total imperial area (Taagepera 1978), and even group solidarity (Oak 2011); while these provide mechanisms, they do not yield an overall lifetime distribution of empires. However, similar work that has examined the lifetimes of Italian cabinet governments (Cioffi-Revilla 1984), Roman emperors (Khmaladze, Brownrigg, and Haywood 2007), and Chinese emperors (Khmaladze, Brownrigg, and Haywood 2010) have all yielded exponential distributions, so the findings presented here are not unreasonable, albeit at longer timescales.

In addition, examining the relevance of the Red Queen effect in social systems merits further consideration, and additional data will place the theoretical discussion here on firmer analytical ground. Nevertheless, the exponential distribution of the lifespans of empires found here indicates certain important similarities between empires and other complex systems and the possibility of a greater synthesis of these varied areas of quantitative study.

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Appendix—Empires' Lifetimes and Adulthood Dates

TABLE A1. Empires' Lifetimes and Adulthood Dates

Empire	Adulthood date	Duration (centuries)
Hsia-Shang (China)	1350 BC	4
New Empire (Egypt)	1500 BC	5
Old Empire (Egypt)	2800 BC	5
New Assyrian (Mesopotamia)	700 BC	0.8
Middle Empire (Egypt)	2000 BC	3
Hittite (Anatolia)	1320 BC	1.3
Late Period (Egypt)	715 BC	1.9
Akadia (Mesopotamia)	2310 BC	1.0
Babylon—Hammurabi (Mesopotamia)	1700 BC	2
Elam (Mesopotamia)	1600 BC	10
Hykso (Syria)	1650 BC	0.8
Lydia (Anatolia)	610 BC	0.6
Mitanni (Mesopotamia)	1500 BC	1.4
Middle Assyrian (Mesopotamia)	1090 BC	0.5
New Babylon (Mesopotamia)	610 BC	0.7
Babylon (Mesopotamia)	1000 BC	2.5
Urartu (Mesopotamia)	810 BC	0.9
Phrygia (Anatolia)	760 BC	0.6
Old Assyria (Mesopotamia)	1800 BC	1.0
Ch'in (China)	90 BC	2.9
Parthia (Iran)	60 BC	7.0
Rome (Europe)	0	4.0
Achaemenid (Iran)	540 BC	3.2
Byzantine (Europe)	395	3.5
Hsiung Nu Hun (C. Asia)	190 BC	1.0
Maghada-Maurya (India)	300 BC	0.9
Kushan (Indo-Iran)	75	2.0
Liu-Sung (China)	330	2.1
T'u Chueh Turk (C. Asia)	550	0.9
Hun (Europe)	380	0.8
Saka (Indo-Iran)	50 BC	1.2
White Hun (Indo-Iran)	460	1.0
Western Turk (C. Asia)	582	0.7
Toba (China)	440	1.3
Ptolemaic (Africa)	323	2.9
Bactria (Indo-Iran)	200	0.6
Yuen-Yuen (C. Asia)	400	0.3
Gupta (India)	370	0.9
Andhra (India)	170 BC	3.7
Avar (Europe)	580	2.0
Visigoth (Europe)	470	2.4

Sources: Rein Taagepera, "Size and Duration of Empires: Growth-Decline Curves, 3000 to 600 B.C.," *Social Science Research* 7, no. 2 (1978): 180–96; and "Size and Duration of Empires: Growth-Decline Curves, 600 B.C. to 600 A.D. *Social Science History* 3, no. 3/4 (1979): 115–38.