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US Nobel laureates: Logistic growth versus Volterra–Lotka

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ABSTRACT

The logistic-growth equation is a special case of the Volterra–Lotka equations. The former describes competition only between members of the same species whereas the latter describes competition also with other species. In the study of US Nobel laureates considering laureates *per population* improves the quality of the logistic fit but the Volterra–Lotka approach suggests that a logistic description would be a good approximation for data *per unit of time* rather than *cumulative* data. Fitting logistic S-curves on cumulative data – although proven successful in many business and other applications – constitutes treacherous terrain for inexperienced S-curve enthusiasts. The Volterra–Lotka analysis of Nobel laureates reveals other insights such as that Americans and other nationalities are locked in a win–win struggle with Americans drawing more of a benefit, and also that American Nobel laureates "incubate" new Nobel laureates to a lesser extent than other nationalities.

1. Introduction

It has been suggested that the competition for Nobel Prize awards can be described by logistic-growth curves [1]. My first attempt fitting a logistic to the cumulative number of US Nobel laureates in 1988 concluded that the US Nobel niche was already more than half full and implied a diminishing annual number of Nobel Prizes for Americans from then onward [2]. Ten years later I confronted those forecasts with more recent data in my book *Predictions – 10 Years Later* [3]. The agreement was not very good. The forecasts fell below the actual data and despite the fact that there was agreement within the uncertainties expected for a 90% confidence level the discrepancy did not go unnoticed. A technical note published in this journal in 2004 highlighted the inaccuracy of my forecasts and cast doubt in the use of logistics to forecast US Nobel laureates [4]. On my part, I refit the updated data sample with a new logistic pointing to a higher ceiling and began wondering whether there was evidence here for the known bias of logistics to underestimate the final niche size. The new forecast again indicated an imminent decline in the annual number of American Nobel laureates.

Years later while preparing a new edition for my book – *Predictions – 20 Years Later* – I once again confronted forecasts with data. The situation turned out to be the same as ten years earlier, namely the forecasts again underestimated reality and despite agreement with the result of ten years earlier within the uncertainties expected for a 90% confidence level there was now a clear disagreement between recent actual numbers and the original forecasts of twenty years earlier. The situation was reminiscent of the celebrated Michele-parameter episode in experimental physics where a measurement repeated many times over the period of fifty years kept reporting an ever-increasing value always compatible with the previous measurement but finally ending up in violent disagreement with the very first measurement.

So in this paper I want to settle the question of the ever-growing ceiling of the logistic curve fitted to the US Nobel laureates once and for all.

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2. Historical/theoretical considerations

Logistic growth – yielding S-curves – originally conceived to describe the growth of species populations in nature has also been extensively employed throughout the 20th century to describe and forecast animate and inanimate populations stemming from social activity. Alfred Lotka in the early 20th century, Cesare Marchetti in late 20th century and many other scholars have quantitatively applied the principle of Darwinian competition – survival of the fittest – via its logistic-equation formulation to obtain descriptions and forecasts for the widest range of growth processes. Despite the fact that the mathematical formulation is derived from species competing in nature, the analogue to social phenomena and competition among inanimate populations has been demonstrated to be valid [5]. Forecasts made in this way enjoy scientific objectivity, i.e. they are free of the human bias that typically plagues forecasts based on socio-politico-economic theories most of which are founded on beliefs and opinions of experts.

In this paper we address the process of winning Nobel Prizes. It constitutes a competitive process because Nobel Prizes are desirable and at the same time they are a "limited resource" with a restrained number of them being awarded each year. By definition, the best-fit candidates win. Obviously, a peace Nobel Prize is very different from a Nobel Prize in Physics. Moreover, some prizes may be shared among as many as three individuals whereas others are given to only one individual. Following Marchetti's first attempt to forecast US Nobel laureates here too each laureate is counted as one independently of what discipline he or she was in and independently of how many colleagues shared the prize. The justification for this is that we are counting individuals with exceptional contributions to the benefit of mankind and on the average relative underachievements are compensated for by relative overachievements.

In the Volterra–Lotka system of equations logistic growth for two or more species has been generalized with cross terms and coupling constants. This formulation describes not only competition among the members of the same species but also how the species' rate of growth will be affected by the presence of another species. For our Nobel-Prize study the first-order approximation of a 2-species world has Americans competing against all others.

Generalizing the concept of competition for Nobel Prizes to national competition is not justified only *a posteriori* from the goodness of the model description. National competition emerges spontaneously as it does in the Olympic Games for non-team

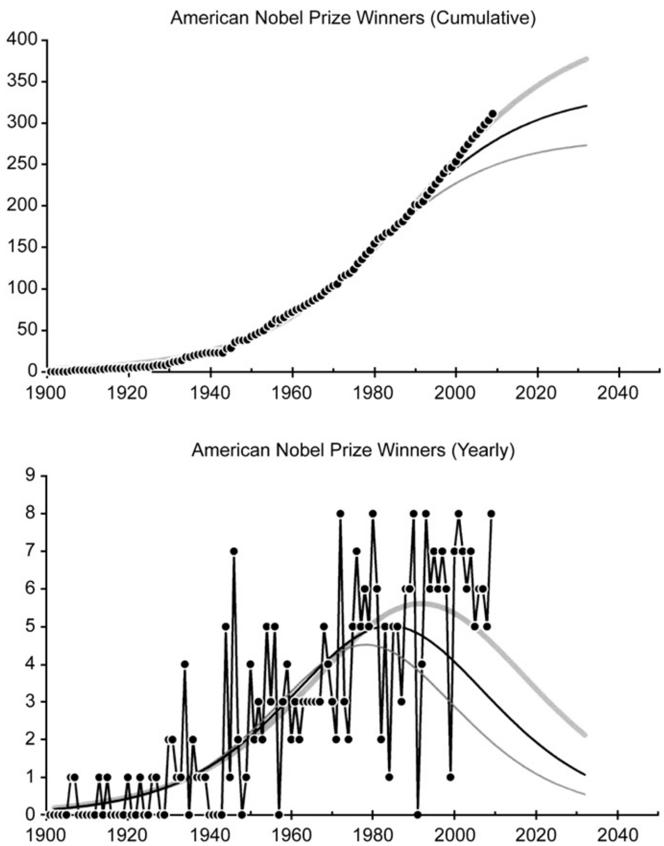

Fig. 1. At the top cumulative data and logistic fit for three different periods: 1900–1987 (thin gray line), 1900–1998 (thin black line), and 1900–2009 (thick gray line). At the bottom, the life cycles (annual numbers) corresponding to the curves and the data at the top.