Journal of Economic Psychology 58 (2017) 1–14

Contents lists available at ScienceDirect

Journal of Economic Psychology

journal homepage: www.elsevier.com/locate/joep

Exponential-growth bias and overconfidence ☆

Matthew R. Levy [a], Joshua Tasoff [b,*]

[a] London School of Economics, Houghton Street, London WC2A 2AE, United Kingdom
[b] Claremont Graduate University, Department of Economics, 160 E. Tenth St, Claremont, CA 91101, United States

ARTICLE INFO

Article history:
Received 9 September 2015
Received in revised form 31 October 2016
Accepted 3 November 2016
Available online 10 November 2016

JEL classification:
D03
D14
D18

Keywords:
Exponential-growth bias
Overconfidence
Financial literacy
Overestimation
Overprecision

ABSTRACT

There is increasing evidence that people underestimate the magnitude of compounding interest. However, if people were aware of their inability to make such calculations they should demand services to ameliorate the consequences of such deficiencies. In a laboratory experiment, we find that people exhibit substantial exponential-growth bias but, more importantly, that they are overconfident in their ability to answer questions that involve exponential growth. They also exhibit overconfidence in their ability to use a spreadsheet to answer these questions. This evidence explains why a market solution to exponential-growth bias has not been forthcoming. Biased individuals have suboptimally low demand for tools and services that could improve their financial decisions.

1. Introduction

> *Chess . . .was invented for the entertainment of a king who regarded it as a training in the art of war. The king was so delighted with the game that he offered the inventor any reward he chose to name. The latter said he only wished to have the amount of corn resulting from placing one grain on the first square, two on the second, and so on, doubling the number for each successive square of the sixty-four. This sum, when calculated, showed a total number of grains expressed by no less than twenty figures, and it became apparent that all the corn in the world would not equal the amount desired. The king thereupon told the inventor that his acuteness in devising such a wish was even more admirable than his talent in inventing [chess].*—A.A. Macdonell, "The Origin and Early History of Chess", *Journal of the Royal Asiatic Society*, January 1898, 30(1): pp. 117–141.

Exponential-growth bias (EGB) refers to the systematic tendency to underestimate compound growth processes (Stango & Zinman, 2009). The passage above highlights the unintuitive difficulty in perceiving exponential growth. But this

☆ We would like to gratefully acknowledge the financial support of a Fletcher Jones Foundation Faculty Research Grant from Claremont Graduate University. We are grateful to Masyita Crystallin, Peiran Jiao, Andrew Royal, Quinn Keefer, and Oliver Curtiss for research assistance. We thank Ananda Ganguly, Matthew Rabin, Paige Skiba, Justin Sydnor, Charles Thomas, Jonathan Zinman, and various seminar participants for helpful comments. Some results in this paper were previously circulated in a working-paper version of "Exponential-Growth Bias and Lifecycle Consumption". Institutional Review Board approval was obtained from OHRPP at UCLA [IRB #12-001092] and CGU [IRB #1591].

* Corresponding author.
E-mail addresses: m.r.levy@lse.ac.uk (M.R. Levy), joshua.tasoff@cgu.edu (J. Tasoff).

http://dx.doi.org/10.1016/j.joep.2016.11.001
0167-4870/

misperception also implicates a second and equally important error; *the king is surprised by the magnitude of his misperception*. We refer to this mistake as overconfidence in exponential estimation, and it is the focus of this paper.

Misperceptions of fundamental financial processes may at first seem to lead to important inefficiencies. However, conventional economic thinking suggests that a well-functioning market should solve this problem. In the same way that people are not fully self-sufficient in modern society but acquire most needs through markets, a person could in principle do the same for their financial decisions. A financially unskilled agent could simply outsource financial decisions to an expert, and a competitive market for advice would eliminate the effect of EGB on financial decisions. But if people are not self-aware of their misperceptions they will exhibit insufficient demand for corrective tools and advice. Thus the presence of overconfidence in exponential estimation is fundamental to the welfare relevance of EGB.

In our experiment, subjects answer questions that involve exponential growth and are paid based on their accuracy. They may obtain either a spreadsheet or the true answer to improve their payment. We obtain incentive-compatible measures of subjects' willingness to pay (WTP) for the spreadsheet and for the correct answer. A risk-averse subject who expects to lose x on a question relative to the maximal earnings should be willing to pay at least x for the correct answer, and strictly more than x if she is strictly risk-averse over the experimental stakes. Any disutility from answering the questions without aid would further increase her WTP.

We find that subjects exhibit a high degree of EGB. We use the model of Levy and Tasoff (2016) to parameterize the accuracy of subjects' perceptions as α, where $\alpha = 1$ implies the person correctly perceives exponential growth and $\alpha = 0$ implies that a person perceives exponential growth as linear. The average α is 0.65 which is slightly higher than the distribution in a representative sample of the population US (Levy & Tasoff, 2016) and represents unawareness of 2/3 of the impact of compounding. Average performance earnings across the control group were \$11.33. Given that maximum earnings were \$25, and the correct answer, barring trembles, guarantees maximum earnings, the optimal average WTP should thus be at least \$13.67. Instead we find that the average WTP for the correct answer is only \$5.70. We construct a normalized measure of overconfidence defined as (Optimal WTP – Actual WTP)/\$25, where the Optimal WTP is defined conservatively as the earnings-maximizing WTP (\$25 – actual earnings without help). This gives us a measure on $[-1,1]$ where 1 signifies that the person earned \$0 without help but believed he would earn the maximum, and -1 signifies that the person earned \$25 without help but believed he would earn \$0. The mean overconfidence is 0.31, and 86% of subjects exhibit overconfidence. Thus overconfidence may act as a significant damper on the market's ability to correct EGB through professional advice. Moreover we find evidence of "illusory superiority" (Kruger & Dunning, 1999), as less skilled individuals—i.e. those with lower α—tend to be the most overconfident. This suggests a pathological selection in the marketplace, whereby the people who need help the most have the lowest demand for it.

Given these findings, one may expect sub-optimally low demand for the spreadsheet as well. Surprisingly, we find the reverse. The spreadsheet had no significant positive impact on subject performance. Consequently, any positive WTP for the spreadsheet indicates a different type of overconfidence: overconfidence in one's ability to use the spreadsheet. The average WTP for the spreadsheet is \$4.59, indicating an average overconfidence in ability to use the spreadsheet of 0.165. We find that 75% of subjects in the spreadsheet group have significant overconfidence in their ability to use the spreadsheet. The experiment shows that people are willing to pay for tools that do not in practice improve their performance. That is, not only does this tool not improve performance, it lowers overall earnings because subjects are willing to pay for it.

Recent work has shown that EGB is widespread and correlated with important financial outcomes. Many psychology and economics papers, beginning with Wagenaar and Sagaria (1975), have shown robust evidence for EGB in the lab (Benzion, Granot, & Yagil, 1992; Eisenstein & Hoch, 2007; Keren, 1983; MacKinnon & Wearing, 1991; McKenzie & Liersch, 2011; Wagenaar & Timmers, 1979). Stango and Zinman (2009) use the 1977 and 1983 Survey of Consumer Finances and find that those with a larger error on a question about interest rates have higher short-term debt to income ratios, lower stock ownership as a percentage of portfolios, lower savings rates, lower net worth, and no difference in long-term debt to income ratios. Goda et al. (2015) measure EGB in a representative sample of the US population and find that about one third are fully biased meaning that they perceive compound interest as simple interest. They find that all else equal, the un-biased type is associated with 40% more retirement savings at retirement age than a fully biased type than a fully biased type, or \$50,000 in absolute terms. It is therefore important to understand the mechanism underpinning the correlation.

While the evidence is mostly correlational, there are reasons to believe that some of these associations are causal in nature. First, theory predicts that EGB can lead to sub-optimally low savings. The model of Stango and Zinman (2009) predicts the correlations found in their empirical analysis, and the lifecycle-consumption model in Levy and Tasoff (2016) predicts that biased people will likely undersave. Second, there is observational evidence that a law designed to curb the negative effects of EGB heterogeneously affected consumers as a function of their bias. Stango and Zinman (2011) find that people who make larger errors on an interest rate question in the Survey of Consumer Finances have higher APR's on their personal loans prior to mandated APR disclosure. Mandated disclosure then compressed the interest rates on the loans of the relatively biased and unbiased people. Regulation seems to have prevented firms from price-discriminating on borrowers' cognitive biases.

These associations require some explanation for why market solutions have not eliminated the problem. This is the first paper to present evidence that people are unaware of exponential-growth bias, and therefore exhibit sub-optimally low demand for financial advice and tools that could improve their financial decisions. Overconfidence is a widespread cognitive bias but not universal. A common finding in the overconfidence literature is that people tend to be overconfident on hard tasks but under-confident on easy tasks (see Moore & Healy, 2008, for a discussion of the literature). Given that both