Time to Nuclear Armageddon[1]

Spencer Graves[1]
[1]Founder, EffectiveDefense.org, 4550 Warwick Blvd 508, Kansas City, MO 64111 USA

Abstract
This work estimates an 11 percent chance of a nuclear war in the next 40 years based on two components: First, it assumes that there have been only two major nuclear crises worth considering: The 1962 Cuban Missile Crisis and the 1983 Soviet nuclear false alarm incident. This gives one observation of 21 years and another censored at 36 years of the distribution of time between such incidents. This leads to an MLE of 57 years for mean time between such incidents assuming a constant exponential distribution. Second, it assumes a beta distribution with parameters 8 and 10 for the probabilities that such incidents would trigger a nuclear war and winter. This beta distribution provides an 80% equal tail confidence interval of (0.3, 0.6) for such probabilities. These numbers seem conservative considering the published literature on those two incidents and other related publications. Details are provided in the Wikiversity articles on "Time to extinction of civilization" and "Time to nuclear Armageddon" as well as the vignette on "Time to nuclear Armageddon" in the `Ecfun` package for R.

Key Words: Survival analysis; nuclear war; nuclear winter; Armageddon

1. Introduction

This work was inspired by Daniel Ellsberg (2017) *The Doomsday Machine* (Bloomsbury). In this book Ellsberg says that as long as the world maintains large nuclear arsenals, it is only a matter of time before there is a nuclear war. He also claims that such a nuclear war would almost certainly lead to a nuclear winter that would last over a decade, during which 98 percent of humanity would starve to death if they did not die of something else sooner.[2]

Ellsberg's claims suggest statistical questions regarding the probability distributions of the time to a nuclear war and the severity of the consequences.

The following outlines a methodology for addressing these statistical questions, reviews relevant literature, mentions other leading figures supporting Ellsberg's claims, and notes that nuclear proliferation is continuing, before outlining future work.

2. Methodology

We suggest here the following methodology:

---

[1] Based on Wikiversity, "Time to nuclear Armageddon", copyright 2019 CC BY-SA 4.0.
[2] Ellsberg, Daniel; Goodman, Amy; González, Juan (2017-12-06), Daniel Ellsberg Reveals He was a Nuclear War Planner, Warns of Nuclear Winter & Global Starvation, Democracy Now, retrieved 2017-12-06.

1. Select a list of incidents.
2. Model the time between such incidents.
3. Estimate subjective probabilities for (a) an essentially equivalent repetition of the each incident on the list leading to a nuclear war, and (b) the distribution of the severity of the consequences of the war. And
4. Combine "2" and "3" into compelling communications.

Someone attacked item number "3" saying, "You, Spencer Graves, are willing to speculate. That's just a rank speculation. I am not willing to speculate."

My response is that an unwillingness to speculate is behaviorally equivalent to saying that the probability is negligible, and I think that is an unrealistic speculation.

This article discusses a prototype use of this methodology considering only two incidents:

(1) The 1962 Cuban Missile Crisis, and
(2) The 1983 Soviet nuclear false alarm incident.

President Kennedy, US President during the Cuban Missile Crisis, said that there was a probability of between a third and a half that that incident would have gone to a nuclear war. He died before learning that Soviet nuclear weapons were in Cuba at that time. The crisis ended less than 48 hours before a planned invasion by the US, predicated on the belief that there were no such weapons in Cuba at that time.[3] At a 30th anniversary conference in 1992, Fidel Castro (Cuban head of state in 1962) told Robert McNamara (US Secretary of State in 1962) that if the US had invaded, those nuclear weapons would have been used, even though Castro knew that not one person on Cuba would have survived.[4]

The 1983 Soviet nuclear false alarm incident occurred when US President Ronald Reagan was building up the US military and challenging the Soviets. Andropov, the Soviet Premier, and his inner circle believed that the US was preparing for a nuclear first attack.

This gives us one observation of t_1 = 21 years of the time between the 1962 Cuban Missile Crisis and the 1983 Soviet nuclear false alarm incident. In addition, the time to the next comparable incident is censored at the t_2 = 36 years between the 1983 Soviet nuclear false alarm incident and 2019, as this is being written. Standard statistical theory says that the likelihood for these two observations is the product of the density at t_1 and the survival function at t_2:

$$L = f(t_1)\ S(t_2).$$

It seems reasonable to assume, at least for an initial demonstration of this methodology, an exponential distribution. This means the likelihood is as follows:

$$L = \exp[\,-\,(\,21 + 36\,)\,/\,\tau\,]\,/\,\tau.$$

[3] Ellsberg (2017, p. 206).
[4] McNamara and Blight (2003, pp. 189-190)

To the extent that this is accurate, it says that the maximum likelihood estimate (MLE) of the mean time to the next comparable nuclear crisis is 21 + 36 divided by 1, which gives 57 years:

$$\hat{\tau} = 57.$$

We can get an equivalent answer by exploiting the well-known duality between exponential and Poisson distributions by considering this history as consisting one Poisson distributed observation on the number of such incidents in each of the 57 years between 1962 and this writing in 2019: We have one such incident in 1983 and 0 in the other 56 years. The likelihood for this formulation is as follows:

$$L = \lambda \exp(-57\,\lambda).$$

This is maximized with $\hat{\lambda} = 1/57 = 0.018$ such incidents per year.

The Poisson formulation is useful, because the `bssm` package for R (programming language) can model a normal random walk of log(Poisson mean). This will not be pursued here but could be useful in future work, either with a larger list of incidents or with nuclear proliferation, discussed below.

3. Relevant Literature

Simon Beard[5] shared a literature review of studies estimating something like the probability of a nuclear war in the next year, summarized in Table 1. He compiled this in joint with Tom Rowe of Virginia Tech and James Fox at the University of Oxford.[6] Beard's analysis is augmented here with the probability of a nuclear war in the 70 years between (a) the first test of a nuclear weapon by the Soviet Union (now Russia) in 1949 and (b) 2019, as this is being written. This uses the fact that if there is a constant probability p of a nuclear war in a given year, the probability of at least one nuclear war in 70 years is $[\,1 - (\,1 - p\,)^{70}\,]$. The upper limit of 7% probability of a nuclear war in the next year (Barrett et al., 2013) is clearly not plausible as a constant probability of a nuclear war each year during that period: Otherwise the probability that we would already have had one is 99%.

It seems useful to highlight the Good Judgment Project (2018), because it uses a methodology developed by a 20-year project funded by the Intelligence Advanced Research Projects Agency (IARPA) and documented in Tetlock and Gardner (2015). Their methodology produced 30% better forecasts than intelligence agents with access to classified information. It is as follows:

1. Recruit volunteers and ask them a series of forecasting questions, like estimating the probability of a certain event in a specific time period (typically 1, 2 or 3 years).
2. Identify the volunteers with the best forecasts.
3. Organize them in teams.
4. Study what the best teams did.

---

[5] Academic Programme Manager and Senior Research Associate, Centre for the Study of Existential Risk, University of Cambridge

[6] Cited from private communication from Simon Beard. Used with permission.

The result is documented in Tetlock and Gardner (2015). This methodology might potentially be crowdsourced on Wikimedia Foundation projects like Wikipedia, Wikiversity, and Wikidata.

Table 1: Summary of Literature Estimating the Probability of a Nuclear War

Source	Probability of a nuclear war			
	annualized		in 70 years	
	lower	upper	lower	upper
Hellman (2008)	0.02%	0.5%	1%	30%
Barrett et al. (2013)	0.0001%	7%	0.007%	99%
Lundgren (2013)	1.4%		63%	
Project for the Study of the 21st Century (2015)	0.3%		18%	
Good Judgment Project (2018)	0.7%		40%	
Turchin (2008)	0.5%		30%	
Pamlin and Armstrong (2015)[7]	0.1%		7%	
Sandberg and Bostrom (2008)[8]	0.4%		25%	

4. Other leading figures supporting Ellsberg's claims

Ellsberg is not alone in his concern about this. Robert McNamara also said that as long as the world has large nuclear arsenals, it's only a question of time before there is a nuclear war.[9] Similar concerns led former US Senator Sam Nunn and media executive Ted Turner to found the Nuclear Threat Initiative, also supported by former US Secretary of Defense William J. Perry, and former US Secretaries of State Henry Kissinger and George Schultz.

Atmospheric scientists Owen Toon, Alan Robock et al. (2017) have estimated that a relatively minor nuclear war between India and Pakistan would likely involve at least 100 nuclear weapons, leading to a nuclear autumn during which two billion people not involved in the nuclear exchange would starve to death.

[7] On p. 16 of 212 they wrote, “The likelihood of a full-scale nuclear war between the USA and Russia has probably decreased. Still, the potential for deliberate or accidental nuclear conflict has not been removed, with some estimates putting the risk in the next century or so at around 10%”. This makes the risk in 1 year of [1-.9^(1/100)] = 0.001053, and the risk in 70 years = 0.071, ignoring their comment that “The likelihood ... has probably decreased” and ignoring the chances of a nuclear war involving other nuclear weapons diads. Later, they write, “Based on available assessments the best current estimate for nuclear war within the next 100 years is 5% for infinite threshold [and] 0.005% for infinite impact” (p. 148).

[8] On their p. # 1 (p. 2 of 6 in the pdf), they reported a 30% chance of “at least 1 million dead” “total killed in all nuclear wars” by 2100 from 2008.

[9] McNamara and Blight (2003).

A hundred nuclear weapons is only about 2 percent of the US nuclear arsenal. A nuclear war involving the US would likely be closer to Ellsberg's doomsday scenario than the two billion dead mentioned by Toon, Robock et al. (2017).

5. Nuclear Proliferation

The fact that nuclear proliferation is continuing suggests that any model that assumes that the risk of a nuclear war is constant or declining is probably wrong; see the accompanying figure.

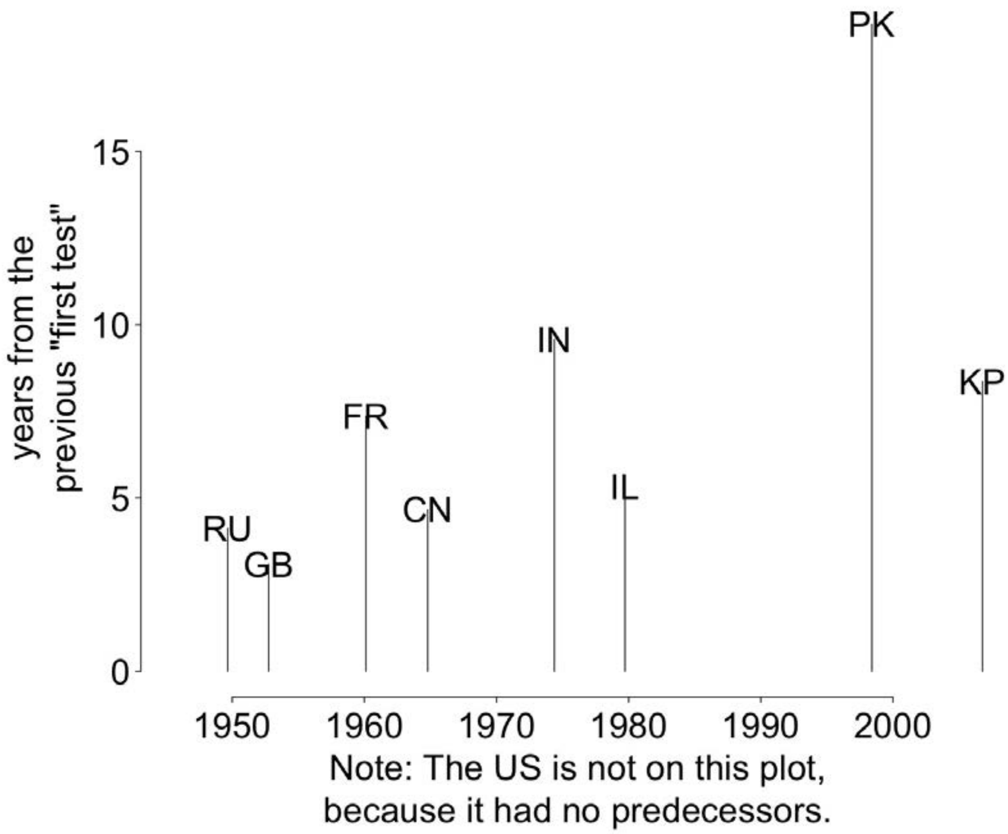

Figure 1: Time between New Nuclear Weapon States. RU = Russia (the USSR in 1949). GB = United Kingdom. FR = France. CN = China. IN = India. IL = Israel, recorded here with the date of the Vela Incident. PK = Pakistan. KP = North Korea.

When the Nonproliferation Treaty treaty took effect in 1970, there were 5 nuclear weapon states. When US President George W. Bush announced an “axis of evil” consisting of North Korea, Iran and Iraq on 2002-01-28, there were 8. As this is being written in 2019, there are 9; see the accompanying Table 2.

As long as nuclear weapon states continue to threaten countries without them, the pressure for nuclear proliferation will continue, and the risks of a nuclear war will likely grow.

Table 2: Nuclear Proliferation: Number of nuclear weapon states when the Non-Proliferation Treaty took effect, when US President George W. Bush condemned an "Axis of Evil", and today.

year	number of nuclear-weapon states	event
1970	5	Non-Proliferation Treaty Effective
2002	8	Speech identifying North Korea, Iran and Iraq as an "Axis of Evil"
2006-	9	North Korea's first nuclear test

6. Future Work

It should be relatively easy to use the `bssm` package for the R (programming language) to model a random walk in the log(Poisson mean) of the number of first-tests of new nuclear-weapon states each year.

Beyond this, it could be useful to try to crowdsource assessments for a larger list of incidents threatening nuclear war using Wikimedia Foundation projects, especially Wikipedia, Wikiversity, and Wikidata.

Stanford Engineering Professor Emeritus Martin Hellman has estimated that the probability is at least 10 percent that a child born today would die prematurely from a nuclear war.[10] It would be useful to write an R function to convert probability distributions generated by these kinds of models into estimates of the probability that a person of any age, especially a child born today, would die prematurely from a nuclear war: This could make it easier to translate estimates of the probability distributions considered here into terms that most people could more easily understand and relate to their own lives.

Acknowledgements

The author wishes to thank Simon Beard for the literature review summarized in Table 1.

References

Anthony M. Barrett; Seth Baum; Kelly Hostetler (May 2013) "Analyzing and Reducing the Risks of Inadvertent Nuclear War Between the United States and Russia", *Science and Global Security*, 21 (2).[11]

Simon Beard (15 September 2017), "Less Hollywood, More Car Crash", Centre for Research in the Arts, Social Sciences and Humanities, University of Cambridge.

Christine Blackman (17 July 2009), "Chance of nuclear war is greater than you think: Stanford engineer makes risk analysis", *Stanford News*.

Daniel Ellsberg (2017) *The Doomsday Machine: Confessions of a Nuclear War Planner, Bloomsbury Publishing* (Bloomsbury Publishing).

Good Judgment Project (2018): nonpublic data, cited in comment 2018-08-06 by Carl Shulman to Rhys Lindmark (6 August 2018), "Current Estimates for Likelihood of X-Risk?", *Effective Altruism Forum*.

[10] Blackman (2009).

[11] Hyperlinks accessed 2019-08-16.

Martin Edward Hellman (May 2008) "Risk Analysis of Nuclear Deterrence", *The Bent of Tau Beta Pi*.

Carl Lundgren (27 June 2013) "What are the odds? Assessing the probability of a nuclear war", *Nonproliferation Review*, 20 (2): 361–374.[12]

Robert McNamara; James G. Blight (2003), Wilson's ghost: reducing the risk of conflict, killing, and catastrophe in the 21st century (PublicAffairs).

Experts see rising risk of nuclear war: survey, *Project for the Study of the 21st Century*, 12 November 2015.

Dennis Pamlin; Stuart Armstrong (2015) *Global Challenges: 12 Risks that Threaten Human Civilisation*, Global Challenges Foundation.

Anders Sandberg; Nick Bostrom (2008) *Global Catastrophic Risks Survey*.

Philip E. Tetlock; Dan Gardner (2015) *Superforecasting: The art and science of prediction* (Crown).

Owen B. Toon; Alan Robock; Michael Mills; Lili Xia (May 2017) "Asia Treads the Nuclear Path, Unaware That Self-Assured Destruction Would Result from Nuclear War", *The Journal of Asian Studies*, 76 (02): 437–456, doi:10.1017/S0021911817000080.

Alexei V. Turchin (2010) *Structure of the global catastrophe. Risks of human extinction in the XXI century* (Lulu.com).

[12] Cited from Beard (2017).