SURVIVAL, EXTINCTION, AND THE FUTURE OF HUMANITY

Even far-sighted reflections on human activities tend to look only a century or two ahead. In this thesis, however, I will focus on the prospects for humanity's long-term survival or extinction. I will consider the questions of what our survival might require, and whether 'we' might meaningfully survive even if the species *Homo sapiens* becomes extinct. I will argue that our extinction is extremely likely in the long-term if we remain confined to Earth, and I will claim that some form of interstellar expansion is likely to offer humanity's descendant potentially billions of further years of survival. Finally, I consider whether the Fermi Paradox casts doubt on whether such expansion is even possible.

PART ONE: WHAT ARE EXTINCTION AND SURVIVAL?

In part one of the thesis, I consider a range of theories concerning what 'our' survival would entail. I argue that this need not be confined to the survival of the species *Homo sapiens*, but might meaningfully be extended to our distant evolutionary descendants.

(1) Strict biological survival: the only meaningful criterion for our extinction is the extinction of the species *Homo sapiens*.

Problems: highly chauvinistic; relies on vague species concepts; counterintuitive insofar as it neglects possible evolutionary or technological developments of humanity.

(2) Genetic survival: we will partially survive as long as there are biological individuals who share our genetic material.

Problems: chauvinistic (failing to consider non-biological descendants such as uploaded minds) and excessively liberal (if our sole surviving ancestors were slime moulds, we would surely not have survived).

(3) Cultural survival: we will survive if a civilisation exists that is culturally continuous with our own.

Problems: excessively liberal (if some of our cultural values were embraced by extra-terrestrials shortly before the termination of our civilisation, we would not survive). Perhaps chauvinistic (why should cultural continuity rather than mere cultural similarity matter?)

(4) Similarity not survival: there is no special moral status to the survival of our civilisation. All that matters is, e.g., the proliferation of beings relevantly like us throughout the universe.

Problems: arguably counterintuitive; additionally, makes many moral questions (such as whether we should expand to other planets) dependent on how widespread intelligent life is in the universe.

PART TWO: PROSPECTS FOR EXTINCTION AND SURVIVAL

In part two of the thesis I make three claims concerning the future of humanity and its descendants. The conclusion of these three claims is that humanity can realistically hope to avoid extinction in medium-term if it expands to other worlds.

(1) The short-term survival claim: excepting drastic and unprecedented shocks, there is little prospect of human extinction within the next few centuries.

Evidence: The human population is extremely large and occupies a range of ecosystems. Additionally, technological and cultural knowledge is increasingly widely distributed, allowing rapid recovery from disasters. Our ability to predict and avert extreme events (such as large bolide impacts or catastrophic climate change) is improving. Unpredictable events are either relatively unlikely (e.g., global thermonuclear war, gamma ray bursts) or insufficiently lethal to pose a serious extinction threat (e.g., localised nuclear conflicts, pandemics).

(2) The medium-term extinction claim: if humans and their descendants remain confined to Earth, then the likelihood of survival drops away drastically over time.

Evidence: A single unpredictable disaster (e.g., a super volcano) might cause widespread death, destruction, and breakdown of some civil institutions, thereby making it difficult to predict or respond to a second disaster (e.g., a large bolide impact). Such a 'double whammy', although unlikely, becomes probable on a sufficiently long timescale. Additionally, on long enough timescales, Earth will become effectively uninhabitable: within a few billion years, the slowing down of tectonic processes will disrupt the geological carbon cycle and make photosynthesis impossible, while increasing solar luminosity will eliminate liquid water on Earth.

(3) Long-term survival claim: if our civilisation spread to multiple worlds, the likelihood of extinction would drop off drastically. Assuming we could rebuild or replace devastated worlds within a few thousand years, only extinction events on an interstellar scale could wipe out our entire civilisation. There are very few such events, and they seemingly offer only limited risks; for example, although supernovae are highly destructive events, they are both relatively rare and would pose extinction risks only to civilisations exclusively habiting systems very close to the supernova itself. Finally, star formation is expected to continue for at least another 100 trillion years. Even if our galaxy becomes uninhabitable long before this, interstellar civilisations including our own might be able to survive for several orders of magnitude longer than the lifetimes of individual stars.

PART THREE: MECHANISMS FOR SURVIVAL

In part three of the thesis, I argue that if we accept the claims in part two, we should endeavour to prevent our extinction. These steps depend on which the account of survival is adopted.

(1) Biological and genetic survival: could be achieved by directly settling other planets. The distances involved are immense, thus necessitating either large or technologically sophisticated craft, e.g., generational vessels, sleeper ships, or probes that carried frozen zygotes to other habitable systems to be gestated on arrival and raised by AIs.

(2) Cultural survival: could be achieved either by settling other worlds using artificial intelligences that shared our culture and values. The potentially robust nature of AIs would dramatically expand the range of habitable systems and worlds and eliminate the need for elaborate life support systems. Alternatively, we could simply broadcast our culture to other stars and hope someone is listening.

(3) Similarity not survival: if life in the universe is abundant and there is good reason to think that civilisations will come into resource conflict, then we would have little reason to expand. If life is rare, however, then we have independent reason to pursue the above courses of action.

PART FOUR: SURVIVAL AND THE FERMI PARADOX

In the final section I examine the Fermi Paradox and its relation to interstellar expansion and extinction. In particular, I consider if the absence of evidence of interstellar civilisations should make us conclude that interstellar expansion is improbable. I present the following formulation of the Fermi Paradox

(1) Galaxies typically foster multiple intelligent civilisations.

(2) Some civilisations will be able and inclined to expand to other systems via interstellar travel.

(3) The odds of extinction events decrease dramatically as interplanetary societies expand to other stars. **(4)** Such civilisations are likely to continue to expand indefinitely.

(5) The timescales required for interstellar expansion are brief compared to the lifetimes of galaxies.

On these assumptions, galaxies will quickly be heavily or completely colonised by one or more civilisations in their lifetimes. That this has apparently not occurred suggests one of the premises is false. I consider a range of scenarios and argue that premise (4) is the most likely to be false. Specifically, I claim that civilisations may tend to follow a single course from a biological stage to a technological stage in which all individuals are artificial intelligences. This may naturally

disincentivise widespread expansion. However, this would need to be a ubiquitous trend; otherwise, even one highly expansionist biological civilisation could swamp the galaxy, and this has seemingly not occurred.