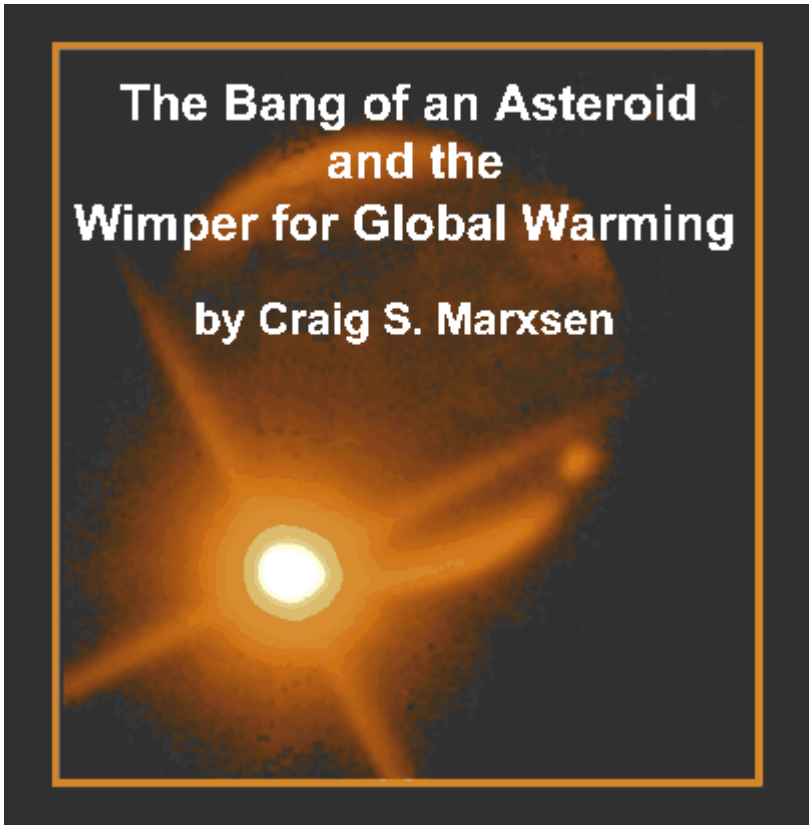


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## Abstract

The asteroid and comet impact peril appears to be, in several respects, more momentous than environmental hazards such as global warming. Building on Gregory Canavan's analysis that he derived from impact frequency data, an estimate in the order of $40 billion is obtainable as the present value of the risk from cosmic impactors. Presently contemplated strategies to reduce the human carnage from a large impactor instill little confidence. The present value of probability adjusted damage from extinction level impactors dwarfs the present value of potential losses from other environmental disasters when, as Martin

Weitzman urges, the lowest possible discount rate is used for distant future losses. Separating extinction level threats from the ordinary analytics of risks in general also implies domination by the asteroid threat over threats such as the greenhouse effect from anthropogenic carbon dioxide. Declining performance in space launch activities accompanies productivity growth stagnation in the U.S. economy. Economic growth and technological progress seem most urgently mandated in response to cosmic collision fears that probably should gain greater priority relative to fear of greenhouse warming. The impact peril gains inadequate attention because it fails to offer the kind of rent seeking opportunities that abound from global warming fears.

## Introduction

U. S. Representative Dana Rohrabacher (R-California), Chair of the Space and Aeronautics Subcommittee of the House Science Committee, has claimed that the danger of impacts from space objects such as asteroids and comets is greater than the threat posed by global warming (Bates, Jason, 2002). The representative suggested that some of the money we spend on global warming research should fund increases in efforts to locate and track space objects instead. In concert with David Morrison, Edward Teller, a mastermind of the first hydrogen bomb, has advocated experimental space missions dedicated to improving mankind's ability to nuke a would be impactor off its collision course (Morrison and Teller, 1994, pp. 1135-1143). Murray Weidenbaum (1998, p. 71) reported that the United States government was spending about $2 billion annually on climate change research. A 2003 report from The Independent Institute (p. 12) explained that, at the time of its publication, the proposed U.S. federal budget for research on global environmental change was an annual $4.2 billion. Meanwhile, during 2004, NASA devoted just $3.5 million (not billion!) of its annual budget to searching for asteroids greater than 1 kilometer in diameter, which might threaten the destruction of civilization, according to Robert Roy Britt (2004).

T. S. Eliot ("The Hollow Men," 1925) wrote, "This is the way the world ends: not with a bang but a whimper" (Yeats, 1937, p. 285). Richard Posner (2004) devotes a book to catastrophes that threaten the human race. He respects the peril of the bang of a big cosmic impactor but adds still other threats that might send most of us whimpering to our deaths. Posner discusses the prospect of runaway greenhouse warming and fears bio-terrorists and nanomachines, for example, and he raises issues concerning civil liberties. In October of 2002, *The Times Higher Education Supplement* (p. 18) featured a special section titled "How Will the World End?" In it, John Leslie explained several hypotheses including run-away global warming that might conceivably raise the earth's average temperature to the boiling point of water. The mechanism by which a run-away buildup of carbon dioxide might occur is reminiscent of George Woodwell's theory (Woodwell, 2001, p. 30) that holds that warming could thaw out much frozen organic material that would consequently

rot and release its carbon massively into the atmosphere in a sort of chain reaction. However, snowfall or clouds offer an unknown potential to stop such a process cold.

Many human extinction-level catastrophes, including runaway greenhouse warming, fall within the category of imaginable and yet hypothetical disasters that history has never actually demonstrated. None of them has ever seemed nearly as threatening as a nuclear war that might completely annihilate humankind some day, although it might just turn out to be a very devastating, but not extinction level, event. Conceivably, we risk invasion by beings from outer space as in H. G. Wells' "The War of the Worlds." An incredible disease might wipe out humanity – a designer disease deliberately created, as Posner reasons, by some malevolent sociopath similar to the people who create computer viruses. It is conceivable that a predatory human subspecies (e.g., the Morlocks of Wells' "The Time Machine") might arise from our own numbers and displace humankind as we know it. Mutant animals might take over the earth after some malevolent experimenting with genetic engineering, or new strains of venomous insects might arise (e.g., killer bees). A new ice age might spontaneously begin suddenly. Computers of the future might take over the earth and extinguish humankind.

The previously mentioned section of *The Times Higher Education Supplement* also features Aisling Irwin discussing a number of possible doomsday scenarios in addition to asteroid impact: wandering black holes, gamma-ray bursts, and several other sci-fi tantalizers. Rather than quoting T.S. Eliot, Irwin starts his essay by summarizing the apocalyptic vision found in "The Revelation" in the *Bible*. The *Bible* passages Irwin summarizes suggest not a whimper but a bang rather, and they, in fact, seem to describe the details of asteroid impact catastrophe rather well. Indeed, a casual search of the Internet reveals numerous evangelical writers promoting the theme that The Revelation in the *Bible* is foretelling a cosmic impact event and a great tribulation to follow. To name just a few, these include Larry W. Wilson, William D. Brehm, Dr. Ernest L. Martin, and David Hughes, all of whom have posted literally thrilling materials on this topic. Asteroid impact differs from threats such as the others just mentioned, including global warming, in that past catastrophic impacts are written all over the landscape of both the earth and the moon, and they are inevitable over long time horizons, while the prospect and significance of the other threats, including global warming, remains scientifically speculative.

Certain key justifications for giving inordinate attention to global warming include arguments in favor of near zero discount rates for assessing such distant future perils and organicist preoccupation with events that could threaten the continuation of the human species. Both of these lines of thought suggest that cosmic impact fears should trump society's preoccupation with global warming. However, global warming prevention offers manifold opportunities for exploitation by rent seekers who can grasp it as a tool for limiting entry of competitors into

economically concentrated industries, much as described by George Stigler (1971). Cosmic impact protection requires no such provision of contrived monopoly power and fails, therefore, to pick up the support of a multitude of rent seekers like those who support global warming prevention, and in fact, environmental protection in general.

This paper focuses on asteroid and comet impacts, comparing their implied policy imperative with motivations to mitigate global warming risks. After discussing Gregory Canavan's approach to placing a dollar value on the impact peril, the paper looks at our prospects for mitigating a future impact catastrophe and then finishes by reflecting on the political economy of such collective action. It closes with the thought that economic stagnation may effectively set the stage for our nemesis, with our misplaced policy emphasis being part of the root cause of our thus fatal stagnation.

# Asteroid Impact: History and Risk

The harm that might result from global warming is hypothetical and subject to uncertainty. In contrast, history tells us what sort of damage big meteorites can do. The National Geographic Society features Eugene and Carolyn Shoemaker and David Morrison in a video titled "Asteroids: Deadly Impact," that recently became available on a DVD disk (2003, NGT, Inc.) and provides an outstanding account of recent breakthrough discoveries concerning the power of cosmic impactors. Hazel Muir (2001, p. 42) reports that an individual living today faces about the same probability of dying because an asteroid or comet hits the earth as from dying due to a passenger aircraft crash – about 1 in 20,000. About sixty-five million years ago, an asteroid impact near Chicxulub on the Yucatan Peninsula evidently caused the extinction of the dinosaurs as it left its signs of arrival imbedded in the Cretaceous/Tertiary, or K/T, boundary layer known well to paleontologists (Smit, 1994, p. 859). The K/T impactor, probably about the size of Halley's comet (about 10 km), caused a global firestorm, darkened the entire planet for a number of months, lethally changed ocean chemistry and brought about a general collapse of terrestrial ecosystems (Morrison, 1994, pp. 60-65). David Morrison (1995, p. 37) reports that the object caused an explosion on impact that had "…an astounding energy equivalent to more than five billion Hiroshima atomic bombs (100 million megatons)." When much smaller fragment G of Comet Shoemaker-Levy struck Jupiter in July of 1994, it produced a fireball that, in some photos, looked larger than the whole earth (NASA has many photos posted on its website). Fiery plumes of debris that reached 5,000 Kelvin splashed down over areas clearly larger than the earth when some of the Shoemaker-Levy fragments struck (Cowen, 1996). Smaller impactors, that explode with the power of an atomic bomb, strike the earth frequently enough to occur within an average person's lifetime. Large impactors approaching the destructiveness of the K/T impactor come every few million years. However, the number of deaths from such events argues for taking the threat very seriously in spite of the low probability of a huge impactor arriving anytime soon.

Following traditions established within the "dismal science," considering a methodical estimate of the value of losses from impending cosmic collisions helps bring this threat into perspective relative to other threats. While some dollar equivalent estimates of warming damage are now well-known, global warming theories seldom posit potential loss of life as their unit of measurement of harm. In dollar terms, the global expected value of all future expected cosmic impacts is perhaps in the neighborhood of $40 billion presently. Gregory Canavan (1994) used impact frequency data to derive an annual expected value of economic loss from meteor, asteroid, and comet hits on the earth. Canavan summed the probabilities of hits, during any particular year, times a crude estimate of the economic value of the lost output impacts might cause. Using impact energy models, Canavan estimated the radius of destruction around hypothetical impacts by objects of various sizes. He then calculated the area of destruction as a fraction of the area of the surface of the entire earth. Canavan multiplied this fraction times gross world product (GWP was about $20 trillion at the time when his figures were current) and then multiplied the result times twenty. Thus, an impactor that would destroy ten percent of the surface of the earth would cost humankind ten percent of that year's GWP every year thereafter, perpetually, because ten percent of the world's resources would have been presumably lost utterly to the impact. He obtained the factor of twenty by reasoning that the present value of a perpetual annuity paying a five percent real rate of interest would equal twenty times the annuity's annual payment. Moreover, the five percent real discount rate seems appropriate for getting the present value of losses of the kind we are considering.

An additional sum accrues for the damage probable from tsunamis likely from ocean hits by intermediate size objects ranging from 200 meters to 2 kilometers in size (pp. 1165-1167). Canavan's probability derived loss estimate totaled $514 million per year where small objects contribute $9 million, intermediate objects, $105 million ($5 million from land impacts; $100 million from tsunamis from ocean impacts), and $400 million from large (greater than 2 kilometer) object impacts (p. 1169). Canavan obtained a comparatively small estimate of $400 million for the probability-adjusted damage from a large space object hit by assuming that people would detect the object well in advance of its arrival. Time would permit, he reasoned, provisioning shelters and evacuating populations into such shelters to subsist through the duration of the otherwise lethal climatic perturbations (p. 1167). To assume otherwise confronts humankind with an extinction level, essentially infinite loss multiplied by a virtually infinitesimal probability, giving a presumably incomprehensible result, he reasons (p. 1167). At $400 million, the expected loss from large object impacts dominates the loss equation. Canavan thus concluded that, during a single year, the expected loss from impactor hits during that year was $514 million at a time when the whole world was producing a gross world product of $20 trillion.

We can use Canavan's five percent perpetual annuity rate to estimate that the present value of the damage from hits by all the impactors that will ever hit

the earth between the present time and the far-distant future. It would be 20 times $514 million or $10.28 billion, assuming (unrealistically) that GWP remains constant at $20 trillion per year from now on. A present value of $24.16 billion would be appropriate for a GWP of $47 trillion that would be near the GWP prevailing at the beginning of the 21st century. We should decrease the annuity discount rate to three percent in order to approximate the present value for GWP growing at two percent per year from now on, resulting in a present value 33.3 times the annual figure rather than twenty times it; producing $40.22 billion for a world with $47 trillion GWP today. We are implicitly discounting at a five percent real interest rate (the three percent figure comes from two percent growth offsetting two percentage points of the five percent) a sequence of future catastrophes that periodically might almost completely wipe out human civilization repeatedly in the future, if we look forward far enough. Thus, Canavan's probabilistic approach leads to $40.22 billion as an estimate of the probability adjusted, discounted present value of the economic impact of these cosmic cannon balls.

Canavan, having obtained a result similar to estimates of the value of risks that insurance companies deal with, proceeds toward weighing marginal costs against marginal benefits. Stopping short of that inquiry, let us examine several issues that might challenge whatever comfort this relatively modest estimate invokes. First, Canavan's assumption that large impactors will fail to make an end of us because humankind will retreat to well-provisioned shelters seems questionable. Second, criticism of discounting future catastrophe, refined within debates that have raged over other threats such as future global warming damage, applies equally well to analysis of the impact peril. Third, is it reasonable to attach a dollar value to events endangering the survival of the human species, per se? Fourth, the ability to divert or destroy an incoming impactor is path dependent, varying substantially with the extent of economic growth or stagnation that precedes it. Natural disasters that fall short of the extinction level might actually stimulate economic growth and thus prove less costly than the present value of a full return to the lost capital might suggest. Little impactor disasters might save us from the big one.

# Sheltering

First, consider how reasonable Canavan's assumption regarding sheltering might be if we seek a damage estimate to compare with global warming damage. The next giant impactor might arrive with little or no warning at all and assuming shelters assumes away the greatest part of the problem! Any costs of building needed dikes and levees generally add to estimated major financial losses attributable to global warming itself. Moreover, in the global warming debate, we never seem to assume, for example, that Bangladesh will landfill to elevate above the hypothetical rising seas and thereby blunt the harm from warming. No one seems to argue that society will barge its garbage to Antarctica to spread it as insulation over the ice cap and thus prevent a polar

melting from raising sea levels. Canavan should not be so generous to opponents of impact prevention spending.

Would shelters withstand a very large impactor? Striking the earth to its more fluid core, a large enough object might destroy people taking refuge in even the sturdiest caves and caverns, since the greatest mountains might bounce and crumble from an earthquake exceedingly greater than any previously known to man. Yet, Canavan, necessarily confining the scope of his paper, provided no in-depth analysis of human prospects for surviving a large impactor by sheltering on the earth's surface – an issue that seemingly remains open. The September 11, 2001 collapse of the World Trade Center illustrated what the imagination had failed to visualize. Once the tops of the great buildings had fallen downward just a couple feet, their momentum pulverized the entirety of the concrete and steel twin-tower structure beneath them as if it were stale gingerbread or rotten plaster under gigantic falling anvils.

While the K/T impactor was about ten kilometers wide, the Hale-Bopp comet is about forty kilometers, making it a spectacular sight in the night sky whenever it passes near the earth, going extra fast as such long-period comets do. Hale-Bopp would be a truly spectacular impactor were it ever to return from its cosmic pinball machine orbit on a collision course with earth! David Morrison (1994, P. 78) explains that comets larger than 100 kilometers are known to exist and, as impactors, might kill literally everyone on the earth. Vitaly Adushkin and Ivan Nemchinov (1994, pp. 749-752) analyze the magnitude of seismic disturbances that would propagate from an impact site, scaling known effects measured from underground nuclear blasts. The K/T impactor, they reason, probably had impact energy equivalent to about $6 \times 10^7$ Mt or megatons of TNT (1994, p. 722). Since Adushkin and Nemchinov (1994, p. 750) calculate that impact energy between $10^5$ Mt and $10^6$ Mt would produce an earthquake that would register M = 9 on the Gutenberg-Richter scale over a 1000 kilometer radius around the impact, the K/T impactor must have produced a seismic disturbance far in excess of any earthquake ever experienced in human history. An earthquake measuring M = 8.5 on the Gutenberg-Richter scale in China in 1920 resulted in 100,000 deaths in a 600 km radius of destruction, while earthquakes with M > 9 have never been measured during the $20^{th}$ century, according to Adushkin and Nemchinov (1994, p. 750). Every mountain and island might have moved out of its place when the K/T impactor struck; when ejecta rained like stars seeming to fall from heaven and the sky, to all appearances, subsequently receded like a scroll rolling up.

# Discounting

Should we really discount future expected damage at a five percent real interest rate? Martin L. Weitzman (1998) attempts to justify near zero discount rates for discounting costs anticipated in the "far-distant future," without rejecting the customarily higher rates for discounting costs coming in the near future.

“Costs,” in the case of catastrophic impacts, means the value of damage that they would do, although Weitzman does not address the asteroid problem explicitly. Professor Weitzman develops a seemingly rigorous mathematical proof of the validity of minimal discount rates for the very long run -- a time frame that seems implicitly cosmological as Weitzman takes limits as t approaches infinity. Weitzman reasons that all but the lowest possible discount rates discount away their own probability's present values from an expected return function. Looking through eternity, only the lowest conceivable ultimate discount rate could have a nonzero discounted probability at the present. Weitzman relates his conclusion to environmental policies. Professor Weitzman explains that, with customary discount rates, "the logic of exponential discounting forces us to say that what we might otherwise conceptualize as monumental events 'do not much matter' when they occur in future centuries or millennia.” (p. 201). He cites examples including global warming, loss of biodiversity, and groundwater pollution (p. 201). He says his paper relates to very long-term projects under uncertainty such as ameliorating global warming (p. 207). His paper should bias our "choice of policy instruments and levels of stringency as if toward what is optimal for the low-interest-rate scenario," he reasons (p. 207). Weitzman is explicitly arguing that we should not assign to problems global warming might cause decades or even centuries from now a negligible present value today. We should spend lots now to prevent the warming. However, a neglected extinction level cosmic impact becomes a virtual certainty if we look far enough into the future and, applying Weitzman’s principle, ignoring it today is almost infinitely costly in a present value sense. Weitzman’s present value principle applied to asteroid and comet impacts mandates that spending to prepare should dwarf whatever we find prudent to spend on global warming prevention! Some day an extinction level impactor will arrive and, with no interdiction, the losses will be immensely larger than any losses seriously anticipated from global warming. Using the lowest possible discount rate largely neutralizes the significance of every expectation that warming will likely occur sooner than any catastrophic asteroid or comet impact.

If one has a time preference tilted not at all toward the present, then discounting far distant future losses at near zero rates still ordinarily clashes with the expectation that small amounts of resources committed today, for use in the distant future, can grow at compound interest well above a zero rate, if invested wisely. A few dollars invested today can grow to become a multi-billion dollar defense fund centuries from now – even many trillions of dollars can accumulate in such a fund by the more distant future. The capital market continually selects activities and projects forming capital that promises a competitive and positive rate of return under presently perceived circumstances. The most general defense against unknown disasters of the future is probably economic growth. Economic growth, for example, raises one nation’s GDP above another’s, slanting the odds concerning which nation would win in a military conflict. However, Weitzman’s analysis logically dismisses all but the future’s most stagnant scenarios, so that the return to capital must be virtually zero in the far

distant future, because he discounts away the present value of the probability of every future scenario that exhibits a positive return to incremental capital accumulation. Weitzman leaves us a reversal of a familiar enigma. If one's time preference has no tilt toward the present, then Weitzman offers, a priory, a probable eternal stagnation to avoid contradiction by any positive marginal productivity of capital. Weitzman is appropriate for analysis here because he characterizes environmentalists opposed to discounting on grounds that it threatens to trivialize the global warming threat that is only a long run problem. While, unlike global warming, a big meteorite can drop in suddenly tomorrow, it too becomes more likely as the far distant future unfolds.

# Use of Benefit-Cost Analysis

Some environmentalists challenge the idea of attaching a dollar value to true global human catastrophe. In the November 1994 issue of *Land Economics*, Michael A. Toman clarified the concept of sustainability, explaining that many ecologists and some economists have abandoned "neoclassical presentism" in favor of "ecological organicism." As Toman elaborates the distinction, an ecological organicist emphasizes the survival of the human species and fears the irreversible pollution induced degradation of the environmental life support system sustaining the species. Ecological organicists lead us to thinking that cost benefit comparisons are inappropriate when pursuing sustainability since no conceivable magnitude of material benefits could possibly compensate for loss of the human species. Organicists likewise reject discounting, noting that the present value of such catastrophe is immeasurable and not meaningful. Toman nearly captures the idea concisely when he writes, "Proponents of a safe minimum standard argue that, with low information but high potential asymmetry in the loss function, the evenhanded assessment of benefit-cost analysis should give way to a greater presumption in favor of species preservation unless society judges that the cost of preservation is intolerable" (pp 406-7). Toman writes in the context of a standard of environmental cleanliness. Ironically, the dinosaurs probably exercised exemplary harmlessness to an environment they fit in perfect natural harmony, until the day the impactor arrived!

Ecological organicists have locked on to the almost certainly remote chance that anthropogenic pollution might ultimately make the earth uninhabitable for humankind, while they forget that extinction-level impactors, in contrast, are very certainly coming. Morrison (1994, P. 71) explains that extinction level impacts visit the earth about once every 100 million years. If humankind fails to intervene, an asteroid will surely destroy us all eventually, given enough time, unless something else destroys us first, instead.

The conceivable threats to species survival perhaps add up to an alarming total in number – maybe even an infinite total since there is no real limit to human imagination. Yet, the probability of any one in particular, global warming, for instance, is likely small among the total. We do not want to expend our

resources preventing global warming only to discover that our actual demise is fated to be from alien invasion from outer space. We must diversify our defenses, providing some against this peril and some against that peril, remembering that a budget constraint applies just as it does to problems that are more mundane. If the object is to gain the greatest protection against loss of the human species, in the face of uncertainty, we must admit that we do not know exactly which threat will actually overtake us and which will end up just frightening us as the specter of the possible (but improbable) so often does. As we ponder dissipating our capital among prophylactic measures to head off global warming, annihilating bio-terrorism, killer smog, and other threats to the survival of our species, we must recall that the French built the Maginot Line, expending their resources based on a faulty assessment of their prospective confrontation. When World War II came, they had so committed their resources to a false vision of the future that they had no flexibility to meet the real threat as it actually arrived. Likewise, humankind does not know the precise nature of the true terrors that wait in even the next century. Squandering resources obsessively against a false threat can help bring the human species to the nemesis it is attempting to avoid. Ultimately, if all the other unsubstantiated doomsday horrors fail to materialize, the asteroid or comet destined to hit us will yet arrive; it is just a question of when.

## The Wrong Stuff and Where We Stand

We do not know if warming is coming, or when, or if it would be good or bad. Meanwhile, public perception of low probabilities greatly restrains political action to thwart the peril from cosmic impactors. Jason Bates (2002) reported that, as of the summer of 2002, NASA was spending about $4 million per year to track space objects greater than 1 kilometer in size, but was not tracking smaller, yet still quite dangerous objects. As a matter of fact, David Chandler (2002) reported that NASA completed a radar tracking and computer projection of the course of Asteroid 1950 DA – an asteroid that is about 1.1 kilometer in diameter. The computer projection showed that this asteroid will strike the earth on March 16, 2880. It will cause very widespread devastation when it does, unless we somehow prevent it from hitting us (Chandler, 2002, p. 44). Chandler explained that, as such computer projections go, this one had a very high probability of being right – one in 300 (Chandler, 2002, p. 44). Asteroid 1950 DA was, at the time, the most menacing of all known asteroids and we were fortunate to have detected the peril while plenty of time remains to do something about it.

Destroying or deflecting the course of an incoming asteroid before its arrival requires knowing that it is coming. In the interest of promoting economic growth, governments could create incentive for private efforts to detect such threats rather than taking the responsibility for detection entirely upon themselves. They could devise a schedule of bounties or rewards for discovering objects on collision course with earth based on the degree of threat presented by each specific object discovered. Whoever discovers an extinction

level collision threat might receive a fabulous reward dwarfing the Nobel Prize. Since the probability of discovering such objects is even lower than the probability of dying because of them, the taxpayer could offer a considerable reward without incurring much of an expected cost. The taxpayer could offer large rewards without incurring expected costs that would exceed expected benefits. This strategy could further harness the considerable efforts of hobbyists the world over, turning the watching of the heavens into a virtual California gold rush. More importantly, the strategy could limit increasing the role of government whose growth so easily promotes economic stagnation. Ideally, reallocation of resources from less meritorious government activities could be especially helpful. Representative Rohrabacher's proposal is particularly meritorious in this regard.

The previously mentioned National Geographic video explains that three people using a small telescope discovered the comet that crashed into Jupiter in July 1994. Eugene Shoemaker, Carolyn Shoemaker, and David H. Levy, after seeing the 21 pieces of Comet Shoemaker-Levy 9 through a microscope focused on a photograph they had taken, alerted astronomers operating a larger telescope, who subsequently confirmed the sighting. Because of this effort, astronomers photographed, from some of the world's most powerful telescopes, the exceedingly rare event of the comet impacting Jupiter and the results were awesome!

A recent report prepared by a team assembled by the National Aeronautics and Space Administration (Stokes, 2003, P. 16) emphasizes that long-period comets may pose the greatest threat of extinction-level impacts from very large objects: "While Earth impacts by long-period comets are relatively rare when compared to the NEA impact flux, the present number of Earth-crossing asteroids drops very steeply for asteroids larger than 2 kilometers in diameter, more steeply than the flux of cometary nuclei…. Hence, it is possible, perhaps even likely, that long-period comets provide most of the large craters on the Moon (diameter > 60 km) and most of the extinction level large impacts on Earth…. "

This 2003 NASA report (P. 14) points out that, because long-period comets take a long time to complete an orbit around the sun, one on a collision course with the earth would give a warning time, if detected at all, measured in months, not years. Any previous appearance might have occurred centuries or millennia ago. While such comets have lower mass than stony asteroids, their velocity is typically more than twice that of near-earth asteroids and thus carry about 6 times the impact energy of an equal mass asteroid (Stokes, 2003, P. 14).

Protectors of the earth might like to think of mankind as another sort of defense layer – a layer between the atmosphere and the hard crust of the earth – a defense layer that can actively scramble to launch a future last-minute nuclear attack on any significant incoming impactor threat. Defending the earth might set

man apart from all other creatures. Hollywood has provided movies depicting successful nuclear attack against incoming extinction level impactors, demolishing them as a clay pigeon turned to smoke by a good skeet shooter. However exciting and satisfying these “space westerns” might be, they do not comport well with the reality of dealing with a potential impactor. V. A. Simonenko, V. N. Nogin, D.V. Petrov, O. N. Shubin and Johndale C. Solem (1994, p. 951) reason, "the consequences of a pulverized object entering the Earth’s atmosphere can be compared with the consequences of ash and dust thrown out during the eruption of a volcano." This claim seems sharply contradicted by estimates based on conservation of energy of impact that indicate ejecta would have had enough energy to start fires all over the earth's surface from the heat that such material would have radiated downward upon re-entry of the atmosphere (Toon, Owen B., Zahnle, Kevin, and Turco, Richard P., 1994, p. 811). The same total energy would enter the atmosphere were it imbedded in countless fragments of the remains of a pulverized K/T impactor, possibly starting global fires just the same as ejecta would do. As an analogy, cluster bombs are generally no less harmful than the old-fashioned single burst bombs. In fact, Paul R. Weissman (1994, p. 1198) argues that a giant “shotgun blast” of smaller impactors might produce a cumulatively much larger destructive effect than a single impactor of similar mass would. What was it that did the actual killing at the end of the Cretaceous era? The dinosaurs stood helpless when, as a leading NASA authority on the subject reports, ejecta rained back down on them like falling stars so numerous that a global firestorm ignited, consuming virtually all the grass and trees blazing at once during a single day 65 million years ago (Morrison, 1995, p. 37). It evidently stayed pitch-black back then for months following in a seemingly endless night that brought with it a change in the weather comparable to more extreme visions of nuclear winter.

Moreover, even supposing disintegration would work, the current ability of human civilization to shoot apart an incoming large object is uncertain at best, given current technology. U.S. leadership in space programs means that efforts led by some other nation would seem even less promising than what America might manage to do. Decades of poor productivity growth have taken their toll on America’s capabilities already. Stan Crock (2002) reported signs of deterioration in the recent record of space launch successes by the U.S., citing the following examples. Averaging one failure per year out of 200 launches from 1987 to 1999, the U.S. had experienced five failures out of 25 launches in 1999 (through October). Since 1998, there had been a 146% increase in partial or complete loss of operation of satellites. Employment in the launch sector in the U.S. had fallen from 208,000 in 1988 to 82,000. Patriot missile tests, shortly before his writing, had achieved only four hits out of seven tries. The Pentagon had been recently leaning toward high-flying unmanned aircraft as an alternative to space, Crock lamented. The space program thus hardly inspires confidence if humankind’s survival is possibly contingent on one successful shot of a cutting-edge, untested launch system aimed at an incoming asteroid! Given current human technological ability, the most likely outcome of another incoming

projectile like the K/T impactor, arriving detected or undetected, would be an unsuccessful gesture of launching interceptors, followed by the near total disappearance of humankind from the earth.

Even if we could feel fully confident in out ability to launch a successful interception mission, our survival still appears dubious. This is the opinion of Keith Holsapple, a professor at the University of Washington who studies the effect on various materials of simulated nuclear explosions. Holsapple emphasizes the likelihood that a large incoming impactor would be a "rubble pile" that our presently contemplated methods of diverting could not be relied upon to stop from hitting us (Holsapple, 2002, p. 3). Like a giant popcorn ball, such an impactor would just absorb our attacks and keep coming. We might infer from Holsapple that we need further advances in technology and a greater accumulation of resources for a big impactor on a collision course, if we wish to assure our long-term survival. NASA crashed a coffee table sized probe into comet Tempel 1 at 23,000 miles per hour, on July 4, 2005, in an effort to learn more. Experimentally nuking a comet seems worthy of NASA's future agenda.

## Political Economy

Governments of many nations display willingness to take drastic actions to curb the use of fossil fuels even though the predicted result would be a substantial reduction in citizens' standards of living. While the United Nation's Intergovernmental Panel on Climate Change concluded in the mid-1990s that global warming could eventually cost developed countries between one percent and 1.5 percent of GDP annually, and developing countries two to nine percent (Shogren and Toman, 2000), the UN failed to emphasize that probabilities might be small and time lags lengthy for this speculative occurrence. Other investigators play along with the supposition that a significant warming is actually coming by analyzing the implications, though they do not endorse the supposition of warming as actually valid.

William Nordhaus and Joseph Boyer use a sophisticated model to discern the expected benefits from achievement of the goals of the Kyoto treaty. They conclude Kyoto compliance benefits would have a maximum present value around $160 billion, although they allow modeled global warming damage ultimately to run as high as $4 trillion (Nordhaus and Boyer, 1999, p. 8-16). Under their modeled assumptions, an efficiently designed Kyoto goal compliance mechanism would have costs around $59 billion while yielding benefits worth about $108 billion, according to Nordhaus and Boyer (1999, p. 8-20). In 1998, Mary H. Novak, senior vice president of WEFA Inc., reported that Wharton Econometric Forecasting Associates estimated compliance would cost the United States alone $300 billion annually to achieve Kyoto targets through then widely proposed methods (Novak, 1998). However, even granting that warming will come does not eliminate probabilistic qualifications that should inhibit drastic action. Thomas Gale Moore argued that if global warming does occur, it would

be, on balance, beneficial rather than detrimental, bringing net benefit to the U.S. worth about one percent of GDP (Moore, 1998, p 127).

Why have we paid so much attention to the threat of global warming or the pollution threat in general and so little to the asteroid threat? The answer, perhaps, is that the pollution threat provides a political cloak for manifold rent seeking activities and the asteroid threat does not. Mancur Olson's theory (1982) contends that all societies, like ships with barnacles multiplying on their hulls, accumulate the results of special interest rent seeking activities. Distributional coalitions seize opportunities to deflect legislation for the benefit of small groups and to the detriment of economic growth. While, in his 1982 book, Olson did not elaborate this theme with environmental regulation in particular, efforts to protect the environment have enabled lobbyists to enhance monopoly power, for example, at the cost of impeding innovation and the entry of new enterprises into otherwise stagnating industries. Regulating the environment multiplies attractive opportunities for rent seekers to restrict would-be competitors and these rent seekers propel environmental regulation as if they were playing at a legislative foosball machine with rows of lobbyists on its shafts. Bruce Yandle (1999a, pp. 19-20) explains the Kyoto Treaty by saying: "The real effects of the protocol relate to cartelization and efforts by interest groups and countries to gain competitive advantage in a globally competitive world. Global warming may be just the right wrapping for a major rent-seeking package."

Mentioning the asteroid peril generates derision, while, on the other hand, less threatening environmental alarms miraculously bring disproportionately militant political action and the difference is the force of hidden rent seeking. Bruce Yandle (1999b) describes the political propulsion mechanism in his "bootleggers and Baptists" model of the demand for social regulation. In his discussion of the Kyoto treaty (1999a, p. 30), Yandle cites Enron's backing of President Clinton's efforts to fight global warming. Enron had an interest in burning gas to generate electricity because Enron was a major producer of low-carbon natural gas. He (1999a, p. 30) also cites the National Corn Growers Association lobbying efforts to preserve the subsidy on ethanol on the grounds that it will help fight global warming. The inevitability of a large incoming asteroid calls forth no similar restrictions that interest groups (other than NASA) might divert toward enhancing their market power.

The disasters that might result from intermediate sized impactors could conceivably stimulate economic growth. Lesser disasters therefore may possibly increase humankind's protection from more apocalyptic sized impactors – other kinds of disasters such as global warming could exhibit unexpected benefits in this sense also. Mark Skidmore and Hideki Toya (2002) recently completed a statistical investigation of the effects on growth from natural disasters of a variety of kinds. They find that "climatic disasters" have correlated with increases in the rate of economic growth while "geologic disasters" seem to have historically diminished growth. "Climatic disasters" include floods, cyclones, hurricanes, ice

storms, snowstorms, tornadoes, typhoons, and storms, while Skidmore and Toya define “geologic disasters” to include volcanic eruptions, natural explosions, avalanches, landslides, and earthquakes. Since most of the damage from intermediate sized impactors would come from tsunamis, intermediate impactor disasters would seem to fall within the “climatic disaster” category, much as would global warming induced disasters. Olson (1982, pp. 75-76), citing the “economic miracles” of Japan and Germany that followed their defeat in World War II, sheds light on how disasters sometimes tend to improve the productivity of labor and capital. He explains that such events break the grip of many rent seeking special interest coalitions and help society reorganize production activities along more rational lines. All societies otherwise tend to stagnate due to rent seeking achievements of very many relatively small groups. Olson’s reasoning suggests that only very upsetting disasters would possess such a helpfully disruptive quality. Only a tsunami-sized baptism can adequately wash away our sins. Skidmore and Toya reason that disasters help usher in advances in technology, among other benefits. The survival of our world perhaps requires technological progress and economic growth, so that humankind might gain the power to defend against what is coming.

## Conclusion

A doomsday asteroid or comet is coming and only the date remains unannounced. Overzealous effort to head off the rather speculative threat of a global warming catastrophe risks impeding technological and economic progress. Modern governments tend to overemphasize problems such as global warming because, by so doing, they benefit a multitude of rent seekers who hoist them into power in the first place. Such rent seeker appeasing, then, according to Olson’s theory, impedes economic growth and development. In addition to stifling the accumulation of economic strength sufficient to assure deflection of a large cosmic impactor, modern government tends to show disinterest in preparing for the next enormous meteorite. In the spirit of writers who believe that they have found an asteroid or comet impact foretold in the *Bible*, one might think of such an end to our present society as damnation for a world that acquiesced to rule by the rent seekers and the government they exalted.

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The picture at the top of this article is of the impact of fragment G of comet Shoemaker-Levy on Jupiter. Permission was obtained to use this picture from the Australian National University's Research School of Astronomy and Astrophysics.

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