

# **Do Nuclear Weapons Make Financial Sense?**

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## **Introduction**

Does it make sense for states to invest in nuclear weapons? The question of whether to pursue nuclear weapons has heavy moral, political, and military implications, but it is one that every industrialized country must face nonetheless. Such is the nature of these weapons that they force a state to take a side. Every industrialized country invests in their national defense, and nuclear weapons are existential in their capabilities, meaning states must devote considerable energy in deciding to pursue their acquisition, maintain current status, or eliminate existing weapons.

There are many issues surrounding such decisions from the philosophical to the practical. But of all the lenses one can use to examine this choice, one of the less common is economic. On top of whatever else they do or represent, nuclear weapons cost money and resources to build. Evaluating their cost-effectiveness is then necessary to determine if these weapons are a worthwhile investment of state resources.

The study of economics is conventionally defined the study of the allocation of scarce resources, by an individual or group. One of the underlying assumptions of many economic theories is that actors are rational, that is, they will make choices that will increase their utility. Another key element of many economic theories is that actors have all the relevant information needed to make a choice. In these theories, price and quality are assumed to be the only relevant factors, and the actor is assumed to be able to know the price and quality of the item in question. Thus a rational actor will, all other things being equal, chose a less expensive item

of similar quality over a more expensive item because doing so will increase their utility.

In the area of national defense, these assumptions become problematic. In modern warfare, large, technically complex weapons systems are difficult to accurately price. Their development is many years long, meaning the budgets for their development are spread out over several iterations of different pieces of technology, and safety and environmental standards change to increase the development cost of many projects. Additionally, the goals for a large weapons system may change over time, making their quality, or degree to which they accomplish their goals, difficult to gauge.

### **Problems with Knowing Price – Long Development Periods**

Accurately pricing complex weapons systems has several challenges. Long development periods and changing generations of technology make the decision of what to include in development costs problematic. If a new submarine or aircraft carrier is developed over a period of a decade or more, investments in purpose-built facilities for testing and construction would be necessary, versus the possibility of short-term use of existing facilities for weapons with shorter development periods. It takes decades to design and build a new aircraft carrier, meaning whole facilities would have to be built for the purpose and staff dedicating their careers to it. A new short-range missile would not need such purpose built facilities, and thus would not have to include such costs in their development. Sorting out what gets included thus becomes more complex. Further, changing health and environmental standards over time adds uncertainty to the long term costs. If the costs for clean-up of a toxic site comes only years after the site was

used for the development of a weapons system, is that cost included in the total price of a particular weapon?

Changing generations of technology also make accurate pricing difficult. If a large weapons system uses a newer, more efficient piece of technology that cuts down the development cost, how is the cost of that new technology included in the cost of the weapons system? For example, an airplane may borrow technology such as electronics produced for a different project without having to include that development in its own costs.

Similarly, it costs more to develop ground-breaking technology than does it does to build a system that relies on existing technology. Building an entirely new jet fighter will be cheaper than building the very first one because those making the new one won't have to do the basic discovery. Further complicating the analysis, however, is the idea that once a basic concept is developed, there will soon be negative returns to scale on investment for improvements. That is, it will take more and more work to make smaller and smaller improvements on a concept. Graphing these costs would then make a u-shaped curve, but it is difficult to know where one is currently at on this curve. Thus comparing the costs of a newer system like a jet fighter where many basic discoveries needed to be made, versus other elements such as hydro dynamics for ships, is complicated.

### **Problems with Knowing Price - Changing Goals**

The question of how the goals for a weapons system affect the pricing of said systems is related to the changing nature of warfare. As the needs of an army changes, and the moral standards by which a state wages war change, the goals for a weapon system will also change. If a large, complex weapons system, whose development takes a long time, has the goals for which it was developed change, this can result in features or functionality change that add or subtract to the cost. For instance, if a piece of equipment is developed for combat in an open field gets replaced by a new version for use in urban environments, it will necessarily have some different features. How does one compare costs?

Further, if a weapons system is built, but then changes roles, can the costs of developing that system be subtracted from the overall costs of its original realm? For instance, if a submarine is built to carry SLBMs, it would naturally be added, in part, to the tally for developing nuclear weapons. But if it is refitted with new goals that do not involve missiles, will the cost of developing that sub be removed from the tab for nuclear weapons?

### **Problems with Knowing Quality**

Quality in a physical product is often related to elements such as durability or efficiency. These characteristics help it achieve its goals better, faster, or for a longer period of time. But for things that have larger, more complex goals, gauging quality is more difficult. One can't simply examine the physical characteristics of the system. Instead, one must work backwards and ascribe quality from an examination of the completeness of goals. For the purposes of this essay, the quality of a weapons system will be seen as a measure of how well it accomplishes its

goals. This, in turn, requires a clear understanding of these goals and the ability to evaluate how effectively a system fulfills them.

Before continuing, there is a further evaluation necessary when examining goals for a weapons system. Not all goals are of the same value. If the primary goal of a piece of technology is to directly ensure the very survival of a state, that is a higher ranked goal than something that merely improves the performance of a part of the military, and thus is indirectly related to the survival of the state. If the goals for which a system is built are of the greatest importance and it contributes a great deal to those goals, then the value awarded to it can be considerably higher than if the goals are of lesser importance.

Determining the goal or goals of a complex weapon system is difficult. With deployment periods that often stretch over decades, there is a natural drift in goals as the approach to national security changes over time. The B-52 bomber was developed to carry a massive payload for saturation bombing, but is more often used now to drop precision guided munitions. If it is less adept at the latter goal, is it then of a lower quality?

The second element in evaluating quality is determining to what degree a weapons system accomplishes its goal. This is easier if a piece of technology is used directly. Does a jet fighter outperform its competitors? Is stealth technology effective at evading radar? However, if the goal of a piece of technology is to induce a particular action on the part of another state, then knowing how well that technology was effective in doing so is exponentially more difficult.

Particularly if the state in which one wishes to induce action is an adversary, knowing the factors that influence their decision is bound to be difficult. States often take actions that are ostensibly for reason of international statecraft, but in reality have much more to do with domestic politics. The current crisis in Ukraine is an example where the actions of Russia are overtly stated as being in response to the situation on the ground, but are in fact seen by many to be closely based on domestic political considerations. If, using this example, the United States were to develop or deploy a weapon system to influence this situation, it is not at all clear that we could ascribe any change on the part of Russia to the influence of this system.

### **Choices in a World of Incomplete Information**

The end result of the difficulty of knowing the price and quality of a complex weapons system is that the market for these systems will inevitably be inefficient. A perfectly efficient market relies on timely, accurate information, precisely the opposite of what a long, complex development period provides. This means that states making decisions regarding nuclear weapons are operating in an environment where it will be difficult to gauge if their decisions are economically sound.

However, while accurately pricing complex weapons systems may be difficult, states do still live in a world of finite resources and must make decisions in regards to national defense based on the best available information and based on the perceived needs of their state. With enormous sums of money and national survival on the line, evaluating the economic soundness of their

decisions, then, is both very difficult and extremely necessary.

### **An Understudied Area**

There are many interesting and even incredible facts about nuclear weapons, such as their relatively small size, tremendous destructive power, their proliferation, etc. However, less common are evaluations of the economic value of these weapons. It is somewhat odd that the literature regarding this question is not more robust. The question of the economic utility of nuclear weapons is one that lends itself very naturally to economics. Michael Leidy and Robert Staiger (1985) were two of the first academics to examine this issue, addressing it indirectly as they were primarily modeling arms races. Writing in the 1980s, at the height of that era's arms build-up, they stated that the "potential contribution of the economics profession to arms race analysis is constrained not by a body of traditional subject matter, but by the limits of positive economics methodology. The nuances that compose the arms race problem fundamentally involve instances of constrained human choice. As such, the economic approach is well suited indeed." (1985, p. 504) This essay will, nonetheless attempt to examine questions surrounding nuclear weapons with an economic lens.

As with any expenditure, there is an opportunity cost to nuclear weapons, with resources put into their development and acquisition are resources not put into other military procurement, or indeed into social spending. This essay, however, will for the most part, leave aside the question of military spending versus social spending. The most relevant comparison for the resources devoted to nuclear weapons is to other military expenditures, not to social spending

on things such as health care and education. For this essay, it will be assumed that states feel it necessary to invest resources in their militaries, that such resources can be increased or decreased, but are fixed at any given time.

Thus, I will attempt to further this discussion by directly examining questions related to the economic value of nuclear weapons.

### **Thesis**

At its height, the Manhattan Project employed approximately 130,000 people (Jones, 1985, p. 344) and the final weapons cost two billion dollars (in 1945 dollars) according to a contemporary article in the *Edmonton Journal*. A huge sum, but does this necessarily mean that nuclear weapons are expensive? More specifically, can we say that they achieve their goals more cheaply than a conventional alternative and thus are economically efficient?

Generally the term 'economically efficient' refers to an economy that has reached the point where it is Pareto efficient, meaning goods or services cannot be increased without an increase in inputs, and production occurs at the lowest per-unit cost. (Mathur, 1991, p. 173) However, for the purposes of this essay, the term 'economically efficient' will refer not to the working of an entire economy, but strictly to the realm of national security. Nuclear weapons or their alternatives will be said to be economically efficient if they accomplish their stated goals at the lowest input costs, both in terms of financial and human resources, and that improvement upon these goals cannot be achieved without increased investment of resources. Also, they

must accomplish these goals using fewer resources than their conventional alternatives. Given the variety of roles that nuclear weapons play, conventional alternatives will include not simply chemical explosives, but all non-nuclear military expenditures - troops, ships, airplanes, etc.

Speaking of nuclear weapons as a category necessarily involves some generalization. Not all these weapons and delivery systems are the same, nor is the degree to which they accomplish their goals. Much like conventional weapons, which are also taken to be a single category here, there is a broad spectrum of nuclear weapons. However, as countries debated whether to acquire these weapons, there is little evidence that a differentiation was made between types of nuclear weapons. It was not as though, for instance, small air-delivered tactical nuclear weapons were acceptable while larger missiles were not. Decisions regarding nuclear weapons generally treated them as a singular category. Despite the dangers of overgeneralization, for the purposes of this essay, nuclear weapons will be viewed a single category.

The question of whether nuclear weapons are economically superior is a surprisingly difficult one to answer. They are a perfect example of a large, complex weapon system discussed above, with all the complications of evaluating their price and quality. This essay will lay out some of the methodological considerations that would be necessary for a state to make this evaluation.

Further, I will attempt to draw tentative conclusions based on the available data about the economic efficiency of nuclear weapons. Specifically, my analysis of the literature on this question shows that nuclear weapons are only economically efficient for a very limited role,

one that is relatively short-lived. In terms of pure destructive power, and the role that plays in military thinking, nuclear weapons are vastly more economically efficient than any conventional alternative. However, from the perspective of national security taken as a whole, the literature shows there is a very weak case to be made for the economic efficiency of nuclear weapons.

### **Methodological Considerations**

The first step in an examination of the economic efficiency of nuclear weapons is a review of the literature dealing with their development and role in national security decisions.

For something to be considered cheaper than its alternative, it must reduce overall costs.

For example, if a car is actually cheaper than its rival, it must be so when factors beyond the sticker price (maintenance, fuel efficiency, resale value) are factored in. If nuclear weapons have additional costs that are not immediately visible, such as requiring more highly trained personnel and greater environmental clean-up costs, these too must be factored in to the overall analysis. The reverse would also be true. If nuclear weapons save money, they may only do so in the long run. Their savings may not appear for years or even decades after their acquisition.

To show that nuclear weapons are cheaper than conventional weapons, one would have to find examples of states lowering their defense budgets in response to the acquisition of nuclear weapons, or increasing the size of their militaries with the same budgets. Reductions in states' defense budgets after the acquisition of nuclear weapons would indicate that the real impact of

these weapons is to lower the cost of national defense when compared to conventional alternatives. Any such reduction would also need to be distinguished from a general reduction in national defense spending. In cases where national defense budgets do not fall after the acquisition of nuclear weapons, it is still possible that the weapons are economically efficient. In such cases, it is possible that a lack of political pressure to lower defense spending meant military planners and political leaders could simply use the savings from nuclear weapons on other weapons or a larger overall military. Sujeet Samadda writes that

“One way of quantifying the expected payoff in the military sector ..., would be to assess the impact on military expenditure of exercising the nuclear option. Would nuclearization cause military expenditure to increase, decrease, or remain the same? Would conventional weapons backed up by nuclear weapons provide the same degree of security? If yes, then from a military perspective, a state would profit by acquiring nuclear weapons. If going nuclear compromises national security by, say, triggering an unsustainable nuclear arms race, then the nuclear option is not militarily profitable.” (p. 448)

This opens up another complication in the analysis. Given the moral dimension to nuclear weapons, there are implications to their acquisition that extend beyond the simple fact of the weapons themselves. There are costs to nuclear weapons that are not related to the handling and use of the things themselves, but are incurred through the actions of others based on the norms surrounding nuclear weapons. An example is seen in the costs to the Iranian economy

from sanctions imposed by countries who suspect it of pursuing nuclear weapons. This is an expense that is not seen, at least to anything approaching the same degree, in conventional weapons. It is, however, still a cost, and must be taken into account.

Another scenario would be that nuclear weapons do not replace any part of a conventional army and the budgets for their development are simply added to existing military spending. In this case, nuclear weapons would be addressing a unique set of needs and their cost would mean states would be simply spending more on total national defense, making a judgement about their economic efficiency compared to conventional alternatives more difficult, if not impossible.

### **Why Look At This Question**

There are currently nine states possessing nuclear weapons (to be referred to henceforth as nuclear states), but the list of states with the technical capabilities and materials to produce nuclear weapons, referred to as nuclear latency, is much larger. Sagan (2012) argues persuasively that it is difficult to be definitive, but depending on the criteria one uses for being able to “quickly” produce a bomb, the number of nuclear latent states is between 12 and 40.

Nuclear latent states can be sub-divided into two categories. Some of these states simply have the natural resources, technical expertise and experience with nuclear energy, and the industrial base necessary to produce the associated technologies, but have not taken any specific steps towards nuclear weapons. Though they have the potential to become nuclear

states, doing so would require significant time and investment. Other latent states possess what is referred to as break-out capability. This occurs when a state develops nuclear capabilities that fall just short of producing actual weapons. They are said to be able to 'break-out' of their current nuclear-free status in a very short amount of time and have weapons ready in a time-frame measured in months and not years as is usually the case. This requires a state to have taken specific steps towards the production of a bomb including experience with highly enriching uranium or producing plutonium, advanced weapons designs, and a reliable delivery mechanism. For break-out states, factors other than economic ones prevent them from crossing the nuclear threshold. Since most of the cost of a small nuclear weapons arsenal is in the development of the weapon and delivery systems, building a nuclear program that can produce a bomb, but not going the final step is not a significant cost savings.

While the range in the number of nuclear latent states is fairly wide, even the lowest number would more than double the current number of nuclear states. That they have not all acquired nuclear weapons already makes clear that the case for acquiring these weapons is not straightforward.

Additionally, different states may place a different value on various levels of nuclear capability. For some states, it may be more economically efficient to have a break out capability than the actual weapons themselves, especially given the costs associated with breaking the norms surrounding nuclear weapons. The international standing of a country such as Japan, with its

robust nuclear energy program is higher than that of North Korea, which places little value on international standing. Values of and purposes for nuclear weapons may vary among states.

Allison (2010) writes that at a minimum, there have been 13 countries that have started nuclear weapons programs. This includes states with:

“serious intent, and were technologically capable of completing the journey, but stopped short of the finish line: Argentina, Australia, Brazil, Canada, Egypt, Iraq, Italy, Libya, Romania, South Korea, Sweden, Taiwan, and Yugoslavia. Four countries had nuclear weapons but eliminated them. South Africa completed six nuclear weapons in the 1980s and then, prior to the transfer of power to the post-apartheid government, dismantled them. Belarus, Kazakhstan, and Ukraine together inherited more than 4,000 strategic nuclear weapons when the Soviet Union dissolved in December 1991.” (p. 82)

Thus there is a calculation about the relative costs and benefits of these weapons done on the part of leaders of nuclear states, nuclear latent states, and of the latter by states who began to develop them and ended their nuclear programs, and of states who possessed these weapons but gave them up.

If nuclear weapons truly provided a value greater than that available through other means, then it would be logical for the number of nuclear states to be larger than the number of nuclear latent states. That that is not the case clearly shows the need for an examination of the value of these weapons. While economic considerations cannot be seen as solely

determinative, the huge sums of money involved mean that they clearly play a role. What is less obvious is the proportion we ascribe to economic considerations when evaluating states decisions regarding the acquisition of nuclear weapons. Given the variety of reasons states may have for their acquisition, this proportion may vary.

But as mentioned, it is nonetheless important to at least attempt to answer what proportion economic considerations play. Given the capabilities of these weapons, understanding why states decide for or against going nuclear is a central challenge of the study of international relations.

### **Defining Costs for Nuclear Weapons**

As discussed above, large, technically complex weapons systems are difficult to accurately price. Simply adding up the budgets for nuclear weapons development and deployment, while surprisingly difficult in and of itself, does not fully account for the costs of nuclear weapons.

How does one include costs such as the opportunity cost of researchers who could be engaged in different work, but instead spend their careers in nuclear weapons production and design?

How does one account for the time spend by various branches of the military in escorting and guarding nuclear weapons? If a submarine is built solely to carry nuclear missiles, surely its

costs are counted in this tally. But what of an escort ship that can perform multiple functions?

What if this submarine is subsequently refitted to perform a different role?

Since nuclear weapons are new, it is easier in some ways to trace and account for their development costs compared to the development of conventional munitions and delivery means whose histories can be up to hundreds of years long. There was negligible spending on nuclear weapons research prior to the 1930s. Artillery, on the other hand, dates to the Napoleonic wars, and even earlier.

Maintenance and retirement costs are another complication. While all military equipment requires upkeep and will be retired eventually, doing so with nuclear weapons is much more involved than conventional munitions. A new jet may require significantly more maintenance than a propeller aircraft, but it is a change in degree, not in kind. Nuclear weapons introduce a whole new element of safety when it comes to maintenance, given the radiological danger. Additionally, maintenance costs were poorly understood when most nuclear weapons were built, given that they were an entirely different category of weapon. States already have considerable experience developing procedures and protocols for evaluating the maintenance costs of conventional weapons, and yet often understate these costs. As Mark Arena writes, there is “a presumption in defense acquisition that the final cost is typically greater than that estimated. Our assessment of the historical record in the United States is consistent with the belief of a bias of higher actual costs relative to estimates.” (p. 1) Likewise for retirement costs, nuclear weapons presented not just a change in degree, but a change in kind. A new jet can be retired to a desert depot in similar fashion to a propeller aircraft, but a nuclear bomb or missile cannot be retired and disassembled in a fashion similar to conventional munitions.

While these costs may be difficult to estimate and incorporate into decisions regarding nuclear weapons, they cannot be eliminated from an evaluation of the weapons' economic efficiency. States do still have to pay these costs, and that does affect the relative value of the weapons. Stephen Schwartz, author and editor of the comprehensive account of U.S. expenditures on nuclear weapons, *Atomic Audit: The Costs and Consequences of U.S. Nuclear Weapons since 1940*, highlights some of the difficulties in getting an accurate measure of the cost of nuclear weapons. He writes that the "very size of the nuclear weapons complex, not to mention the secrecy surrounding many of its activities, the lack of rigorous accounting procedures, and poor historical records, make it extremely difficult to determine the costs incurred at each facility." (1998, p. 53) Moreover, he discusses the difficulties in deployment issues with dual use equipment, issues such as guarding and secrecy, etc. What portion of the military's expenditures should be counted towards the nuclear tally? To be conservative, the figure he uses is 15 percent:

"If even 15 percent of the cost of equipping, operating, and supporting U.S. general-purpose forces over the past fifty years were allocated to the nuclear mission, the [overall] costs associated with the nuclear weapons activities ... would grow by another \$1.2 trillion. Moreover, given the extent to which nuclear weapons were integrated into the training and doctrine of the U.S. general purpose forces during much of the cold war ... 15 percent might well be a serious underestimate." (p. 111)

However, because he cannot know for sure whether it is an underestimate, he uses the 15 percent figure for his work. Schwartz breaks down the costs for nuclear weapons into nine major categories: building, deployment, targeting and controlling, defence against nuclear attack, dismantlement, nuclear waste management and environmental remediation, victims, nuclear secrecy, and congressional oversight. (p. 3-4). While it is not necessary for the purposes of this essay to so clearly delineate the costs of nuclear weapons, this breakdown is a useful reference to keep in mind.

### **Defining the Role of Nuclear Weapons**

As mentioned above, the quality of nuclear weapons will be gauged by how well they accomplish their goals. This then requires a specific definition of those goals. Unfortunately, this is no more a straightforward task than calculating total cost.

Early in the development of nuclear weapons, the mentality surrounding their use, especially in military circles, was that they could be used to fight wars. It is only later that they came to be thought of in terms of their deterrent value. (Schelling, 1966, p. 24-26) With the mass testing of the nuclear weapons, leaders in both the United States and Soviet Union realized that the fallout from large-scale usage or from small-scale but close proximity usage of nuclear weapons meant there were significant costs not found in conventional weapons. The fallout from such usage would under many circumstances nullify any gains made. Territory would be unusably radioactive and/or fallout would drift back towards the home state.

However, this fact did nothing to undermine the zeal with which the super powers built their arsenals. Obviously then, nuclear weapons hold some other value than direct application for advances on the battle field. Wilson (2013) writes that nuclear weapons, “military thinkers and government officials around the world concluded, were unlike any conventional weapon. This weapon could deliver a blow so horrifying that it could coerce surrender when all else could not. This is the first and most important idea about nuclear weapons. It is the idea on which all others are built: Nuclear weapons have a psychological power that enables them to coerce and deter when other weapons cannot.” (p. 6) However, it should be noted that the type of psychological power exerted by nuclear weapons might vary depending on a state’s adversary. For instance, Pakistan may have its nuclear forces as a means of deterring Indian attack, but it does not necessarily hold that India’s nuclear weapons are used for the reverse purposes. India’s arsenal may be a means of competing with China for prestige.

Thus defining any goal for nuclear weapons will have a psychological component. It is not enough to simply say this weapon outperformed its competitor based on a reasonably objective analysis of their performance in the field. Analysing the ability of nuclear weapons to achieve their goals involves analyzing the actions of geopolitical opponents. If those opponents can be said to have acted in a way that a nuclear state desired, without direct military action, then nuclear weapons can be seen as having achieved their goals by psychological means.

### **Deterrence as the Role of Nuclear Weapons**

Given the limited military utility of nuclear weapons, their role rests largely on the concept of deterrence. But what is meant by this, exactly? In general terms, deterrence is the dissuasion of another party from some original course of action. Glenn Snyder (1960) referred to it as a species of political power, writing that deterrence is “simply its negative aspect. It is the power to dissuade another party from doing something which one believes to be against one’s own interests, achieved by the threat of applying some sanction.” (p. 163) However, what level of dissuasion is meant by deterrence? What degree of change is required? Does the other party have to accept a full range of points to avoid the sanction? Also, does it mean changing the course of action in the full range of international events, including trade and the movement of people, or is it strictly related to military matters? While the concept of deterrence as a whole might be applied to a full range of actions, with regards to nuclear weapons, it is related strictly to military matters. Few trade agreements are negotiated under threat of nuclear attack.

It follows then that nuclear weapons are useful in dissuading a competing state from some course of military action. Wilson writes that according to deterrence theory “before leaders decide to go to war, they calculate what the likely costs of doing so would be. Deterrence works by persuading the decision makers that the costs will be greater than the benefits.” (p. 67) Nuclear weapons, in this thinking, dissuade other states from some original act of aggression by making the costs too high. But how exactly do they make those costs high?

The doctrines for the use of nuclear weapons has undergone several iterations. The first “explicit U.S. doctrine on the use of nuclear weapons was the doctrine of massive retaliation ...

[where] the U.S. eschewed using limited military responses in opposition to Soviet political and military initiatives around the world and instead threatened the Soviet Union with nuclear attack for any of an unspecified list of military and political actions.” (Jenson, 1979) However, the central idea of this threat, that nuclear weapons are so destructive no one would risk actions that could result in their use ended up being the downfall of the doctrine. Responding to a non-nuclear event with a nuclear attack is in almost all cases disproportional. This disproportionalality led to problems with its credibility.

Credibility is central to deterrence as the opponent must believe there is a good probability that the threat will be successfully carried out. Gormley argues that despite nuclear weapons not being used in most military activities, the credibility of their use needs to still be based on some military function. He writes that “nuclear utilization target selection ... argues that the design of nuclear weapons should derive from the need to perform a specific military mission (say, attacking deep underground targets with a minimum of collateral damage) with great effectiveness. The latter quality renders nuclear use credible in the mind of one’s adversary, without which, so goes the NUTS argument, deterrence is unachievable.” (p. 184) However, one can argue that this view of credibility isn’t absolutely necessary for the threat of nuclear weapons to be credible.

Given the incredible destructive power of these weapons, even a small probability of their being used would alter the calculation for any state. China, for instance, has a relatively primitive nuclear arsenal in comparison with other major powers, but does not feel the need to

increase either the size or technical sophistication of that arsenal, despite that country's rising domestic advanced manufacturing capacity, in order to trust in the credibility of their threat. As Schwartz writes, "There is clear historical evidence... that even the possession of nuclear weapons usable materials and actual or presumed nuclear expertise can, in some circumstances, serve as a deterrent. Similarly, there is also evidence that a state with a relatively small proven arsenal, such as China or France, can deter nuclear attacks by states with far larger arsenals. Furthermore, there is no evidence that a huge nuclear arsenal is more effective than a small one in deterring a conventional attack." (p. 22) Thus any use of nuclear weapons would be catastrophic, a fact which has two results. The first is that small nuclear arsenals can still maintain strong deterrent value. The second is that threats surrounding nuclear weapons must be in proportion to their destructive power. Given that threats need to be credible to be effective, but that a small risk of a catastrophic event is still a significant risk, what doctrine for the use of nuclear weapons would then be credible?

In the doctrine of massive retaliation, there was only one possible response to any action - a nuclear attack. There was no possibility of scaled escalation and de-escalation. It became clear that responding to any minor incursion with a massive nuclear strike killing millions of people, was not credible. This led this doctrine to be abandoned not long after its adoption, which is fortunate because nuclear states have engaged in wars, even large-scale ones, where they have not fared well. Both the United States and the Soviet Union, by far the pre-eminent nuclear weapons powers, engaged in prolonged, costly, and ultimately failed wars with non-nuclear states in Vietnam and Afghanistan. Additionally, nuclear states have been attacked. Argentina

invaded the Falkland Islands, and Indian and Pakistani have engaged in cross border raids, and yet none of these actions led to the use of nuclear weapons. These examples demonstrate the problem of an inflexible doctrine. The Falklands Islands' were very far from the British mainland and thus their sense as being part of Britain was more tenuous. Few citizens would fear for the safety of the homeland based on such an invasion. The same goes for cross-border raids between India and Pakistan. They cannot be seen as existential attacks. But massive retaliation was an inelastic policy. One either responded with nuclear counterstrike or let the attacks happen and argue after the fact why they didn't fit the definition of an attack requiring a nuclear response.

Clearly, nuclear weapons and the doctrine of massive retaliation did not deter attacks. The requirement that this doctrine placed on clarity and strict distinctions fit poorly with the flexibility of ideas like territorial integrity in the real world. But if not massive retaliation, what then does nuclear deterrence mean? Because the engagements listed did not represent existential threats to the states involved, perhaps nuclear weapons deter states from launching existential-level attacks?

Indeed, there is considerable backing for this view. On a theoretical level, Sujeet Samadda (2005) writes that realism "provides a convincing justification for the acquisition of nuclear weapons, since it believes that the possession of a potent nuclear arsenal is the guarantee of absolute security, whereas conventional forces may only provide relative security." (p.440) And Allison writes that the "British strategist Lawrence Freedman summarized the lessons drawn by

national security analysts around the world this way: 'The only apparently credible way to deter the armed force of the US is to own your own nuclear arsenal.' Many Iranians, and even a few Iraqis, have wondered whether the United States would have invaded Iraq in 2003 had Iraq been armed with a nuclear arsenal as large as North Korea's current one." (p. 81-82) Indeed, nuclear weapons were seen as the only way for non-superpower countries to afford the ability to deter attack from the superpowers. As Avery Goldstein writes, "The attractiveness of nuclear deterrence for dealing with the superpower threat to the second-ranking powers' national security was based not only on the strategy's robustness but also on its feasibility when compared with the defensive alternative. Procuring the forces sufficient to support a defensive rather than deterrent approach to dissuading aggression by an adversary with vast military superiority would have placed enormous strains on the economy of a second-ranking power." (p. 489-90) So nuclear weapons are seen as an effective deterrent to existential attacks by superior military powers.

However, if nuclear weapons reliably deter existential attacks, or are perceived to reliably deter existential attacks, the question of why every country with the capability to produce or acquire these weapons does not seek them returns. Surely the primary concern for any country is the continued security and existence of that country. And as discussed, the list of nuclear latent countries is larger than nuclear states. This is especially the case for states that are not under the so-called nuclear umbrella, the protection of a state by the nuclear arsenal of another. Brazil and Argentina, for example, are rival nations, outside the nuclear umbrella, both with the

potential to acquire nuclear weapons, both with nascent nuclear programs, but both countries abandoned those programs long before a weapon was produced.

Thus a more parsimonious definition of deterrence which nuclear weapons provide is needed.

One possibility would be a definition that limits the role of nuclear weapons to dissuading nuclear states from using these weapons against another nuclear state. In this case, nuclear weapons would be used to deter other states from launching only nuclear-based existential attacks. Another formulation holds that nuclear weapons are used to deter existential level attacks of any kind against a state. This broadens the purpose for nuclear weapons in a fashion similar to that laid out by Scott Sagan that will be examined further.

Another extension of the idea of deterrence whereby one state guarantees the security of another is appropriately called extended deterrence. Anderson, Larsen, and Holdorf define this approach thusly: "As a strategic concept, extended deterrence involves the United States using all the tools of state power, to include the use of military force, to deter a foreign actor from undertaking hostile actions against a third party." (p. 5) Most commonly, extended deterrence came to prominence during the Cold War whereby the US promised to defend Western Europe from Soviet conventional attack, even up to including the use of nuclear weapons.

This variation keeps the idea of nuclear weapons only being useful in dissuading an enemy from launching a nuclear attack against a nuclear state, but enlarges the definition of that nuclear attack. In extended deterrence, non-nuclear states are considered nuclear states for the

purposes of protection. This growth of the idea of deterrence suffered from problems of credibility that the original idea did not. The idea that a nuclear state would respond to a nuclear attack against itself with its own nuclear arsenal is easily believable. But it is less obviously believable that they would respond to a nuclear attack against another state with a nuclear attack of its own and risk a retaliatory strike in turn. As De Gaulle himself asked, would the Americans trade New York for Paris?

The Cuban Missile Crisis is another interesting, often studied case of the deterrent value of nuclear weapons. The often stated narrative is that nuclear weapons deterred the powers involved from direct engagement. Further, it is an example of extended deterrence as the Soviet Union provided nuclear weapons to an ally, while Kennedy declared that any nuclear missile launched “from Cuba against any nation in the Western Hemisphere as an attack by the Soviet Union on the United States requiring a full retaliatory response upon the Soviet Union.” (*Prologue Magazine*, 2002) However, a closer examination complicates the simple narrative of the deterrent value of nuclear weapons.

It is true that both the United States and Soviet Union took actions that avoided escalation in response to incidents that could easily have escalated in a non-nuclear world. The United States did not respond with an attack of any kind after losing one of its spy planes, and the Soviet Union did not attack when its submarines were forced to the surface in open waters. However, this forgets that both states took provocative actions, hoping the other side would back down first. Khrushchev deliberately placed missiles in Cuba after Kennedy made clear this would be

an escalation, while Kennedy's statement itself was an escalation as he knew that placing missiles in Cuba would not alter the strategic balance and was legal by all standards of international law. Thus nuclear weapons did not deter the states involved from engaging in aggressive actions nor from escalation to near the point of war.

Perhaps the role of nuclear weapons is, quite contrary to Gormley, not as closely related to pure military function. As Yost writes, "While there might well be some merit in the decades-old argument that weapons with more limited and controllable effects would enhance deterrence by making a threatened nuclear response appear more feasible and hence more credible in the eyes of a specific adversary, such weapons would probably not in fact simplify decisions ... in an actual crisis to threaten to use or to actually employ nuclear weapons by more than a marginal degree." (p. 713) The reasoning Yost uses here involves the norms surrounding nuclear weapons. These weapons are seen as a category in and of themselves. While in a strictly utilitarian sense, there may be tremendous differences between different types of nuclear weapons, for the purposes of norms, they are all of a category. Thus, their use would all equally violate those norms, regardless of their particular characteristics. A weapon that served a more defined military role would not significantly be more likely to be used and thus be more credible.

Further, Frank Barnaby (1998) writes that the "military-technological fact of life is that very powerful conventional weapons can now be delivered with such precision that the use of nuclear weapons can no longer be justified." (p. 44) This formulation assumes the role of

nuclear weapons to be to take out targets that are difficult to hit, given their location or shielding. A nuclear weapon in these situations makes up for a lack of precision with the ability to take out the entire area. For example, a target that is deeply buried would require a very accurate strike on the entrance to the tunnel. A nuclear weapon detonated near the entrance would be sufficient. However, the new generation of conventional weapons are precise enough to not require that kind of overkill. Barnaby writes further that "Put simply, in today's world nuclear weapons are obsolete [in the military sense]. And the moral, legal, military, and political reasons against the use of nuclear weapons are so strong that the use of conventional weapons would be, to say the least, the preferred option under all circumstances." (p. 44) This view is shared by Brito and Intriligator (1993), writing that "One of the major difficulties in using economic analysis in studying nuclear weapons is that there is no well-defined or commonly accepted technology of warfare in which nuclear weapons play a role. If viewed from a strictly military viewpoint, nuclear weapons may be an anomaly, doomed to extinction by advances in technology, like crossbows and mounted knights." (p. 289) They write that the development of nuclear weapons and their use in the Second World War was an extension of the idea of massive bombing of an enemy's territory, as was practiced using conventional munitions in that war. Nuclear weapons were far more efficient at that than conventional forces, but the strategy fell out of favour shortly after the war after it was seen as having been very expensive in terms of aircraft and crews, but did not result in significant decreases of enemy production. Nuclear weapons were left, according to this analysis, without a well-defined role in military matters.

Brito and Intriligator sum up this analysis of the direct application of nuclear weapons by writing that "it became clear that nuclear weapons were not a very effective means for a nation to use in pursuit of its political and economic objectives, and it became necessary to develop complicated and sophisticated strategic doctrines so as to rationalize these weapons. Ultimately, it was seen that the role of nuclear weapons was primarily to deter their use by other nations." (p.290) While this ignores the possibility that nuclear weapons could be used to deter existential level attacks with conventional forces, it is nonetheless a view of their role that has gained wide acceptance.

Thus, while there is a general consensus that the role of nuclear weapons is deterrence, there is little agreement of what exactly that means, and few historical examples that clearly show nuclear weapons achieved this goal reliably. Eliminating their direct operational military application leaves only a psychological role for nuclear weapons. But given their poor performance in this realm, it is easy to conclude that they have not successfully achieved their goals. Based on the definitions outlined above, we can conclude that nuclear weapons are of a poor value as they do not reliably achieve their goals. This seriously undermines the case for their economic efficiency.

### **Another View of the Role of Nuclear Weapons**

In his seminal work, *Why Do States Build Nuclear Weapons?: Three Models in Search of a Bomb*, Scott Sagan (2006-2007) writes that the question of what motivates nuclear proliferation is understudied. This inattention, he writes, "appears to have been caused by the emergence of a

near-consensus that the answer is obvious. Many U.S. policymakers and most international relations scholars have a clear and simple answer to the proliferation puzzle: states will seek to develop nuclear weapons when they face a significant military threat to their security that either cannot be met through alternative means.” (p. 54) If correct, there are several elements wrong with this analysis by these states. How do the states know that a military threat either cannot be met by any other means or is most effectively or efficiently met by nuclear weapons? Are there examples where states are deterred from invading a neighbour based on that second state’s nuclear capacity, but not its conventional military strength? Further, even if such examples are available, it would be very difficult to ascertain with any degree of confidence what exactly caused that deterrence. The conditions for such a situation are relatively particular, but more importantly, discerning why an adversarial state acts as it does is an exercise fraught with speculation. As mentioned, there are examples of wars between nuclear and non-nuclear states but nuclear weapons do not appear to have played a role in their outcome. Argentina invaded the Falklands long after Great Britain became a nuclear state, but was defeated through conventional arms. North Vietnam and the United States spent years at war, without nuclear weapons playing a role.

Further, this analysis is problematic because not all states that acquired nuclear weapons could be said to have faced a direct threat to their security. Both Great Britain and France gained independent nuclear capability after having explicit guarantees from the United States to be protected under the so-called ‘nuclear umbrella’, de Gaulle’s concerns about trading New York for Paris notwithstanding.

Instead, Sagan recognizes that nuclear weapons have roles that go beyond national security and encompass domestic politics, international symbols and norms, and identity. Thus no single element can explain the motivations of all proliferating states. Instead, he presents three models of state behaviour that would explain nuclear proliferation: the security model, which deals with the traditional, threat-based view, the domestic politics model, which deals with purely internal political reasons for proliferation, and the norms model, which deals with a state's identity on the international stage.

This complication of the motivations for proliferation would seem to add an order of magnitude to the difficulty of the present analysis. If states acquire nuclear weapons for a multitude of reasons, examining whether this acquisition is economically efficient would seem to require more comparisons, with each one examining whether the nuclear weapons were more economically efficient than the conventional equivalent in the security, domestic politics, and norms models, to take only Sagan's views of why states would acquire nuclear weapons.

### **How much do Nuclear Weapons Cost, Exactly?**

To be sure, by almost any measure, nuclear weapons are expensive. According to Schwartz, the amount spent by the United States from the dawn of the atomic age to 1996 is \$5.5 trillion (in 1996 dollars). This represents 29% of all military spending during this period. (p. 3) In fact, this sum is so large, it constitutes the third largest historical expenditure by the U.S. government

during this period, behind only national defense (non-nuclear) and social security. (p. 5)

As mentioned above, it may also be an underestimate. In addition to money spent directly on nuclear weapons, Schwartz makes the conservative estimate of 15% of general expenditures also being for nuclear weapons. The reason he could not be precise and had to opt for a conservative figure is that the “very size of the nuclear weapons complex, not to mention the secrecy surrounding many of its activities, the lack of rigorous accounting procedures, and poor historical records, make it extremely difficult to determine the costs incurred at each facility.” (p. 53) And this is considering only the United States, which has a history of being relatively open about military expenditure. The amount spent by the Soviet Union/Russian Federation is even harder to determine. In general, different political, administrative, and military structures will affect the methodology of identifying the costs of nuclear weapons. The case is most evident in the differences between the United States and Soviet Union, but is also the case for the other nuclear states, and indeed the nuclear latent states. That being said, “the intertwined nature of the Soviet political, economic, and military systems makes separating costs much more difficult. Also, there is and was much stricter security regarding such information and a general attitude away from such questions in the Soviet culture. The best that can be determined is that such costs were similar to the US, though given the smaller size of the Soviet economy, it represented a much greater burden.” (Schwartz, p. 611-12)

Given the caveats above, we do still have a much more accurate picture of the current amount spent on nuclear weapons. According to publicly available data analyzed by Schwartz, which

includes government reporting on the nine categories of expenditure listed above, the current amount spent by the United States stands at \$35 billion per year, “with about \$25 billion going toward operating and maintaining the arsenal and the remainder allocated to environmental remediation and waste management, arms reduction measures, and the storage and disposition of excess fissile material (these figures are in 1998 dollars).” (p. 31) Knowing this, we return to the question of what this figure means.

### **Nuclear Weapons Are Cheap *or* The Economic Incentive for Nuclear Weapons**

The initial idea that nuclear weapons are economically efficient dates to 1946, mere months after their first use, appearing in an essay by none other than Robert Oppenheimer himself. While he too had difficulty in calculating the total costs of their production, which is important given that he oversaw the production of the world’s first nuclear weapons, he was nonetheless sure of their relative costs. He wrote that “none of the uncertainties (in the total cost of nuclear weapons) can becloud the fact that it will cost enormously less to destroy a square mile with atomic weapons than with any weapons hitherto known to warfare. My own estimate is that the advent of such weapons will reduce the cost, certainly by more than a factor of ten, more probably by a factor of a hundred.” (p. 67) This formulation, however, does run into problems. Oppenheimer is here stating that the military efficacy of nuclear weapons is related to the ability to destroy a square mile. This ignores the possibility of other uses for nuclear weapons outlined above. Such destruction was and is seen as a means to achieve an end, namely the surrender of the enemy. Thus the goal of the weapon is not the destruction of the square mile per se, but the surrender. The destruction is only a means to an end. Saying that they are

dangerous because it is cheaper to perform that destruction conflates these ultimate goal with the intermediary one.

That being said, the reason he could be so sure that nuclear weapons are cheaper than their alternative, despite not having an exact count of their costs in what was likely the best possible instance for calculating this figure, lay in a comparison with the direct material costs of producing conventional explosives in amounts comparable to nuclear weapons in destructive power.

### **They Are Cheap Because the Materials are Cheap**

The idea that nuclear weapons are inexpensive because their material costs are low is a seductive one. The amount of matter “that you could hold in one hand, if fashioned into a bomb, could destroy an entire city with blast and mass fire, a scale of destruction that by 1943 would be barely within the capability of a fleet of a thousand Allied heavy bombers loaded with conventional high explosives and firebombs.” (p. x) Based on this, it is not hard to come to the conclusion that atomic weapons, as they were first called, are “hundreds, even thousands of times less expensive than conventional explosives. ‘Ton for equivalent ton, atomic explosives are vastly cheaper than ordinary explosives... Atomic explosives vastly increase the power of destruction per dollar spent, per man-hour invested; they profoundly upset the precarious balance between the effort necessary to destroy and the extent of the destruction.’” (p.64-5) Additionally, the following quote, and its date illustrate the issue of the economics of nuclear weapons quite well: “Even if the atomic bomb shortens the war by only nine days, its financial

cost will have been more than justified. President Truman announced the project has cost \$2,000,000,000. Treasury experts said Tuesday this represents the cost of less than nine days of war, at the present rate of spending.” It is from the Edmonton Journal, dated August 7th, 1945 - one day after the bombing of Hiroshima and two days before the bombing of Nagasaki. The article was titled “Atomic Bomb Seen as Cheap at Price”.

Another example: according to Johnston (2009), a single W-53 thermonuclear warhead, of which there were approximately 60 built for the US arsenal, had a yield (explosive power) of nine megatons, the equivalent of three times the explosive power of all the bombs dropped during the Second World War, including both nuclear weapons. The cost of producing such a weapon, including development and other related costs, would obviously have to be several orders of magnitude lower than the costs of producing and delivering the equivalent destructive power in conventional munitions.

This is a view to which Schwartz adds both additional supporting information and some of the consequences of this thinking. He writes that both Truman’s and Eisenhower’s defense policies were “predicated on the assumption that nuclear weapons were a cost-effective means of addressing the Soviet military threat... The general notion that nuclear weapons are less expensive than conventional ones can be traced to the fact that a given amount of fissile material (plutonium or highly enriched uranium, HEU), when fissioned in a nuclear bomb, can produce more explosive power than an equivalent amount of conventional high explosives. Therefore, the reasoning went, while 10 pounds of high explosives might kill or injure 100

people, 10 pounds of plutonium could kill or injure 100,000 people.” (p. 18) The simple fact of the relatively inexpensive explosive power of nuclear weapons had consequences for military planning.

### **The Economic Promise of Nuclear Weapons**

Nuclear weapons were seen as an economic salvation as they could provide a level of deterrence that, if even possible with a regular army, would require an enormous diversion of state resources to achieve. The massive build-up of Soviet conventional forces at the end of the Second World War was seen as a daunting challenge for the United States to match. Per unit costs for the Soviets were much lower, but the destructive power of nuclear weapons could even the field. “This outcome [military security at the cost of economic ruin], McMahan proposed, might be prevented by increasing reliance on the atomic bomb. Although a ‘hideous weapon,’ it could, if deployed by the thousands, deter Stalin.... The ‘startling fact,’ he continued was that atomic deterring power was ‘actually hundreds of times cheaper than TNT.’

Money spent upon the atomic bomb could pulverize a dozen enemy war plants at no more expense than destroying a single plant with TNT, to say nothing of the fact that one plane can deliver one A-bomb as against the huge armadas deeded to deliver an equivalent cargo of block-busters.... If we mass-produce this weapon, as we can, I solemnly say to the Senate that the cost of a single atomic bomb will become less than the cost of a single tank. (p. 19)

Not only could nuclear weapons allow the United States to deter the Soviet Union in a cost-effective way, it would allow the US to redirect its resources to a higher overall standard. A leaner, nuclear-equipped armed forces would allow the US to spend more in other areas. "This would save the country from economic ruin because in all logic and common sense, an atomic army and an atomic navy and an atomic air force ought to mean fewer men under arms. They ought to mean a major reduction in the tens of billions of dollars we would otherwise spend upon stacks and stacks of conventional armaments. They ought to mean a sloughing off of outmoded operations and out-dated expenses." (p. 20) Interestingly, the reverse of this situation now holds for Russia. Where once the West used nuclear weapons to counter the conventional superiority of the Soviet Union, now it is Russia that clings to nuclear weapons to make up for weaknesses in its conventional forces. As Yost writes, "The second function is to serve as an 'equalizer' or 'counterbalance' to the conventional force superiority of potential adversaries. That is, NSNF might compensate for Russia's shortcomings in conventional military capability and thereby enable the country's armed forces to avoid defeat in combat." (p. 535) However, the idea of nuclear weapons being able to inexpensively counter conventional superiority led to fears of the consequences of the economic efficiency of nuclear weapons.

### **Consequences of Nuclear Weapons Being Cheap**

The idea of the incredible cost-effectiveness of nuclear weapons gave rise to fears, from Oppenheimer and others, that any nation that had the resources, and there would soon be many nations in this category, would pursue and develop these weapons. Among liberal and neo-liberal international relations scholars, this proliferation of weapons would be an

unmitigated disaster as it would increase the chances of use, either deliberate or accidental, exponentially. Brito and Intriligator, writing in 1993, believed that economic incentives would play a significant role in nuclear proliferation, leading to significant global instability. They write that “there has been an increase in the value and a decrease in the cost of acquiring nuclear weapons, making proliferation a more attractive option for many nations and presenting a major threat to global security.” (p. 289) However, as we saw, the military utility of nuclear weapons fell far short of their initial promise. Thus the indirect roles they could play come to the forefront of this analysis.

### **They Are Cheap Because of the Outcome They Produce**

Another way to calculate the economic efficiency of nuclear weapons is to evaluate not just their upfront costs, but the outcome they produce. If nuclear weapons can help bring about a high priority national security goal that would not be possible with conventional weapons, then even if the former are more expensive in terms of direct costs, they would be judged to be economically efficient. This is case with the view that the first use of the bomb on Hiroshima shortened the war, as seen in the quote from President Truman. A few other examples illustrate this point well.

The first concerns the strong belief by some in the United States that the Strategic Defense Initiative (SDI) was a major cause of the implosion of the Soviet Union. If true, nuclear weapons, which were at the heart of SDI, would have achieved the primary national security goal of the United States. Former Secretary of Defense and retired General of the Armed Forces Robert

Gates writes that by 1983 “already panting hard as they tried to keep pace with current and prospective U.S. military deployments, the Soviet leaders were left breathless by one U.S. military initiative that, in its ambition and implications, truly horrified them - Reagan’s determination to build a space-based ballistic missile defense.” (p. 539)

It is a view with which Richard Allen agrees, writing of SDI that is “scared the hell out of the Russians. They were not sure whether they should believe it or whether it was a massive hoax. They rolled out all their propaganda tools to counter it, they blustered and threatened, but to little avail.... Their antiquated command economy and pitifully weak technological base, at least fifteen years behind in computer technology, could not hope to sustain an effort against a determined and wealthy Western adversary.” (Atomic Audit, p. 297) Using nuclear weapons as a tool in an economic struggle is a lesson the Russians learned well.

The second example involves Russia’s use of nuclear weapons to maintain global relevance when faced with the deterioration of its conventional forces. Martin Hellman (2012) writes about Russia’s reliance on its nuclear weapons as a counterweight to American military superiority. In his view, because of their conventional military inferiority, “Russian war-fighting plans depend heavily on nuclear weapons. [American] military spending is about ten times larger than Russia’s, giving us unquestioned conventional military superiority. This causes Russian war-fighting plans to be heavily reliant on the use of nuclear weapons if our nations come into conflict over Georgia or some other hot spot.” (p. 7)

In and of itself, this fact may not necessarily indicate that nuclear weapons are cheaper than a large conventional army. It is possible that Russia's reliance on nuclear weapons is a leveraging of expenditures already made by the Soviet Union. Where once it boasted conventional superiority over the United States, Russia now clings to its nuclear arsenal as its counterweight.

Lastly, nuclear weapons were seen by some as being inexpensive as they produced desired outcomes for middle powers that were not possible with conventional forces. As Sagan outlines, a state may have different motives for acquiring nuclear weapons. In the case of national security and international prestige especially, nuclear weapons are seen as providing the security and status of an unaffordable large conventional army. In the case of national security, given the threat of the overwhelming conventional superiority of the two super powers, middle powers would naturally seek a security alliance with whichever of the super powers they most closely identified with. However, the dependency for national security is an uncomfortable position for many states. Nuclear weapons opened up the possibility of a more independent path. As Avery Goldstein writes, "As they (middle powers) contemplate the military strategic component of a more independent national security policy, both are likely to recognize one of the few clear truths about the nuclear era: Over time, maintaining nuclear forces sufficient for retaliatory threats as part of a deterrent strategy is less costly than maintaining conventional forces sufficient to deny a great power adversary its military objectives as part of a defensive strategy." (p. 505) Clearly then, there are examples of states that saw nuclear weapons as cheaper than their conventional counterparts. This does not mean, however, that the case is settled. The historical record is far from conclusive.

As shown above, calculating the cost of nuclear weapons is difficult. Pricing nuclear weapons is difficult because they have long development periods and can be subject to shifting goals. Sagan outlines some differing motives for acquiring nuclear weapons, which complicates the evaluation of how well they achieved those goals. Schwartz provides a very good summary of past expenditures by the United States on nuclear weapons, but he benefits from the ability to look back on costs over decades. For political leaders in the present, there is much more uncertainty knowing what these weapons will cost in the future. There is evidence that they were seen by many as being inexpensive based on the radically more efficient explosive power and on the outcomes they seemed able to produce. This view has at its core the idea that nuclear weapons replace large conventional armies that would be needed to create the same destruction, or induce the same outcomes. However, contrary to the examples above, there are cases where states contemplated acquiring nuclear weapons, but found the value did not justify the cost.

### **Nuclear Weapons Are Expensive**

That nuclear weapons are expensive comes from a couple of factors. The first is the upfront cost, including setting up the entire infrastructure to refine uranium or plutonium, design and develop a warhead, and develop a means of delivery. The second factor involves hidden costs that are not often taken into account by those who argue that nuclear weapons are inexpensive. This includes things such as the expense of highly trained personnel to monitor and operate the weapons and the elaborate security protocols that must accompany the

weapons at all times. Other costs that make nuclear weapons expensive include contamination from the refining process and accidents as well as decommissioning costs. There are also indirect costs to nuclear weapons that can apply to some states seeking their acquisition that are based on violating international norms surrounding their acquisition. Lastly, there is evidence that nuclear weapons did not serve the function described wherein they replace a large conventional army, rather, their cost was simply added to existing military budgets.

The view that nuclear weapons are expensive compared to any conventional alternative has a surprisingly long history in analysis of military spending. While we have seen early reports of the relatively inexpensive nature of nuclear weapons when they were first developed, we also find a strain of thought dating to the early 1950s, about the many costs of these weapons, before much experience with the devices could be had. Indeed, Army chief of staff General J. Lawton Collins “noted at a press conference on September 6, 1952, that non-strategic nuclear weapons would not reduce ‘the number of divisions required initially for the defense of Europe,’ but they would ‘result ultimately in the ability to do the job with a smaller number of divisions.’ After studying the issue in two-sided war games during the winter of 1952-53, Lieutenant General James M. Gavin, commander of the Seventh Army Corps, observed: ‘More rather than less manpower would be required to fight a nuclear war successfully.’ (Schwartz p. 20-21) It is perhaps important to note here the role that simulation, abstract models and war-gaming play in the calculation of costs for nuclear weapons. Given the paucity of experience in the use of these weapons, many discussions surrounding nuclear weapons have a heavy speculative element. Many calculations of the cost of these weapons compared to conventional

alternatives involve anticipating the actions of several actors in complex simulations. While not ideal from an analytical perspective, it is nonetheless a necessary action.

Despite the rapid build-up of nuclear weapons in this era, this view was not an isolated one. In fact, in 1953 “General Matthew P. Ridgway, the supreme Allied commander Europe (SACEUR), ‘held that the new tactical nuclear weapons would not only demand more manpower but would also increase the cost of defense to the taxpayer.’” His successor, General Alfred B. Gruenther, cautioned that ‘new weapons frequently have the effect of adding new problems and new tasks without eliminating those that previously confronted us.’” (Schwartz, p. 21) This idea, that nuclear weapons simply add costs, rather than replace one part of the armed forces, strikes at the heart of the economic argument for nuclear weapons.

### **The Hidden Costs of Nuclear Weapons**

One of the surprising findings that has come about since deployment of nuclear weapons, and one that both would have been difficult to predict but that seriously undermines the idea that nuclear weapons are a cheaper alternative, is that these weapons ended up requiring a large amount of personnel time. Each weapon, and further each battery of weapons, requires highly trained maintenance and security teams, as well as specially fortified facilities. Because of the risk that nuclear facilities themselves would be targeted for attack, there were extensive costs around secrecy of locations and presence of weapons at any one location.

As Avery Goldstein writes, “The opportunity costs of competing with a superpower in the creation of limited retaliatory options would be staggering for such states, especially since producing the weapons is only a necessary and not a sufficient condition for the effectiveness of this sort of deterrence. The strategy of deterrence that relies on threats of limited retaliation also requires extremely durable command and control. Indeed, this may be the technologically and economically more formidable obstacle for a resource-constrained second-ranking power.” (p. 486) In this case, limited retaliation is a nuclear strike capability that does not rely on massive numbers of weapons to ensure its survivability. Middle power countries could not afford the massive arsenals of the superpowers. The United States and Soviet Union could build tens of thousands of weapons and scatter them across their huge countries, not to mention in missile submarines, and thus ensure that at least some of these weapons would survive any attack. But the small arsenals of the other nuclear states were vulnerable to being taken out in a surprise first attack. While the logistics of a large arsenal presents its own challenges, middle powers had to make sure that their weapons and command and control structures could survive a first attack in order for the deterrent value of the weapons to be realized.

The costs mentioned by political and military leaders when discussing the decision to acquire nuclear weapons often concern only the cost of the production and deployment of the weapons, namely the materials, personnel, and to some degree the opportunity cost of having large numbers of a country’s scientific community working in this field. This last element, the opportunity costs, does not appear in much of the academic literature. Some work on the question has been done by John Page and Ramesh Thak with the Asia Pacific

Leadership Network for Nuclear Non-Proliferation and Disarmament. But what is rarely mentioned is the long term costs of maintaining a nuclear arsenal.

### **Long Term Costs to Nuclear Weapons**

Certainly the rapid build-up of arms by the United States and Soviet Union saw little attention paid to the costs of maintaining such arsenals. "The preceding analysis has demonstrated that for all the reasons behind the build-up of U/.S. nuclear forces, military and civilian policy-makers paid too little attention to the short- and long-term costs of the policies they sought to enact." (Schwartz, p. 31) This is a serious oversight that significantly weakens any argument that nuclear weapons are economically efficient as the long-term maintenance, upgrading, and replacement costs have been increasingly shown to be significant.

Indeed, Doyle writes that there is "the large financial cost of a nuclear deterrent. Maintaining its current arsenal [at the time of writing] of over 10,000 nuclear warheads costs the United States approximately \$31 billion annually. By comparison, the combined US international diplomacy and foreign assistance budget is approximately \$39bn per year." (p. 25) Most of these weapons were designed and built in the 1970s and 80s, during the Cold War, and have set lifespans. To replace these weapons with modern versions will be an enormous strain on defense budgets. Doyle, again, writes that current plans "call for the modernisation of US nuclear weapons manufacturing infrastructure and the construction of a new generation of nuclear missiles, bombers and submarines. This will cost hundreds of billions of dollars over the next 20 years." (p. 22) What to do with a nuclear weapon that is at the end of its planned operational life is another consideration that adds to costs.

Decommissioning of nuclear weapons is another related cost that is rarely taken into account in their initial procurement. It is a perfect example of the hidden costs of nuclear weapons as the very element that makes nuclear weapons so qualitatively different, and that was used early on to argue for their incredibly low costs, is the thing that over time will end up costing quite a bit. On a pure comparison between conventional explosives and nuclear explosives, decommissioning for the latter is orders of magnitude higher. Conventional explosives are easily decommissioned in a controlled explosion. Nuclear materials require large complex facilities with many highly trained staff to carefully extract the materials from warheads, and even then, a final solution to the materials is hard to find. The uranium and plutonium from their cores will remain dangerous and toxic for thousands of years. Whether burying the materials, encasing them in glass, or other means, it is a very involved and very expensive process.

This point, about decommissioning, can be expanded to the wider role of nuclear weapons. If they replace not only conventional explosives, but entire sections of an army, then the legacy costs of those elements must be taken into account. Tanks and airplanes have set lifespans and troops have health care and pension costs to consider. If nuclear weapons are replacing these, they are also replacing their legacy costs. However, except in the case of long-term personnel costs, the cost for decommissioning conventional weapons are relatively upfront and only one-time. Metals can be recycled, other materials consigned to a landfill, etc. Replacing those legacy costs with the need to decommission nuclear weapons is a losing proposition.

### **Cost Did Deter Some States**

Several authors have found that, contrary to Oppenheimer's view that the simple economics of nuclear weapons would prove very powerful, many countries found the upfront costs of developing nuclear weapons daunting. Stanley Erickson (2001) argues that the upfront costs of nuclear weapons is what prevents many countries from pursuing them. He writes that a key factor "against proliferation has been the financial cost involved. The cost of nuclear materials and a weapons program is prohibitive for the smaller or less developed states of the world. Any state with a gross national product (GNP) significantly less than that of pre-war Iraq would be hard pressed to devote enough annual government funding to a nuclear weapon program to actually achieve positive results within a reasonable time, say 10 years." (p. 43) Certainly, the cost of developing an independent nuclear weapons program played some role in the decision by some political leaders to pursue this path.

It seems only the United States and the Soviet Union could, at some level, ignore costs and pursue massive weapons programs, each using the threat posed by the other as justification. For other countries such as Australia and France, the question of cost played a large role in determining whether to develop nuclear weapons, and if so, how many.

In the case of Australia, an independent nuclear weapons program was considered early on in the atomic age. However, the cost was deemed to be too high, thus providing solid proof that the cost of nuclear weapons outweighed their utility in at least some cases. Australia already

invested significantly in its defense in the 1950s. In fact, according to the Australian Bureau of Statistics (2001) defense spending as a percentage of GDP was higher during the 1950s than in the immediate post-war period, and higher than in any decade since. If nuclear weapons were clearly economically efficient, the country would have been persuaded to find room in the budget for this expense. However, T.V. Paul (2000) writes that the cost of “an independent nuclear force was another consideration during the 1950s. In the early years of the nuclear age, Australian leaders had argued that development of nuclear weapons was costly. Prime Minister Menzies told Parliament in 1957 that the country could not develop an independent nuclear capability ‘because of the prodigious expenditure involved.’” (p. 81) This example is tempered by the fact that the economic efficiency of nuclear weapons may only become apparent over longer periods of time. It is possible that Australia was put off by the high upfront cost of the weapons, but would have realized savings over the ensuing decades. However, this possibility runs counter to the examples cited above where unexpected long-term costs of the weapons are poorly understood when the decision to acquire them is made. Thus it is equally possible that Australia would have paid a great deal upfront to produce nuclear weapons, only to find out later that the cost of maintaining them was much higher than anticipated and negates any savings.

Add to this financial cost the impact on norms of behaviour for states, which have come about since the Nuclear Non-Proliferation Treaty (NPT), and the costs mount even more.

### **Indirect Costs of Nuclear Weapons**

The massive and indiscriminate nature of nuclear weapons have led to the development of powerful norms surrounding their use. The NPT was created specifically to cement these norms in a way that limited their proliferation in the short and medium term, and eventually led to their elimination. A state that would now seek the acquisition of nuclear weapons would thus have to incur the costs of going against these norms. This can be seen in the imposition of economic sanctions against Iran on the suspicion that it is pursuing nuclear weapons, and against North Korea for having developed its own arsenal. Thus any state that would seek these weapons would have to not only pay the costs of development, they would suffer from economic sanctions for having done so. Indeed, Erickson goes on to say that the “two most significant negative factors dissuading states from nuclear proliferation appear to be the cost of the program and the fear of discovery and military consequences [of discovery].” (p.44)

Knowing then, that nuclear weapons are a large upfront expense that nonetheless hold potentially tremendous economic promise, but also hidden costs that undermined that promise, how is one to know if those costs are justified?

### **Problems with Determining Value**

The way that costs for nuclear weapons are calculated has serious implications for their value. Bush writes with regards to this idea: “The cost of trinitrotoluol, the TNT that is the most common high explosive, is less than a dollar a pound when it is manufactured in quantity. Built into bombs, delivered on a target hundreds of miles distant by an intricate aircraft manned by a highly trained crew subject to the attrition of war, its cost may well mount to hundreds of

dollars a pound. Behind this ratio lies the opportunity for gross fallacies in reasoning....

Moreover, it is not to ignore the important element that the cost of atomic bombs is largely a peacetime cost, for they cannot be manufactured in a hurry during war, as can high explosive. Costs, that is, effort in terms of labor and materials, are necessarily spread over a long interval to produce atomic bombs, and this fact greatly affects our reasoning concerning them.” (p. 94, 106) This view supports the contention that a long development period complicates the evaluation of the economic efficiency of nuclear weapons, as detailed in the section above. But even without knowing the exact cost of nuclear weapons, we can still make an evaluation that they are economically efficient if there are clear examples of deployment of these weapons being used to reduce other military expenditures. Unfortunately, the evidence for this is mixed.

### **Did Nuclear Weapons Reduce Military Expenditures?**

Contrary to the view that nuclear weapons were and are used to replace or make up for more expensive conventional forces, there is clear evidence that did not happen for at least some nuclear states. Chakma (2011) writes that there is a myth

“in some circles that a nuclear deterrent is cheaper than conventional forces and nuclear weapons are a substitute for conventional military capability. But the fact of the matter is that even if a state acquires a nuclear deterrent, it still has to maintain adequate conventional capabilities. As the Kargil conflict has highlighted, India and Pakistan would need to maintain conventional capabilities despite their possession of nuclear weapons.

According to Reddy, nuclear weapons have not reduced spending on conventional weapons, rather they have further burdened the Indian economy.” (p. 218)

Further, the means by which nuclear weapons are added to militaries has a large impact on the evaluation of their economic efficiency. If the means through which they are added to the military does not respond to some military need, and in fact, they are simply added to existing budgets for reasons outside of military utility, the economic efficiency of nuclear weapons is not tested. There is strong evidence that this was in fact the case for the United States.

Schwartz writes, that “as the production of fissile material increased and more efficient and smaller designs were introduced into the stockpile, there was no effective check on the ability to field larger numbers of different types of weapons, which were, in any event, treated largely as free goods by the military. Indeed, the air force, navy, and army each assessed their nuclear requirements largely in isolation, without considering the forces of their sister services.” (p. 24)

The lack of well-defined goals led to behaviour that is not consistent with economic efficiency.

Schwartz writes further that “... the United States came to associate deterrence with tens of thousands of nuclear weapons. Logic and fiscal accountability were subordinated to uncertainty, fear, interservice rivalries, pork-barrel politics, and an ultimately futile attempt to maintain the upper hand in the face of unimaginable destruction.” (p. 27) This accumulation of nuclear weapons does not respond well to any of the motives outlined by Sagan. It is a mixture of national security, domestic politics and international prestige. The lack of a clear goal in a real world example makes the evaluation of their economic efficiency more difficult.

### **Unclear Roles for Nuclear Weapons**

As noted, an evaluation of the economic efficiency of nuclear weapons requires a clear understanding of the purposes for which they are to serve. However, if the real goals for which these weapons are pursued differ from the stated goals, then an evaluation of the quality of the weapons, per the definition above, becomes substantially more difficult. There is clear evidence that all three branches of the US military competed for a piece of the nuclear pie, not simply because of a national security imperative, but because they feared playing second fiddle to another branch. Amy Woolf writes that since “the early 1960s the United States has maintained a “triad” of strategic nuclear delivery vehicles. The United States first developed these three types of nuclear delivery vehicles, in large part, because each of the military services wanted to play a role in the U.S. nuclear arsenal.” (p. 2) It is a view that is shared by Schwartz, who writes that it is

“important to remember that although the ‘triad’ of nuclear bombers, land-based missiles, and sea-based missiles was and is often touted as a pragmatic and time-tested means both of ensuring that an adversary cannot, in a single blow, destroy the entire U.S. nuclear arsenal and insuring against the unforeseen catastrophic failure of any one leg, the triad itself developed not by design but in large measure because the air force and navy each wanted ‘a piece of the action,’ in the budgetary and mission-oriented sense.”  
(p. 189)

This lack of a clear role for nuclear severely undermines the possibility of a definitive pronouncement on their economic efficiency.

### **Maybe the Economics Are Not So Good**

In the 20 years since Brito and Intriligator laid out the reasons for increased proliferation of nuclear weapons, only India, Pakistan, and North Korea have acquired nuclear weapons, with India having already developed an initial capability in the 1970s. While it is possible that Syria and Iran have attempted to build the capability to produce nuclear weapons, they have not succeeded in doing so. Additionally, in that time, Libya gave up its nuclear program and Ukraine gave up the many weapons on its soil at the time of the dissolution of the Soviet Union. Other countries that face potential international instability and have the economic and technological ability to develop a nuclear weapons program, such as Japan, Brazil, and several countries in Southeast Asia, have not done so.

It is important to note that economic considerations may not be the sole or even largest determining factor in these decisions, thus tempering the evidence of the lack of proliferation as supporting the idea that nuclear weapons are expensive. There exist strong norms around their acquisition, as just one example of a non-economic factor that could help account, at least in part for the lack of proliferation.

### **Are Nuclear Weapons Cheap or Expensive?**

Oppenheimer believed that the biggest change wrought by nuclear weapons was actually economic. We could already destroy cities through bombing, now we could do it without thousands of planes and millions of tons of explosives. “The biggest change that atomic explosives have made in the nature of airpower is to decrease the cost of destruction... the atomic bomb by comparison dwarfs all other advances.” (p.71)

There is compelling evidence that nuclear weapons appeared to decision-makers as both extraordinarily inexpensive and surprisingly expensive. Masters and Way write that to many “in the U.S. government and military, atomic bombs looked like a bargain, a unique weapon that would offset the commanding Soviet advantage in ground forces still in Europe. President Truman slashed the military budget accordingly.” (p.vii) But other countries were clearly deterred by the cost, as we have seen. Indeed, the evidence of their effect on U.S. budgets, as shown by the White House’s own historical data in from WWII to 2014, does not show a clear pattern. Further, it is not clear, given the variety of roles these weapons play, as shown by Sagan’s analysis, that a simple exchange can be made between their costs and the costs for conventional alternatives since in some circumstances, there are no such alternatives.

Certainly, we can do away with the overly simplistic early evaluations of the economics of nuclear weapons by thinkers such as Oppenheimer et al. Gormley (2007) writes that a simplistic argument “downplays the burdensome challenges surrounding a state’s decision to go nuclear, including the huge commitment of resources, the extraordinary personnel requirements, and the determination required of leadership under adverse international pressure (including the imposition of severe economic penalties). Thus, the nuclear proponents’ case constitutes an

overly simplistic explanation of how and why states proliferate.” (p.190-1) To the extent to which economic factors do play a role, it does not appear to be one that supports proliferation.

Clearly, the cost of the weapons and supporting infrastructure was a deterrent to some countries. But that could be a function of their high upfront cost and not necessarily a reflection of the economic efficiency in the long run. In these cases, countries would not be able to afford a significant deterrent force in either the nuclear or conventional sense. However, in cases, like the one above outlined by Schwartz, where the cost of the weapons was not seriously examined, the economic efficiency of the weapons was absolutely not a factor. If the economics of nuclear weapons were not a significant factor in the decision around their acquisition, the very answerability of the question of their economic efficiency is thrown into doubt.

Understanding the economics of nuclear weapons is important because of their capabilities and the costs involved. Knowing the exact costs is difficult as is defining their goals and evaluating the degree to which they accomplish them. The methodological considerations outlined above detail the kind of analysis that would be needed to evaluate the economic efficiency of nuclear weapons, but the mixed historical record shows that states did consider economic cost at least in part. However, given that the roles they play are unclear and the ways in which they were added to defensive budgets, it is impossible to make a definitive pronouncement at present on the economic efficiency of nuclear weapons.



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