Trading Guns for Butter: Foreign Aid and Nuclear Proliferation

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Trading Guns for Butter

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by

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Foreign Aid and Nuclear Nonproliferation

In April 2009, while speaking at Prague’s Hradcany Square, President Barack Obama declared that the United States would “seek the peace and security of a world without nuclear weapons.” While acknowledging that it was unlikely to be accomplished in his lifetime, he pledged that United States would seek to “reduce the role of nuclear weapons in our national security strategy, and urge others to do the same” (White House, Office of the Press Secretary, 2009).

Since his Prague speech, the president’s greatest nonproliferation policy achievement is widely regarded to be the New Strategic Arms Reduction Treaty with Russia. In December 2010, The U.S. Senate made the final approval to the new arms control treaty with Russia, which only allowed each country to deploy 1,550 strategic warheads and 700 launchers within seven years. At the time of the treaty ratification, the United States had 1,950 deployed strategic warheads and 798 deployed launchers (Baker, 2010). This agreement represents a significant and unprecedented commitment to disarmament by Washington.

However, in the last decade, the international community has had a mixed record in its efforts to dissuade nascent nuclear states from seeking the bomb. On the one hand, Iran’s apparent appetite for a nuclear weapons capability has not
slackened despite a myriad of attempts to discourage its leaders from crossing the nuclear threshold, including threats to use military force, economic sanctions, and sabotage. On the other hand, Libya dismantled its nuclear weapons program in 2003, due in part to debilitating multilateral economic sanctions and Muammar Qaddafi’s desire to open his country’s struggling economy to international trade (Jentleson and Whytock 2005/2006).

Given the threat posed by proliferation and the wide variation in the success of policies to prevent the spread of nuclear weapons, scholars have sought to understand what strategies are most likely to discourage proliferation. A range of factors—from a country’s economic capacity, ideology, and to the strength of the nonproliferation regime—have been argued to affect decisions by governments to acquire nuclear weapons. One foreign policy tool that might affect the likelihood of proliferation but that has been overlooked in the scholarly literature is foreign aid. For instance, Ukraine became the country with the third highest nuclear arsenal after the United States and Russia when the Soviet Union dissolved. The United States has consistently granted foreign aid to Ukraine, mostly recently a $50 million aid package in 2011, to encourage them to remove the stockpiles of highly enriched uranium that ended in their possession after the breakup of the Soviet Union. Thus, in this thesis, I analyze whether foreign aid flows discourage (or possibility encourage) nuclear proliferation.

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1 Iran’s “lack of cooperation” (IAEA report, 6) is thoroughly detailed in the International Atomic Energy Agency (IAEA) in their November 2011 Report, “Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran”.
This thesis has five sections. First, I review the existing literature about nuclear nonproliferation, arguing that there is a void in the literature on how foreign aid can be used as a foreign policy tool to foster nonproliferation in recipient countries. Second, I introduce several new hypotheses on the possible relationship between foreign aid and nuclear proliferation. Third, I outline my research design and describe the variables and measures I use to test these hypotheses. Fourth, I discuss the results of my analysis. I find that the direction of the relationship specific sectors of foreign aid have on the presence of a nuclear program does not necessarily also hold true for the presence of a nuclear program. In the first model I conclude, all three aid sectors (humanitarian, trade and energy) have different relationships in their effect of a nuclear program compared to their effects on the presence of a nuclear weapon. These results are presented in greater detail in the results and analysis section. Finally, I describe the policy implications of these findings and directions for future research.

**Literature Review**

The U.S. government’s emphasis on nuclear nonproliferation can be traced back to the 1960s when, for the first time, a country other than the United States, its closest allies, and the Soviet Union began developing an independent nuclear capacity. Following USSR’s refusal to arm China with a nuclear arsenal, Beijing took the matter into its own hands and successfully detonated a device in 1964. The acquisition of nuclear weapons by middle powers fed the perception that the nuclear-armed great powers needed to establish a nonproliferation treaty. Such an
agreement—the Nuclear Nonproliferation Treaty (NPT)—was initially ratified by the United States, the Soviet Union, and the United Kingdom in 1970.

The growing concerns about proliferation among policymakers also led to increased interest among scholars in understanding the reasons why states pursue nuclear weapons—the idea being that to limit proliferation in the future, we must identify the sources of the demand for the bomb.

There have been two major waves of research on proliferation. The first wave of literature is exclusively qualitative, and seeks to identify the factors that shaped government decisions to proliferate or to eschew the bomb through the in depth analysis of specific cases. The second wave of literature uses quantitative methods to identify the variables make proliferation most likely across the universe of cases.

Below I review the literature on the causes of nuclear proliferation. First, I summarize the findings in qualitative literature on the spread of nuclear weapons. Second, I discuss the quantitative studies and highlight the benefits of using a large-N approach to study proliferation. I also explore the differences between the main nuclear proliferation datasets and statistical approaches used in this literature, and identify how these differences affect their subsequent findings. Third, I underscore the limitations of current quantitative works, and argue that several variables—namely measures of foreign aid—should be included in the analysis of proliferation.
Qualitative Analyses of the Causes of Proliferation

There is a considerable qualitative scholarship on the demand-side of nuclear proliferation. For example, Sagan’s hallmark work (1996) examines why countries choose to proliferate. He states that there are three primary causes of nuclear proliferation. The dominant argument—the security model—theorizes that states may build nuclear weapons in order to “rely on self-help to protect their sovereignty and national security,” especially if these threats are nuclear (Sagan 1996, page 57). He argues that although often used by policymakers, this theory is difficult to test empirically because the most obvious evidence are statements by the decision makers themselves, who have a vested interest in demonstrating that their choices were motivated by national interest. Indeed, Sagan challenges the consensus that governments will only seek nuclear weapons when they face a “potential threat to (their) security” (1996, page 65). Sagan maintains that policymakers tend to focus an inordinate amount on national security considerations as an explanatory variable behind proliferation, and doing so risks ignoring several other factors that contribute to decisions by leaders to go nuclear.

Sagan argues that states may also be motivated to acquire nuclear weapons for domestic political reasons—namely to further the goals of political players or bureaucratic stakeholders. For instance, leaders may develop nuclear weapons to gain more votes in an upcoming election. The history of the Indian nuclear program, he argues, in particular the timing of 1974 nuclear test, seems to corroborate this

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2 Jacques Hymans (2006) similarly finds that security is used as a justification for proliferation decision by using content analysis of speeches by leaders of four major countries: India, France, Argentina and Australia.
theory. Sagan contends that there was no consensus among Indian officials that a nuclear deterrent was indispensible for national security purposes, and the decision to conduct a test in 1974 closely followed a period of weak support for Indira Gandhi's government. And, following the tests, the Gandhi government experienced resurgence in support, with public opinion polls showing strong support and pride in the nuclear weapons program and the government that made it possible.

A third reason governments pursue nuclear weapons is to enhance their prestige internationally. Here, Sagan references the case of South Africa, which developed a weapons program in 1974 but then subsequently chose to relinquish it voluntarily in 1989. He uses the case of South Africa to demonstrate that the policymakers in South Africa intended to use the program to increase its standing in the international community—not to increase the country’s security from external threats.

In another important study of the causes of proliferation, Etel Solingen (2007) conducts case studies of nine separate countries, and she categorizes regimes based on how they derive their legitimacy. Outward-looking regimes derive their legitimacy from economic growth achieved through trade on the global market, whereas inward-looking regimes depend on autarky and nationalistic ideals. Outward-looking regimes cannot risk the international opprobrium that follows a decision to violate the NPT, and therefore will choose not to proliferate. Inward-looking regimes are less dependent on international approval for legitimacy, and hence are more likely to pursue nuclear weapons programs.
A sociological model of proliferation, referenced by Sagan (2006) and advanced by authors such as Suchman and Eyre, and Finnemore, emphasizes the symbolic role of nuclear weapons and the perceptions of countries that possess them. Nuclear weapons, Sagan argues, serve the same functions as flags, airlines and even Olympic teams--countries acquire them in order to be seen as modern nation states. But he also notes that the concept of ‘prestige’ has changed over time. In the 1960s, it was considered very prestigious to possess a nuclear weapon; today it may be more prestigious to be a signatory of the NPT, even if for countries that are capable of producing a weapon.

He uses the case of France and Ukraine case studies to illustrate these points. According to his argument, France attained nuclear weapons in order to secure its position as an ‘important country’ after its emergence from World War II. In contrast, Ukraine’s decision to voluntarily give up the weapons that it fortuitously inherited after the end of the Cold War and the dissolution of the Soviet empire clearly shows how much the meaning of being a ‘nuclear’ country has changed since over time.

Jacques Hymans (2006) argues that it is leaders’ personalities that best explain why some countries choose to proliferate, while others do not. He describes four different types of so-called “national identity conceptions,” that leaders can possess. Only one of these fulfills the prerequisite profile to choose to develop a nuclear program, which he terms the “oppositional nationalist” (Hymans 2006, page 38). The oppositional nationalist sees the world in a dichotomy of “us against them,” and consequently they will desire a nuclear program as a means of being different.
or revolutionary, especially as compared with a superpower. He highlights a simultaneous dependency and resentment of the superpower as being the trademark of an oppositional nationalist, citing Maoist China’s relationship with the USSR as a classic example (Hymans, page 38). He concludes that nuclear proliferation is so rare simply because there are very few leaders who possess this requisite national identity conception in today’s world.

In short, the literature on causes of proliferation has, over the years, produced increasingly complex and detailed explanations for why leaders pursue nuclear weapons. To a certain degree, the goal of generalizability has been lost in these overly nuanced explanations, which are essentially specific to each country studied. Further, these studies tend to weigh only a few causes of decisions to acquire nuclear weapons, rather than testing simultaneously all of the possible determinates of proliferation. Increasingly, scholars have turned to quantitative studies to weigh the relative importance of the full range of causes of proliferation, providing a promising new way to look at the proliferation puzzle.

Quantitative Approaches to Studying Proliferation Decisions

Although there has been no dearth of qualitative studies of the motivations behind countries’ decisions to proliferate, there have only been a few quantitative analyses of nuclear proliferation. Although it is a relatively young field of study, quantitative studies of the determinants of nuclear proliferation have tremendous potential for future research.
The literature has relied almost exclusively on case studies to generate and test hypotheses regarding the demand among states for nuclear weapons (e.g., Sagan 1996; Solingen 1994; Solingen 1998, Solingen 2007, Hymans 2006). Examining proliferation only with case studies has yielded a “poverty of consensus” regarding the causal factors behind the spread of nuclear weapons (Singh and Way 2004). Scholars have recognized that the conditions that make one country prime for proliferation may not apply to another country in another time period. Consequently, as Singh and Way argue, analysts and policymakers have created many nuanced explanations for different countries in different time periods, with a concomitant inability to generalize across time periods and countries.

A qualitative approach does not reveal which causes of proliferation are generally most important. Since nuclear proliferation is, relatively speaking, a rare event in the history of countries, large-N quantitative studies are particularly useful for studying its incidence. Studying each year of the history of each country as a separate observation allows us to generalize what factors tend to cause proliferation choices. In particular, qualitative case studies tend to ignore the large number of cases of countries that have not proliferated. This commits the error of sampling on the dependent variable, and thus overemphasizes the threat of proliferation. The large number of countries and years that have never developed a nuclear program or a nuclear weapon are mistakenly ignored by qualitative studies (Singh and Way 2004, page 860). Large-N quantitative studies are able to counter this threat by identifying trends over the years—to identify those factors that lead to decisions to proliferate as well as those that lead to decisions not to proliferate.
In addition, statistical studies offer the advantage of being able to analyze the effect of multiple causes simultaneously, whereas case studies tend to study only a single cause (Singh and Way 2004, page 860). Indeed, if there is to be any accumulation of knowledge, we must consider the explanatory ability of several variables together.

Perhaps the most important advantage of large-N statistical studies is that they assume that the hypotheses being tested are probabilistic, whereas case study approaches tend to assume (at least implicitly) that they are deterministic. That is, if scholars find one or two cases in which a particular variable, say, security did not matter, they conclude that the insecurity is not a compelling explanation for proliferation. But the argument is that external threat simply makes proliferation more likely. Consequently, only a large-N analysis can accurately test this hypothesis (Singh and Way 2004, page 861). This is true of many other causes of proliferation as well.

**Two Key Quantitative Studies**

There have been two main quantitative studies that examine nuclear proliferation over time (Singh and Way 2004; Jo and Gartzke 2007). In this section, I highlight the differences in these studies in terms of how the dependent variables are operationalized and how the independent variables are measured. I then discuss their key findings.

In both studies, the dependent variables measure possible nuclear proliferation outcomes. Sonali Singh and Christopher R. Way (2004) analyze three
dependent variables: exploring nuclear weapons, pursuing a weapons program, and actually acquiring a usable weapons capability. They view proliferation as a “continuum instead of a dichotomy,” with the likelihood of each next stage in the process being dependent on the presence of the previous stage (Singh and Way 2004, 861).

In contrast, Dong-Joon Jo and Erik Gartzke (2007) observe the decision to proliferate as two separate dummy variables: the presence of a nuclear program and the possession of nuclear weapons. Their justification for this approach is that the former does not always necessarily lead to the latter. Since there are different factors behind the processes leading up to each outcome, and different policy solutions for each, it becomes crucial to make the distinction between the two.

The two studies also vary slightly in terms of which independent variables—that is, potential causes of nuclear proliferation—they examine.

Singh and Way examine three different categories of independent variables. First, they examine the role of technological determinants, which are those variables that determine a state’s ability to develop a weapons program.3 This includes such factors as the state’s level of economic development and industrial capacity. Second,

3 Strategic aid has been found to be indispensable in developing nuclear programs because of the extremely specialized technology and high cost of starting a nuclear weapons program. According to Matthew Furhmann, states have an incentive to provide their allies with technical assistance to develop a nuclear weapons program. He identifies three main reasons: to strengthen allies and alliances, strengthen relationships with enemies of an enemy, and to provide alternative energy sources (Furhmann 2009). This leads some scholars to conclude that if a state has the opportunity acquire a nuclear weapon, it will do so, or, on the flip side, that “whether states want nuclear weapons is irrelevant if they are unable to acquire them” (Gartzke and Kroenig 2009). Kroenig’s crucial empirical analysis (2009) demonstrates that the presence of sensitive nuclear assistance greatly increases the probability of nuclear proliferation.
they examine external determinants of proliferation, meaning those variables that account for the role of the international system and the incentives it provides for states to proliferate. In particular, this entails the extent of foreign threats to a state's security. Thirdly, they study the role of internal determinants of proliferation. This category comprises variables that account for whether the state is democratic, whether the governments are liberalizing, the presence of an autonomous political elite, and a measure of prestige, all of which they use as controls in their eventual quantitative study.

Jo and Gartzke argue that there are two categories of variables that influence whether states proliferate: factors that shape their opportunity to establish a nuclear program and build nuclear weapons and those that shape their willingness to acquire nuclear weapons. Opportunity variables account for whether states have the capability to produce a nuclear weapon, and measures of a state's technological prowess, access to fissile materials, and economic capacity. According to the authors, these variables will reveal whether or not a state can develop a weapons program, which is a necessary condition for a weapons acquisition.

The other category of independent variables includes those factors that affect willingness—or a country’s desire to possess nuclear weapons. Jo and Gartzke use Sagan’s research to identify three reasons why states want to proliferate: international security reasons, domestic political reasons, and prestige or symbolic reasons.

Of course, as Jo and Gartzke note, both opportunity and willingness are required for states to build nuclear weapons. Simply put, if a state does not have the
opportunity to develop a nuclear weapons program, proliferation is impossible. And there are countries with the opportunity to develop weapons that consciously choose not to. This highlights the importance of including variables that measure both willingness and opportunity in the model.

The findings of the studies are also divergent. Singh and Way’s analysis confirms several aspects of the ‘conventional wisdom’ on nuclear proliferation. For example, until a certain threshold of development is achieved, countries with higher development are less likely to proliferate. Above this threshold however, the relationship between development and nuclear weapons acquisition relationship is less certain. In addition, the argument that countries that choose to proliferate because they face some dominant security threat also holds true statistically. Finally, their study shows that countries that have more externally-oriented economic policies have a tendency not to proliferate, confirming Solingen’s research. Jo and Gartzke find that the number of states with weapons or programs is likely to grow at a gradual pace, and U.S. hegemony has the ability to influence proliferation significantly—by actually encouraging weapons possession. Although these prior quantitative studies are groundbreaking in that they allow us for the first time to assess the relative importance of multiple causes of proliferation across a large number of cases, they suffer from several limitations.

First, it is often difficult to find accurate information on the start and end dates of states’ nuclear programs, and different datasets use different dates, importantly resulting in different conclusions. For example, in Jo and Gartzke’s dataset, Israel is coded as beginning its weapons program in 1955. However, in
Singh and Way’s dataset, Israel is coded as having launched a weapons program in 1958, which is a three-year difference. Similarly, according to Jo and Gartzke, Israel possess an actual nuclear weapon in 1966, whereas according to Singh and Way, this does not happen until 1972, which is a much more dramatic twelve-year difference. When conducting time-series analyses of rare events, these gaps in time can and do have an impact on statistical results. Thus, these differences matter.

Second, the studies also use different measures for independent variables, which lead to varied results. For example, Singh and Way use a country’s per capita Gross Domestic Product (GDP) to measure its economic strength, and code its industrial capability as a separate variable. Jo and Gartzke, however, use a proxy for steel production to measure economic strength. Thus, if Country X has a low GDP per capita with a strong steel production sector, the study conducted by Jo and Gartzke may overemphasize its likelihood to have a weapons program due to its relatively strong steel sector. In contrast, Singh and Way may conclude that it is not as likely to acquire nuclear weapons because of its relatively low GDP.

Third, the current quantitative studies empirically confirm what is already believed to be true (Montgomery and Sagan 2009). Singh and Way conclude, for example, that most of their findings simply have the effect of reinforcing the conventional wisdom with statistical evidence. Thus, these results are not revolutionary in their potential impact on policy. Of course, testing existing explanations is an important contribution to our understanding of proliferation—and it is a necessary first step given that quantitative nuclear proliferation research as a field of study remains relatively young. That said, the moment is ripe for
scholars to incorporate new variables into these analyses, in order to examine the issue of nuclear proliferation from previously unexplored angles.

Most important, there is no study that examines the effect of a particular tool of foreign policy, such as foreign aid, on proliferation. Examining whether foreign aid, in particular, discourages or encourages proliferation may help policy makers identify more effective nonproliferation strategies.

**Hypotheses on Foreign Aid and Nuclear Proliferation**

Although a great deal has been written on the impact of foreign aid on development and economic growth (e.g., Burnside and Dollar 2000), less has been written on other outcomes of foreign aid, in particular its security implications. If scholars examine how foreign aid affects foreign policy, they typically study such issues as arms races (Collier and Hoeffler 2007) and military conflict (de Ree and Nillesen 2009).

That said, most scholarship on foreign aid recognize that external factors that affect the type of aid donors distribute (e.g., Alesina and Dollar 2000; Wright and Winters 2010; Svensson 1999) and who gives aid to whom (e.g., Maizels and Nissauke 1984). The factors that decide which countries are recipients and what category of foreign aid they receive includes a colonial history, economic ties, and importantly, strategic relationships. (Shraeder, Hook and Taylor 1998). If a recipient state is important to the donor state’s strategic interests, as defined by

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4 Alesina and Dollar break down these motivations donor by donor and empirically show the correlations between aid flows and several independent variables, including income, openness, democracy, UN membership, and so on (2000).
their foreign policy, they are more likely to receive foreign aid from a donor country than if they are peripheral to the donor country's interests. In other words, a desire to shape the target's foreign policy may influence to whom a state gives foreign aid. As Morgenthau (1962, page 301) asserts, economic aid "can indeed serve a political function when it operates within a political context."5

There is a very interesting literature, for example, that links foreign aid to UN membership or a holding a temporary seat on the UN Security Council. Kuziemko and Werker (2006) observe that a country experiences an average of 59 percent increase in U.S. aid when it rotates onto the UN Security Council. For our purposes, this suggests that powerful countries may use aid flows to influence the foreign policy decisions of weaker states. Thus, although there has been no substantive work relating foreign aid to nuclear nonproliferation, literature analyzing the strategic uses of foreign aid hints that foreign aid may be used by donor countries to dissuade the target country from beginning a nuclear program or acquiring nuclear weapons. And if the allocation of foreign aid is a common nonproliferation strategy, then it is essential to study its effects empirically to ensure that it has the intended effect—that is, that it does not inadvertently encourage the spread of nuclear weapons.

What is the effect of foreign aid on the recipient states' decisions to proliferate? Here I am going to focus on the likely consequences of foreign aid from

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5 Indeed, Morgenthau (1962, page 302) quotes Nehru, “the more underdeveloped and less viable a nation is, the greater is likely to be its urge to prove to itself and the world...that it, too, has arrived in the mid-twentieth century.” This assertion supports Singh and Way’s conclusion that the likelihood of proliferation is much higher at lower levels of development, and plateaus and may even decrease at higher levels of development.
the existing nuclear powers. This focus is justified because these countries also tend to be prominent donor countries that wield considerable influence with their foreign aid amounts.

With the exception of India, all of the current official nuclear countries are signatories of the NPT. Consequently, we would expect that any countries that receive substantial foreign aid from these donors would be less likely to proliferate. Why? The aid might explicitly be made conditional on the recipient country not proliferating. But it may be that countries that receive greater amounts of foreign aid from these donors are less likely to engage in any behavior that may threaten future aid flows—and acquiring nuclear weapons (and consequently violating the NPT) is one of those behaviors. Thus, the preliminary hypothesis is that countries that receive greater amounts of overall annual aid flows from one of the existing nuclear powers should be less likely to begin nuclear programs or develop nuclear weapons.

**Hypothesis #1:** Countries which receive greater amounts of overall annual aid flows from the existing nuclear powers are less likely to start nuclear programs or acquire nuclear weapons.

Do our expectations change if we break down foreign aid into different types of economic assistance? More specifically, will humanitarian, trade, and energy aid have different effects on the likelihood that recipient countries will proliferate?

It is likely that greater amounts of humanitarian aid, such as emergency response, reconstruction relief, disaster prevention and preparedness as well as debt relief, is likely to discourage the recipient from proliferating (see Appendix A
for detailed list of activities under each sector specified in this study). Most obviously, if a country is in need of emergency aid, it is unlikely that they are in a position to be able to start nuclear programs. But pursuing or acquiring nuclear weapons can also be an isolating decision for a modern country, given the stigma now attached to countries that seek to build the bomb. A country willing to take this decision must be able to afford the potential significant decreases in emergency foreign aid. Since this is unlikely among most recipient countries, I expect humanitarian aid to have a significant negative effect on the likelihood that a state either begins a nuclear program or acquires weapons.

**Hypothesis #2:** Countries which receive greater humanitarian aid from the existing nuclear powers are less likely to start nuclear programs or acquire nuclear weapons.

Countries that receive greater trade aid are also less likely to either start nuclear programs or possess nuclear weapons—but for different reasons. Trade aid generally aims to help recipient countries establish policies that are more compatible with international trade policy, and facilitate regional or multilateral trade agreements and negotiations. This type of aid tends to foster increasing integration into global markets. The stakes are high for countries receiving this type of aid, and consequently they are unlikely to distance themselves from the donor country by developing an unauthorized nuclear program or weapon. Trade aid is likely to have a stronger negative correlation with the presence of nuclear programs or weapons compared to countries who receive humanitarian aid. The latter group comprises of countries which need to immediately rescue themselves from conflict
or a natural disaster, whereas trade aid is likely to have a higher impact due to its long-term consequences.

**Hypothesis #3**: Countries which receive greater aid from existing nuclear countries for trade or business purposes are less likely to start nuclear programs or possess nuclear weapons.

**Hypothesis #3a**: Trade aid is more effective than humanitarian in deterring countries from establishing nuclear weapons or nuclear programs. Thus, countries which receive greater trade aid are less likely to develop nuclear programs or weapons than countries which receive greater humanitarian aid.

Again, countries that receive greater energy aid for purposes other than nuclear energy are less likely to pursue a nuclear weapons program. This is because if they receive support for non-nuclear energy, they have less of a need to establish nuclear weapons programs. However, receiving energy aid is unlikely to have an effect on nuclear weapons. Countries that wish to acquire nuclear weapons do despite the threat of isolation. Thus, receiving energy aid, unlike humanitarian or trade aid, is likely to have no effect on their willingness to build nuclear weapons. If these countries are willing to risk diplomatic isolation by developing a nuclear weapon, the threat of losing potential energy aid is unlikely to be a sufficient deterrent.

**Hypothesis #4**: Countries which receive greater energy aid from the existing nuclear powers are less likely to begin nuclear weapons programs, but the amount of energy aid is unlikely to have an effect on the possession of nuclear weapons.


**Research Design**

My statistical analysis focuses on the effect of foreign aid on recipient countries’ decision to either start nuclear programs or acquire nuclear weapons. As this is the first study of its kind, I examine the effect of foreign aid from the United States on nuclear proliferation. I chose to focus on the United States as the main donor because it has the greatest overlap in years from both my main sources of data: Jo and Gartzke’s study, as well as AidData (Nielsen et al., 2010) and the implications of United States foreign policy would arguably be much more influential than other major donors.

All measures of foreign aid from the United States are drawn from AidData, a development finance portal (see Appendix A). All amounts are in constant U.S. Dollars as of the year 2000. AidData has the benefit of coding aid flows by sector, and also by activity codes, which is a step higher in detail compared to just analyzing total aid flows. This allows us to analyze aid in different sectors as dependent variables, to see the impact specific sectors of aid can have on nuclear proliferation outcomes.

In this study, I used four sectors as four separate aid variables: total aid flows, which counts for aid for every available purpose in a given year, humanitarian aid, energy aid and trade aid. All variables are coded annually for each of the 198 recipient countries. For humanitarian, trade and energy aid, I picked the purpose codes that fell under the sectors that provided aid for these respective purposes. Similarly, under energy aid, I included all the aid for energy purposes, and
intentionally excluded aid for nuclear energy from this study. A detailed list of what codes were selected is provided in Appendix A.

The remainder of analysis replicates Jo and Gartzke’s study of the determinants of proliferation, adding the aid variables as independent variables to this study. I chose Jo and Gartzke’s dataset because it proved to be easier for modification than Singh and Way’s dataset, due to the two dependent variables. Acknowledging Singh and Way’s critique of Jo and Gartzke, that their study places a high emphasis on states that go nuclear very early, I modify the dependent variables in my second model, the multinomial logit, detailed at a later stage.

Jo and Gartzke’s dependent variables, again, are the presence of a nuclear program and the de facto status of nuclear weapons possession. In Jo and Gartzke's study, they code the presence of a nuclear program as starting the first year that the country’s highest decision maker authorized a nuclear program for official states, and the year the state’s highest decision maker officially ends a nuclear program as the last year it is coded as a ‘1’ value. For unofficial nuclear programs, or those not recognized by the NPT, the first year of a nuclear program is coded as the year the state’s nuclear activities increases considerably. Given an active nuclear program, they code for the first year a country possess a nuclear weapon as a ‘1’ value for the state’s de facto nuclear weapon status (See Appendix B for a list of the detailed coding rules for the dependent variables). Both of these variables are dummy variables, with a ‘1’ for the presence and ‘0’ for the absence of a weapons program or weapons possession in a given year, for a given country. Both dependent
variables are led by one year to ensure that the independent variables predate the dependent variables.

I also controlled for the independent variables examined by Jo and Gartzke, namely nuclear weapons production capability, economic capacity, conventional threat, the presence of rival nuclear weapons programs, the presence of nuclear defenders, diplomatic isolation, domestic unrest, democracy, NPT ratification, major power status and regional power status. Using these independent variables in addition to the aid variables will help us gain a broader understanding of their comparative effects (See Appendix B for detailed descriptions of independent variables). I exactly replicate their results with their dependent and independent variables, adding the aid variables, to affirm that my study starts off at the same point as Jo and Gartzke’s study.

Following Jo and Gartzke, I include two variables to control for autocorrelation in the dependent variable, Nonnuclear Years and Nuclear Program Years. They will count the number of years since 1973 that states do not have a weapons program, and the number of years since the state passed the first stage of nuclear proliferation, respectively. In addition, White robust estimation must be performed to correct for spatial dependence. Heteroskedastic error variance is corrected by clustering over states.

Models

There are three estimators used in the existing quantitative research on nuclear proliferation. Singh and Way opt for hazard and multinomial logit models. In
the hazard model, they examine the risk of exploring, pursuing, or acquiring nuclear weapons, given that this event has not yet occurred. In an event history model, once a state crosses a given threshold (e.g., explores nuclear weapons), it exits the analysis. In the multinomial logit model, they examine the probability that states explore, pursue, or acquire nuclear weapons, allowing for the possibility that states can move back and forth across these categories. That is, countries can move from exploring to pursuing nuclear weapons and then back again to exploring over time. However, Jo and Gartzke prefer a probit regression, coding a ‘1’ for every year that a state decides to go nuclear, and a ‘0’ for every year before. In this sense, every year a state decides to stay nuclear counts as an independent decision, according to Jo and Gartzke.

I will use two models in this study, a probit model and a multinomial logit model, to assess the effect of foreign aid on proliferation.

I first estimate a probit model that uses Jo and Gartzke’s dependent variables. However, a critique of Jo and Gartzke, and a fundamental limitation in their study, is that it places undue weight on states that go nuclear very early, as they have more years for which they receive a ‘1’ value, than countries that go nuclear much later. For instance, the United States receives a ‘1’ value for every year since 1945 that it has had nuclear weapons, whereas Pakistan only receives a ‘1’ value for every year since 1987. This affects the results of their analysis by overemphasizing the effect of states who develop programs early, and underemphasizing those who develop programs later. It makes the data appear as though there are far greater cases of proliferation than there are, and makes countries that proliferate earlier have a
much higher correlation with the dependent variables than may necessarily be true. However, understanding these limitations will allow us to interpret the results of the probit regression accordingly.

After first running an exact replication of their study and comparing my results adding the aid variables to theirs, I begin to address the limitations of their study. I then modify their dependent variables slightly, so that countries can either possess either a nuclear program or nuclear weapons—but not both simultaneously. This means that after the first year a country develops a nuclear weapon, I code the nuclear program variable as a ‘0’. This avoids double counting the impact of the foreign aid variables for nuclear weapons and nuclear programs, as states may have different motivations for each decision. This problem with this correction, however, is that countries that receive a ‘0’ for a particular year can be from two very diverse categories. This ‘0’ can include countries that have never even possessed a nuclear program, or countries that have a nuclear program and a nuclear weapon.

Finally, I also use a multinomial logit model. Using this estimator allows the study to overcome a potential critique of the modified dependent variable for presence of a nuclear program. In this model, the dependent variable places countries into three categories. Using Jo and Gartzke’s data, I create a new variable which codes every country for every year with either a ‘1’, ‘2’ or ‘3’ value. ‘1’ represents countries with no nuclear program or nuclear weapon. These are the same countries that code as a ‘0’ in the nuclear program variable under Jo and Gartzke’s study. A ‘2’ value represents a country that has a nuclear program, but no
nuclear weapon yet. This incorporates all country/years that receive a ‘1’ value under Jo and Gartzke’s variable for presence of a nuclear program, but excludes those that receive a ‘1’ value for both presence of a nuclear program and de facto nuclear weapon status under their study. Finally, countries receive a ‘3’ in this new variable from the first year they possess a nuclear weapon, according to Jo and Gartzke’s coding rules.

The benefit of this categorical coding over a hazard model is that it captures cases where a country to shift backwards from a ‘3’ to a ‘1’, if a country decides to give up its nuclear program willingly, such as South Africa in 1989, or unwillingly ends its nuclear program before developing a weapon, such as Japan in 1944. These rare events of reversal must be captured by the model. In a hazard model, these countries would slip away from the study entirely as they would just go back to a 0, rather than be captured as reversing to a previous stage in proliferation. This is a benefit of the multinomial logit model over the probit model.

A comparison of both models suggests that the multinomial logit model may be better for discerning the effects of different sectors of foreign aid on nuclear proliferation decisions of recipient states. It represents a more accurate categorization of the dependent variable, and overcomes the limitation of the possibility of countries with different nuclear statuses all being coded as ‘0’. Countries with no nuclear program could either have the economic capability but choose not to go nuclear for, say, normative reasons, or they could be poorer countries for whom nuclear programs are simply not an option, regardless of their motivation.
These two groups of countries being lumped together would likely skew my analysis of the effect of receiving of humanitarian, trade and energy aid on the probability of proliferation. Wealthy countries generally receive less aid for energy than poorer countries, and countries that are wealthier are likely to be more integrated into the global market, necessitating less trade aid than poorer countries. Putting these groups together would not be particularly useful in a quantitative study, as the value for trade aid or energy aid in each year would not distinguish between these two sets of countries.

Below I discuss the results of my analysis of the effect of foreign aid on a country's decision to acquire a nuclear weapon or a nuclear program.
### Results and Analysis

**TABLE 1a: Replication Model: Nuclear Program Status**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Original Jo and Gartzke Results</th>
<th>Exact Replication Results</th>
<th>Results with Aid Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latent nuclear weapons production capability</td>
<td>0.4836****</td>
<td>0.4735****</td>
<td>0.5087****</td>
</tr>
<tr>
<td>Economic Capacity</td>
<td>1.4826</td>
<td>1.3582</td>
<td>0.4736</td>
</tr>
<tr>
<td>Diffusion</td>
<td>1.0550****</td>
<td>1.0751****</td>
<td>0.3528</td>
</tr>
<tr>
<td>Conventional threat</td>
<td>0.7002***</td>
<td>0.6889***</td>
<td>0.6664**</td>
</tr>
<tr>
<td>Nuclear threat</td>
<td>-0.9140**</td>
<td>-0.8921**</td>
<td>-0.4121*</td>
</tr>
<tr>
<td>Nuclear defender</td>
<td>-0.0976</td>
<td>-0.0915</td>
<td>0.6243**</td>
</tr>
<tr>
<td>Diplomatic isolation</td>
<td>-0.0602</td>
<td>-0.0829</td>
<td>0.6828</td>
</tr>
<tr>
<td>Domestic Unrest</td>
<td>-0.1480</td>
<td>-0.1374</td>
<td>-0.1056</td>
</tr>
<tr>
<td>Democracy</td>
<td>-0.0262</td>
<td>-0.0220</td>
<td>-0.0618**</td>
</tr>
<tr>
<td>NPT ratification</td>
<td>-0.7809**</td>
<td>-0.7910**</td>
<td>-0.7720**</td>
</tr>
<tr>
<td>NPT (system effect)</td>
<td>0.0052</td>
<td>0.0048</td>
<td>0.0147**</td>
</tr>
<tr>
<td>Major power status</td>
<td>2.0000****</td>
<td>2.1239****</td>
<td>1.8841**</td>
</tr>
<tr>
<td>Regional power status</td>
<td>1.5491****</td>
<td>1.5001****</td>
<td>1.4446****</td>
</tr>
<tr>
<td>Trade aid</td>
<td>-</td>
<td>-</td>
<td>0.5353*</td>
</tr>
<tr>
<td>Humanitarian aid</td>
<td>-</td>
<td>-</td>
<td>-0.0907</td>
</tr>
<tr>
<td>Energy aid</td>
<td>-</td>
<td>-</td>
<td>0.1519</td>
</tr>
<tr>
<td>Count 1</td>
<td>-0.1132****</td>
<td>-0.1085****</td>
<td>-0.0939****</td>
</tr>
<tr>
<td>Constant</td>
<td>-6.3543****</td>
<td>-6.3952****</td>
<td>-5.0712****</td>
</tr>
<tr>
<td>Obs.</td>
<td>4,697</td>
<td>4,697</td>
<td>3,565</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-256.71</td>
<td>-257.055</td>
<td>-167.811</td>
</tr>
<tr>
<td>Pseudo R squared</td>
<td>0.824</td>
<td>0.824</td>
<td>0.816</td>
</tr>
<tr>
<td>Wald chi-square</td>
<td>644.5****</td>
<td>685.44****</td>
<td>2150.04****</td>
</tr>
</tbody>
</table>

N/countries=3565/128

Statistically significant parameter estimators using one-tailed tests are denoted by *

(p < .10), **(p < .05), *** (p < .01) and **** (p < 0.001)

Robust standard errors (adjusted for clustering by country)
In Figure 1a, I attempt to replicate Jo and Gartzke’s exact probit using their replication dataset. The minor differences between the results in column 1 and column 2 may have to do with the generation of the count variable. Since Jo and Gartzke’s count variable was not provided, I used the user-written BTSCS stata

TABLE 1b: Nuclear Weapons Possession Status

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Original Jo and Gartzke Results</th>
<th>Exact Replication Results</th>
<th>Results with Aid Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latent nuclear weapons production capability</td>
<td>0.0602***</td>
<td>1.1385****</td>
<td>1.7039****</td>
</tr>
<tr>
<td>Economic Capacity</td>
<td>6.548*</td>
<td>15.7992**</td>
<td>-6.2221</td>
</tr>
<tr>
<td>Diffusion</td>
<td>1.9503***</td>
<td>3.8335***</td>
<td>9.0294**</td>
</tr>
<tr>
<td>Conventional threat</td>
<td>1.3437****</td>
<td>1.1576****</td>
<td>1.2835***</td>
</tr>
<tr>
<td>Nuclear threat</td>
<td>-2.1532****</td>
<td>-2.1250****</td>
<td>-2.5750**</td>
</tr>
<tr>
<td>Nuclear defender</td>
<td>-1.3794**</td>
<td>-1.1753****</td>
<td>-3.0488****</td>
</tr>
<tr>
<td>Diplomatic isolation</td>
<td>1.6953*</td>
<td>-1.0225</td>
<td>1.1513</td>
</tr>
<tr>
<td>Domestic Unrest</td>
<td>0.4322****</td>
<td>-0.0378</td>
<td>-0.3051***</td>
</tr>
<tr>
<td>Democracy</td>
<td>0.0666</td>
<td>-0.0145</td>
<td>-0.0068</td>
</tr>
<tr>
<td>NPT (system effect)</td>
<td>0.0007</td>
<td>0.0086</td>
<td>-0.0109</td>
</tr>
<tr>
<td>Major power status</td>
<td>4.6929****</td>
<td>4.4368****</td>
<td>8.7259****</td>
</tr>
<tr>
<td>Regional power status</td>
<td>1.5459***</td>
<td>2.4878****</td>
<td>3.3398***</td>
</tr>
<tr>
<td>Trade aid</td>
<td>-</td>
<td>-</td>
<td>0.1411</td>
</tr>
<tr>
<td>Humanitarian aid</td>
<td>-</td>
<td>-</td>
<td>-7.3832***</td>
</tr>
<tr>
<td>Energy aid</td>
<td>-</td>
<td>-</td>
<td>14.2499****</td>
</tr>
<tr>
<td>Count 2</td>
<td>-0.0652*</td>
<td>-0.1148****</td>
<td>-0.0685****</td>
</tr>
</tbody>
</table>

Constant | -14.8721 | -21.0364**** | -44.0278*** |
Obs. | 4697 | 4697 | 3565 |
Log likelihood | - | -32.05 | -17.981 |
Pseudo R squared | - | 0.9665 | 0.9617 |
Wald chi-square | - | - | - |

N/countries=3565/128
Statistically significant parameter estimators using one-tailed tests are denoted by * (p < .10), **(p < .05), *** (p < .01) and ****(p < 0.001)
Robust standard errors (adjusted for clustering by country).
extension package to generate. Column 3 shows the comparison between Jo and Gartzke’s and the new model with the aid variables. In Table 1a, we see that using the old coding for the dependent variable for nuclear program causes the goodness of fit results to decrease when aid variables are added. This suggests that adding aid to the study decreases how well these variables predict a change in the dependent variable, nuclear program status. In addition, in comparing the r-squared value from Tables 1a to Table 2, where the dependent variable was re-coded, we find the goodness of fit decreasing even further from 0.816 to 0.6747. This decrease in the model’s overall fit can perhaps be explained by the limitations of the new ‘0’ value, explained at a later stage.

In figure 1b, we see that correcting for time dependency using the btscs method proves inaccurate in replicating the model used by Jo and Gartzke. Despite being unable to derive their exact method for deriving their count variable for the de facto nuclear weapon status variable, I continued running the model, using this as an added justification for the need to run the second probit (Tables 2 and 3) and subsequently, the multinomial logit model (Table 4). Here, even though the coefficient values are different, they are not representative of the strength of the correlation, given that it is a probit model. It is significant that all the directions of the relationship are the same in the exact replication in column 2, as it shows that despite the different count variable, the correlations are not affected.

---

In comparing this original replicated model with the new probit models proposed in tables 2 and 3, modifying the dependent variable improves the model’s fit—that is, it better predicts which states have nuclear weapons (see Table 3). In the original model for nuclear programs status, with the aid variables added, the R-squared value is 0.9665 (see table 1b), while it increases to 0.9617 in Column 3 of Table 1b and Table 3. While acknowledging the limitations of goodness-of-fit statistics, Jo and Gartzke assert that “these findings do show that the models are accounting for many of the determinants of nuclear proliferation” (2007, 176). After including the variables for trade aid, humanitarian aid and non-nuclear energy aid, I find that the R-squared value increases to 0.962. This results suggests that the foreign aid variables help explain which states will the possess nuclear weapons.

On the contrary, after including the foreign aid variables, the R-squared value decreases in the model examining the presence of a nuclear program, from 0.824 to 0.675. Note, however, that the coding of the dependent variable was changed from Jo and Gartzke’s original dataset. In this study, the dependent variable for the presence of a nuclear program only codes the years when a country has a nuclear program and no nuclear weapon as ‘1’, and codes years after a country has acquired a nuclear weapon as ‘0’. Reasons for this change are elaborated in the methodology section above. Given this change, the decrease in the R-squared value should not necessarily be interpreted as a decrease in the model’s explanatory capacity.
## TABLE 2: Effect of U.S. Aid on Presence of Nuclear Programs (Probit)

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Coeff.</th>
<th>S.E.</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latent nuclear weapons production capability</td>
<td>0.4081****</td>
<td>(0.086)</td>
<td>0.000</td>
</tr>
<tr>
<td>Economic Capacity</td>
<td>-5.7055</td>
<td>(12.126)</td>
<td>0.319</td>
</tr>
<tr>
<td>Diffusion</td>
<td>-0.4915</td>
<td>(0.461)</td>
<td>0.143</td>
</tr>
<tr>
<td>Conventional threat</td>
<td>0.3437</td>
<td>(0.288)</td>
<td>0.1165</td>
</tr>
<tr>
<td>Nuclear threat</td>
<td>0.1331</td>
<td>(0.322)</td>
<td>0.3395</td>
</tr>
<tr>
<td>Nuclear defender</td>
<td>1.0365****</td>
<td>(0.290)</td>
<td>0.000</td>
</tr>
<tr>
<td>Diplomatic isolation</td>
<td>0.2743</td>
<td>(0.503)</td>
<td>0.2925</td>
</tr>
<tr>
<td>Domestic Unrest</td>
<td>-0.0692</td>
<td>(0.108)</td>
<td>0.2605</td>
</tr>
<tr>
<td>Democracy</td>
<td>-0.7873***</td>
<td>(0.029)</td>
<td>0.0035</td>
</tr>
<tr>
<td>NPT ratification</td>
<td>-0.1300</td>
<td>(0.368)</td>
<td>0.362</td>
</tr>
<tr>
<td>NPT (system effect)</td>
<td>0.0131***</td>
<td>(0.005)</td>
<td>0.005</td>
</tr>
<tr>
<td>Major power status</td>
<td>-0.3696</td>
<td>(0.387)</td>
<td>0.1695</td>
</tr>
<tr>
<td>Regional power status</td>
<td>0.8441**</td>
<td>(0.455)</td>
<td>0.032</td>
</tr>
<tr>
<td>Trade aid</td>
<td>-0.8821</td>
<td>(0.945)</td>
<td>0.1755</td>
</tr>
<tr>
<td>Humanitarian aid</td>
<td>0.4735*</td>
<td>(0.309)</td>
<td>0.063</td>
</tr>
<tr>
<td>Energy aid</td>
<td>-7.2635 *</td>
<td>(5.132)</td>
<td>0.0785</td>
</tr>
<tr>
<td>Count 1</td>
<td>-0.0920</td>
<td>(0.0067)</td>
<td>-</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.6231</td>
<td>(1.4507)</td>
<td>-</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-202.3577</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pseudo R squared</td>
<td>0.6747</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

N/countries=3565/128  
Statistically significant parameter estimators using one-tailed tests are denoted by * (p < .10), **(p < .05), *** (p < .01) and ****(p < .001)  
Robust standard errors (adjusted for clustering by country)

The hypotheses for the presence of a nuclear program predicted that trade, humanitarian, and energy aid would have a statistically significant negative effect on the presence of a nuclear program. However, in Table 2, trade aid is not statistically significant, though it has a negative sign as predicted by Hypothesis 1.

Humanitarian and energy aid, however, are statistically significant at the 0.1 level. Surprisingly, humanitarian aid has a positive correlation with the presence of nuclear weapons. This suggests that, contrary to Hypothesis 2, the more
humanitarian aid a country receives from the United States, the more likely it is to have a nuclear program. That is, receiving aid for purposes of emergency response, reconstruction relief and recovery, and disaster prevention and preparedness makes a country more likely to begin a nuclear program.

Energy aid, on the other hand, has a statistically significant negative relationship with the presence of a nuclear program. Countries that receive greater amounts of aid for non-nuclear energy purposes are less likely to develop nuclear programs. This is consistent with Hypothesis 3, which states that countries that receive aid to find energy through a non-nuclear source are unlikely to desire nuclear energy, which is comparatively expensive and labor intensive.

To assess the magnitude of the effect of the foreign aid variables, I generated predicted probabilities—in particular discrete changes—using Clarify (King, et al. 2000; Tomz, et al. 2003). I find that when energy and trade aid are set to zero, and all other variables are set to their mean values, changing humanitarian aid from zero to its maximum value increases the probability of the presence of a nuclear program by 0.024. This result is not statistically significant at the 95 percent confidence interval, suggesting that increasing humanitarian aid does not substantially decrease the probability of a nuclear program.

Similarly, changing energy aid from zero to its maximum value, setting humanitarian and trade aid at zero and all other independent variables at their mean values, results in 0.006 decline in the predicted probability of the presence of a nuclear program. The change in predicted probability for energy aid is too small
be substantively significant in affecting the presence of a nuclear program. Indeed, the change is not statistically significant at the 95 percent level of confidence.

<table>
<thead>
<tr>
<th>TABLE 3: Effect of U.S. Aid on Presence of Nuclear Weapons (Probit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable</td>
</tr>
<tr>
<td>Nuclear Weapons Possession Status</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Latent nuclear weapons production</td>
</tr>
<tr>
<td>capability</td>
</tr>
<tr>
<td>Economic Capacity</td>
</tr>
<tr>
<td>Diffusion</td>
</tr>
<tr>
<td>Conventional threat</td>
</tr>
<tr>
<td>Nuclear threat</td>
</tr>
<tr>
<td>Nuclear defender</td>
</tr>
<tr>
<td>Diplomatic isolation</td>
</tr>
<tr>
<td>Domestic Unrest</td>
</tr>
<tr>
<td>Democracy</td>
</tr>
<tr>
<td>NPT ratification</td>
</tr>
<tr>
<td>NPT (system effect)</td>
</tr>
<tr>
<td>Major power status</td>
</tr>
<tr>
<td>Regional power status</td>
</tr>
<tr>
<td>Trade aid</td>
</tr>
<tr>
<td>Humanitarian aid</td>
</tr>
<tr>
<td>Energy aid</td>
</tr>
<tr>
<td>Count 2</td>
</tr>
<tr>
<td>Constant</td>
</tr>
<tr>
<td>Obs.</td>
</tr>
<tr>
<td>Log likelihood</td>
</tr>
<tr>
<td>Pseudo R squared</td>
</tr>
<tr>
<td>Wald chi-square</td>
</tr>
</tbody>
</table>

N/countries=3565/128
Statistically significant parameter estimators using one-tailed tests are denoted by * (p < .10), **(p < .05), ***((p < .01) and ****(p < 0.001)
Robust standard errors (adjusted for clustering by country)
Looking at Table 3, which summarizes the results of the probit analysis of nuclear weapons possession, we see that trade aid is again statistically insignificant, though the coefficient is now positive, which is add odds with Hypothesis 1. The direction of the effect of humanitarian aid and energy aid has also switched. Humanitarian aid now has a negative relationship, as predicted in Hypothesis 2, and is statistical significant at a higher level of confidence—0.01. This result means that the more humanitarian aid a country receives, the less likely it is to possess a nuclear weapon. This suggests that humanitarian aid affects whether governments actually develop nuclear weapons, but not whether they have nuclear programs. The reason may be that they can disguise a nuclear program, arguing that it has a non-military purpose, and avoid jeopardizing their relationship with the donor country. But nuclear weapons only have military applications and going nuclear will threaten the continued flow of aid. Another possible interpretation is that countries requiring humanitarian aid are less likely to be in an economic situation to afford nuclear weapons anyway, so humanitarian aid is really just a proxy for capacity.

While energy aid has a statistically significant, negative relationship with nuclear programs, it has a statistically significant, positive relationship with the possession of nuclear weapons. Greater amounts of energy aid thus make it more likely for a country to possess nuclear weapons, even though it makes it less likely for them to start a nuclear program. This is consistent with Hypothesis 3: If countries are committed to the goal of securing a nuclear weapon, greater energy
aid could actually pave the way for this final goal by providing resources that the government can easily divert towards building nuclear weapons.

I then calculated the effect of changing humanitarian aid from zero to its maximum value on the probability that states possess nuclear weapons, while setting energy and trade aid to zero, and all other variables at their mean values. Here we see that increase humanitarian aid decreases the probability of nuclear weapons by 0.005. But the change in the probability of nuclear weapons possession is even smaller when energy aid is increased from zero to the maximum value, at an increase of 0.003. Neither of these values are statistically significant at the 95 percent confidence interval—neither has a substantial impact on the predicted probability that a country possesses a nuclear weapon.

In the first model, the relatively low predicted probabilities suggest that the effect of foreign aid on security decisions must not be overstated. Although the direction of the effect of greater aid in certain sectors makes us question the overall consequences of US foreign aid on security decisions of aid recipients, the actual magnitude of the effect on the probability of a nuclear program or possession of a nuclear weapon is small.

The second model I use in this study is a multinomial logistic regression. The results of this analysis are detailed below in Table 4. Here, we notice the directions of relationships for the foreign aid variables are mostly the same, with the exception of trade aid. Trade aid has a positive relationship with the nuclear weapon status in the multinomial logit model, whereas the coefficient was negative in the probit model. The other major difference between the models is in significance of certain
variables. Energy aid, which was significant at the 0.001 level in the probit model for nuclear weapon possession, becomes statistically significant at only a 0.1 level in the multinomial logit model. Here, we see that trade aid has a much more significant relationship with the presence of a nuclear program, as predicted in Hypothesis 2A. Receiving larger amounts of trade aid are thus more likely to deter a country’s decision to start a nuclear program than receiving humanitarian aid supports the presence of a nuclear program. Although the direction of these relationships do not support Hypothesis 2A, the relative importance of trade aid vis-à-vis humanitarian aid does.

However, in the multinomial logit analysis of nuclear weapons possession, all of the aid variables are statistically significant, whereas trade was statistically insignificant in the probit model. In the multinomial logit analysis of the presence of a nuclear program, trade is the only statistically significant aid variable. In the probit model, humanitarian and energy aid barely achieved statistical significance at the 90 percent confidence level, whereas trade was not significant.

I again used Clarify to calculate changes in the predicted probability of a nuclear program or weapons possession given changes in levels of aid. Looking first at the presence of a nuclear program, changing trade aid from zero to its maximum value reduces the probability of a nuclear program by 4 percent. This result is statistically significant at a 95 percent confidence interval. Indeed, trade aid is the only type of aid that has a statistically significant effect on the probability of either dependent variable.
Running the same analysis for the aid variables when the dependent variable is the presence of a nuclear weapon, we see similarly small changes in the predicted probabilities. Humanitarian aid shifts the probability of nuclear weapons possession by -0.015, energy aid by 0.004 and trade aid by only 0.0005. None of these changes are statistically significant at the 95 percent level of confidence.

Though small, humanitarian aid clearly has a much bigger impact than trade aid, with energy aid falling between the two. In this case, humanitarian aid is more statistically significant than trade aid, the opposite of the prediction in Hypothesis 2A, and the reverse of the relative influence of both on the presence of a nuclear program. However, in this case, both humanitarian aid and trade aid have a negative correlation with the presence of a nuclear weapon. Thus, larger amounts of humanitarian and trade aid make it less likely for a country to acquire nuclear weapons, which supports my hypotheses above.
<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Nuclear Program</th>
<th>Sig.</th>
<th>Nuclear Weapon</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latent nuclear weapons production capability</td>
<td>0.928****</td>
<td>0.000</td>
<td>5.646****</td>
<td>0.000</td>
</tr>
<tr>
<td>Economic Capacity</td>
<td>-19.642</td>
<td>0.1635</td>
<td>-22.552</td>
<td>0.1385</td>
</tr>
<tr>
<td>Diffusion</td>
<td>-0.096</td>
<td>0.156</td>
<td>39.0928**</td>
<td>0.0315</td>
</tr>
<tr>
<td>Conventional threat</td>
<td>1.246**</td>
<td>0.0165</td>
<td>7.908**</td>
<td>0.015</td>
</tr>
<tr>
<td>Nuclear threat</td>
<td>0.077</td>
<td>0.468</td>
<td>-13.437**</td>
<td>0.0225</td>
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<tr>
<td>Nuclear defender</td>
<td>-0.066</td>
<td>0.4725</td>
<td>-6.777****</td>
<td>0.0005</td>
</tr>
<tr>
<td>Diplomatic isolation</td>
<td>2.492*</td>
<td>0.0875</td>
<td>12.261***</td>
<td>0.002</td>
</tr>
<tr>
<td>Domestic Unrest</td>
<td>0.072</td>
<td>0.3415</td>
<td>0.0768</td>
<td>0.444</td>
</tr>
<tr>
<td>Democracy</td>
<td>-0.013**</td>
<td>0.0275</td>
<td>-0.247</td>
<td>0.1335</td>
</tr>
<tr>
<td>NPT ratification</td>
<td>-1.496**</td>
<td>0.034</td>
<td>-31.879**</td>
<td>0.0145</td>
</tr>
<tr>
<td>NPT (system effect)</td>
<td>0.0488****</td>
<td>0.0005</td>
<td>-0.0235</td>
<td>0.359</td>
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<td>Major power status</td>
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<td>0.000</td>
<td>37.3445***</td>
<td>0.006</td>
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<td>0.006</td>
<td>10.893****</td>
<td>0.000</td>
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<td>Trade aid</td>
<td>-6.209**</td>
<td>0.0355</td>
<td>-2.384*</td>
<td>0.0535</td>
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<td>Humanitarian aid</td>
<td>0.176</td>
<td>0.255</td>
<td>-14.864****</td>
<td>0.0005</td>
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<td>Energy aid</td>
<td>-0.023</td>
<td>0.4765</td>
<td>12.156*</td>
<td>0.0595</td>
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<td>Constant</td>
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<td>0.0205</td>
<td>-189.665</td>
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</tr>
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</table>

Log likelihood
Pseudo R squared
Wald chi-square

N/countries=3565/128
Statistically significant parameter estimators using one-tailed tests are denoted by
* (p < .10), **(p < .05), *** (p < .01) and ****(p < 0.001)
Robust standard errors (adjusted for clustering by country)
The base category for this multinomial logit regression is states with no nuclear program or weapon.
Suggestions for Future Research

In this section, I lay out several potential ways the data or results can inform future studies of foreign aid and nuclear proliferation.

First, there is only partial overlap between the years covered in Jo and Gartzke’s dataset and AidData. Future studies should, therefore, consider expanding either or both datasets to incorporate more cases—in particular to assess the effect of foreign aid from other donor countries on proliferation. Also, Jo and Gartzke’s study ends in 1992, right after the end of the Cold War, but there have been several very interesting scenarios in the nonproliferation world since the end of the bipolar world that the arms race thrived under. The relationship between the United States and Ukraine, with large aid packages facilitating a dismantling of their nuclear weapons and all reactors by 2012, is one such example. Future studies could stand to benefit from expanding Jo and Gartzke’s dataset by another ten years or so, to understand how some of these relationships have played out since the end of the Cold War.

Regarding the methodology of the study, adding a multinomial logit allows us to proceed past the problems of coding the presence of nuclear programs and nuclear weapons as dummy variables. As discussed above, prior studies placed too much emphasis on states that went nuclear very early on. The adjustment of the program dependent variable to only count the presence of a program and not a weapon allowed us to overcome the problem of double counting. But the multinomial logit analysis has its own set of problems. In my study, a zero applies to
countries that have never developed a nuclear program, as well as countries that have a nuclear program and a nuclear weapon.

The changes in the predicted probabilities, both in the probit model and the multinomial logit model, are very small. It is important to note that this is largely due to the nature of how rare the presence of nuclear programs or nuclear weapons is relative to the number of countries and years being studied. Thus, a change in the predicted probability that is statistically insignificant does not necessarily mean that a change in foreign aid amounts has a substantively unimportant effect on proliferation outcomes. However, this does make the predicted probabilities that are relatively larger than the others, or those that are statistically significant, stand out.

One such example is the effect of trade aid on the probability of the presence of a nuclear program, in the multinomial logit model (see Table 3). The change in the probability of a program is -0.04 and is statistically significant. Interestingly, it was not statistically significant in the probit regression. Although it is not immediately clear exactly why changing the coding of the dependent variable has such a large impact on the effect of trade aid on the presence of nuclear programs, it is likely that coding countries that had never proliferated as well as countries with nuclear weapons as zero affected these results. Separating these two groups of countries into two distinct categories in the multinomial logit model produced a significant result. Thus, the multinomial logit model is more likely to reflect the true relationship between trade aid and the presence of a nuclear program than the probit model, in this case.
Future studies may wish to investigate further the phenomenon of trade aid to see why it produces such significant results perhaps at a project-level, to gain a deeper understanding of the dynamics of its relationship with the presence of nuclear programs in recipient countries.

Scholars may also wish to conduct detailed case studies to explore further the effect of US foreign aid on the decisions of recipient countries to proliferate (or not). For instance, conducting a detailed and thorough study on US foreign relations with India in different time periods could reveal the usefulness of foreign aid in specific contexts. Dividing the history of US-India foreign relations into several time periods and looking at the changes in aid flows in different sectors in these time periods, as well as India’s nuclear decisions in those periods, may reveal more about the effectiveness of foreign aid in that particular relationship. This knowledge can then guide foreign aid amounts in different sectors, with the knowledge of its usefulness and persuasiveness towards desired ends.

Conclusions

Results of this study show that different sectors of foreign aid can have different directions of correlation with the status of nuclear weapons and programs, depending on the kind of aid provided. To be specific, humanitarian aid has a statistically insignificant effect on the nuclear program status, but has a very statistically significant and strong negative relationship with the presence of a nuclear program, in both the probit and the multinomial logit model. Getting more humanitarian aid makes it significantly less likely that a country has a nuclear
program. This suggests that humanitarian aid has a significant effect on deterring the production of nuclear weapons.

Similarly, trade aid under the multinomial logit model has a relatively strong negative effect on both nuclear program status and nuclear weapon status, under the multinomial logit model. Receiving large amounts of trade aid also appears to dissuade countries from developing nuclear weapons. On the contrary, energy aid has a statistically significant (albeit at the lowest level) positive relationship with nuclear weapon status in the multinomial logit model, and a much stronger positive relationship with nuclear weapon status in the probit model.

In analyzing the differences between humanitarian and trade aid when compared with energy aid, it must be noted that humanitarian and trade aid have much greater inclusionary effects than energy aid. Humanitarian aid, especially after a crisis or conflict, creates an obligatory relationship between the donor and the recipient. Similarly, trade aid draws states into the global market, allowing them to establish better trade and business practices to benefit from greater trade linkages with other countries. This causes a dependency to other countries that will make them less likely to violate normative conditions that allow them into this club.

Energy aid shares a different relationship with proliferation outcomes. While it does not appear to have a significant relationship with the presence of a nuclear program, it appears that states who are willing and able to acquire nuclear weapons for security or other reasons, are able to either use energy aid to their advantage to use existing resources for weapons programs instead. The results of this study seems to suggest that countries who have support for their energy sources are able
to proliferate with greater ease, and are not discouraged from doing so by the promise of greater integration or stronger bilateral relationships, a promise energy aid lacks compared to humanitarian or trade aid. 

Policy implications of these results suggest that donor countries, particularly the United States, should be wary of the varying effects different sectors of aid can have in proliferation outcomes. While most policy debate centers around total aid flows, and sanctions withdraw all aid flows, knowledge of the impact of specific sectors may result in a more efficient and effective overall foreign aid program. Bolstering aid in some sectors while cutting down aid in others may be able to support security outcomes without compromising on development outcomes, a big lesson for the polarized political debates that guide policy decisions today.
Bibliography


Appendix A: AidData Coding Scheme

These are the purpose codes that were used for each sector. The sum totals for all the purpose codes for each recipient country, for each year, form the values used for each independent variable.

**Humanitarian Sector Aid**

70000: Emergency Assistance and Reconstruction, combinations of purposes
72000: Emergency Response, combination of purposes
72010: Material relief assistance and services
72020: Emergency Health Services/Support
72030: Water and Sanitation Servies/Support
72040: Emergency Food Aid
72050: Relief co-ordination; protection and support services
73010: Recovery and Reconstruction (Reconstruction relief and rehabilitation)
74010: Disaster Risk Reduction (Disaster prevention and preparedness)
52010: Food aid/Food security programs
60010: Actions relating to debt
60020: Debt forgiveness
60030: Relief of multilateral debt
60040: Rescheduling and refinancing

**Trade, Finance and Economic Infrastructure and Services**

21010: Transport policy and administrative management
21020: Road Transport
21030: Rail Transport
21040: Water Transport
21050: Air Transport
21061: Storage
22010: Communications policy and administrative management
22020: Telecommunications
22030: Radio/television/print/media
22040: Information and communication technology
24000: Banking and financial services, combination of purposes
24005: Banking and financial services, purpose unspecified
24010: Financial policy and administrative management
24020: Monetary Institutions
24030: Formal sector financial intermediaries
24040: Informal/semi-formal financial intermediaries
24081: Education/training in banking and financial services
25010: Business support services and institutions
25020: Privatization
25081: Business Education and Training
33100: Trade policy and regulations, combination of purposes
33105: Trade policy and regulations, purpose unspecified
33110: Trade policy and administrative management
33120: Trade facilitation
33130: Regional Trade Agreements (RTAs)
33140: Multilateral Trade Negotiations
33181: Trade education/training

**Energy Generation and Supply**
23010: Energy policy and administrative management
23020: Power generation/non-renewable resources
23030: Power generation/renewable resources
23040: Electrical transmission/distribution
23050: Gas distribution
23055: Petroleum distribution and storage
23081: Energy education/training
23082: Energy research
Appendix B: Variables

Nuclear Program Status: Nuclear weapon program present, lagged by one year.

Modified Nuclear Program Status: Nuclear weapons program and only program, lagged by one year.

De Facto Nuclear Weapon Status: *De facto* status, possession of nuclear weapons, lagged by one year.

Categorical Nuclear Status: Multinomial Logit variable, where 1 represents states with no nuclear weapons or programs, 2 represents states with only a nuclear program, and 3 represents states that have possession of a nuclear weapon, also lagged by one year.

Latest Nuclear Weapons: Latent nuclear weapons production capability, composite index. Assumes that states still have the technology and materials to manufacture nuclear weapons, even if the actual materials in each index is no longer produced.

Economic Capacity: Economic capacity, measured by Jo and Gartzke according to the following equation:

\[
\text{Economic Capacity}_i = \left( \frac{\text{Energy}}{\sum \text{Energy}} \times \frac{\text{Iron/Steel}}{\sum \text{Iron/Steel}} \right)^{1/2}.
\]

Diffusion: Variable measuring diffusion, measured as the log transformation of the number of years since 1938.

Conventional Threat: Conventional Threat, calculated by Jo and Gartzke according to the following equation:

\[
\text{Conventional threat}_{i,t} = \ln \left( \sum_{j=1}^{n} \frac{\text{CINC}_{j,t}}{\text{CINC}_{i,t}} + 1 \right).
\]

Nuclear Threat: Nuclear threat

Nuclear Defender: Nuclear defender

Diplomatic Isolation: Diplomatic isolation, measured by Jo and Gartzke as the ratio of the number of states with which a state has cut off or never had diplomatic ties with, over relationships over the number of neighboring states and
major powers.

Domestic Unrest: Domestic unrest, measured by weighing the number of domestic conflicts in anti-governmental demonstrations, strikes, and riots by the population size.

Democracy: Democracy, score according to Polity III.

NPT Ratification: NPT ratification, except for five declared nuclear powers.

NPT system effect: NPT system effect

Major Power Status: Major power status, according to the Correlates of War Project

Regional Power Status: Regional power status, coded as “1” for states with “at least half of the resources of the most powerful state” in a region” and “0” otherwise (Schweller 1998, 46). Uses the COW project’s code of region and national composite capability index (CINC).

Humanitarian Aid: Total aid from the United States to specified country in specified year for ‘humanitarian aid’, as defined in Appendix A, in Constant 2000 US Dollars (billions).

Energy Aid: Total aid from the United States to specified country in specified year for ‘energy aid’, as defined in Appendix A, in Constant 2000 US Dollars (billions).

Trade Aid: Total aid from the United States to specified country in specified year for ‘trade aid’, as defined in Appendix A, in Constant 2000 US Dollars (billions).