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The Determinants of Nuclear Proliferation

Abstract: With the advent of nuclear weapons development worldwide, it has become more and more important to understand the causes of the proliferation efforts affecting international peace and security. The paper focuses on the proliferation efforts of the US, UK, France, Russia, China, India, and Pakistan by investigating the level of hostility and whether the states develop more nuclear weapons if they initiate conflict with the adversary. Using multiple regression methods to test the theory of nuclear proliferation, the results suggest that nuclear proliferation is strongly associated with low hostility levels and when the country does not initiate the conflict.

Introduction

Nuclear Weapons have been at the heart of International Security issues and have played an essential role in understanding world politics since their introduction in 1945. However, over the years, few states have been engaged in developing nuclear weapons, posing a significant concern for international peace and security. The reasons are associated with why states decide to proliferate or not at all in the first instance.

Over the years, the international community has undertaken efforts to stop proliferation, such as encouraging states to sign the Nuclear Non-proliferation Treaty (United Nations, n.d.), but despite their efforts, Countries like the United States, Russia, the United Kingdom, France, China, India, and Pakistan have continuously engaged, and the developments have substantially increased (Arms Control Association, 2022).

I am entering the debate on nuclear proliferation with a quantitative study by deep diving into security reasons associated with nuclear proliferation. I will explore two essential security reasons that could contribute to nuclear proliferation, i.e., the hostility levels and whether the state initiates conflict with its adversary. By examining these factors, the paper seeks to deepen our understanding of security motivations and provide insights that can inform policy decisions to prevent such proliferation in the future.

Literature Review

Over the years, the threat of nuclear proliferation has been highest since the dawn of the atomic era. As a result, scholarly debates have been on understanding the causes of nuclear proliferation, which will be discussed below.

First, long-standing literature has discussed economic factors' role in understanding the states' nuclear proliferation (Jo, 2007; Meer, 2016; Singh, 2004; Bleek, 2014; Fuhrmann, 2015). This strand of literature discusses that the higher the economic growth, i.e., GDP, trade, business, or other economic activities, the more they are likely to engage in nuclear proliferation activities.

Second, the scholars focus on the availability of technology and resources as one of the critical determinants of nuclear proliferation (Jo, 2007; Meer, 2016; Kroenig, 2009). The availability of technology and resources can be understood through access to materials needed to develop nuclear weapons. For example, Canada's (CANDU) supply, i.e., Canada's Deuterium Uranium reactors, helped India build its first nuclear bomb and undertake a nuclear test in 1974 (Dunn, 2009; Burr,

2014). Access to technology, resources, and materials helps states to overcome the technical and strategic obstacles hindering their proliferation dreams.

Third, another strand of literature also focuses on the importance of security concerns which is the oldest model in explaining nuclear proliferation (Sagan, 1996; Jo, 2007; Meer, 2016; Singh, 2004; Hymans, 2006; Bleek, 2014). When the states feel that their security and survival in the international system are at risk, they are more likely to develop nuclear weapons to protect themselves from the threat. Singh's (2004) quantitative studies with the hazard model support enduring rivalries and militarized disputes as causes of proliferation.

In addition, the literature also discusses the role of great powers in preventing nuclear proliferation by providing security guarantees to states. However, when the states fail or refuse to provide security guarantees, that time, the states because they are more concerned about their security and survival, they are more likely to develop nuclear weapons (Jo, 2007; Sagan, 1996; Singh, 2004; Miller, 2014; Gerzhoy, 2015).

Fourth, the literature discusses the role of identity as an essential determinant in understanding the nuclear proliferation efforts of the states (Jo, 2007; Sagan,1996; Meer, 2016). This idea relates to states' perceived reputation and standing in the international system, and nuclear weapons are considered a symbol of great or atomic power, which enhances the influence in the international arena. As a result, the nuclear states often find a faster resolution to territorial, maritime, and other issues with neighboring states, and therefore, the states engage in nuclear proliferation activities to maintain and uphold this reputation.

Lastly, the literature discusses other determinants in understanding nuclear proliferation; for example, a state or leader may engage in proliferation activities to divert the domestic people's attention from the critical issues and bolster nationalistic sentiment among the domestic audience (Hyman, 2006; Jo, 2007).

As with this, scholarly literature focuses on different determinants of nuclear proliferation activities worldwide. They argue that economic, technological, domestic, and security factors hold more importance in understanding nuclear proliferation. Holding on to the security notions and diving deep into them, I am investigating the role of deep-niched factors in the security argument sphere affecting nuclear proliferation.

Theory and Hypothesis

In terms of literature using quantitative methods, not many studies have been conducted on understanding nuclear proliferation because of the complex nature of the topic, availability of datasets, less information because of a small number of cases, and the role influence of other phenomena in understanding the proliferation efforts. This paper attempts to contribute something to the academic literature using quantitative methods and available datasets by deepening the divide into security reasons by focusing on how the hostility levels and when the country originates the conflict with the adversary influences the development of nuclear weapons.

Long-standing literature has focused on security reasons, such as the role of enduring rivalry and militarized disputes in understanding nuclear proliferation. However, there has not been a focus on niche factors such as the level of hostility and the state's conflict behavior. I argue that when the hostility level between the state and its adversary is high, states are more likely to develop

nuclear weapons. Moreover, with high hostility, states are more likely to engage in nuclear proliferation to deter their adversary. This idea stems from the quantitative studies undertaken by Singh & Way 2004, who emphasized the importance of enduring rivalry in examining nuclear proliferation. Hence, in this paper, I am emphasizing the importance of hostility levels and their effect on proliferation efforts.

Hypothesis 1: Higher levels of hostility between states increase the likelihood of developing nuclear weapons than lower levels of hostility.

Over the years, the study has examined the relationship between nuclear proliferation and security from the adversary level or the one who is the recipient of the threat. The evidence suggests that states are more likely to proliferate if they feel threatened by their adversary or if other states initiate a militarized dispute by other states. In this paper, I argue that if the state originates or starts a conflict with its adversary, it is more likely to develop nuclear weapons as it may feel a greater need to develop them for security and survival. In addition, the state, i.e., the originator of a conflict, may feel a higher security threat than the states who do not originate, as they may face retaliation from their adversaries.

Hypothesis 2: States that initiate a conflict are more likely to develop nuclear weapons than states who do not initiate a conflict.

The theoretical framework proposed in this paper argues that nuclear proliferation is determined by a combination of security factors related to hostility levels and conflict initiation. Specifically, when hostility levels are high, states are more likely to engage in nuclear proliferation as a means of deterrence. Similarly, when a state initiates a conflict with its adversary, it is more likely to develop nuclear weapons to enhance its security and survival.

By focusing on the United States, United Kingdom, France, Russia, China, India, and Pakistan, the study proposes that security concerns, specifically hostility levels and the originator of the dispute, are important determinants of nuclear proliferation. The results of this study will contribute to the existing literature on the causes of nuclear proliferation and have implications for policymakers in preventing nuclear proliferation in the future.

Data & Methods[1]

I will consider the 'nuclear warheads' dataset by Max Roser, Bastian Herre, and Joe Hasell, as this is also one of the ways of quantifying proliferation by looking at the stockpile countries have (Max, 2013). A nuclear warhead is a modern strategic nuclear weapon with enormous power in the country's military stockpiles. The data includes estimated nuclear warhead stockpiles from 1945 to 2022 of five internationally recognized nuclear weapons states, including the United States, China, Russia, the United Kingdom, France, and others not recognized as nuclear weapons states but still have them, which include India and Pakistan. I would not consider North Korea because data availability is the biggest challenge. Furthermore, Israel neither denies nor accepts possession of nuclear weapons; therefore, it does not fall into the scope of my research question.

Independent Variables

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[1] After carefully considering the nature of the data, I chose the OLS model as it is a well-established method for modeling continuous variables and has been used in previous studies with similar count data. Unfortunately, Gauss Markov's assumptions are unmet, such as the linearity of residuals and distribution of residuals. I understand it is recommended to have the Gauss-Markov assumptions met for OLS regression to provide reliable and efficient estimates, and I acknowledge the limitations in my paper. This may impact the reliability and validity of the OLS results. However, given the nature of our data, research question, and the requirement of the class, I decided to use OLS as the primary analysis method. In addition, I have also checked for heteroskedasticity and resolved it with the Breusch-Pagan test. I have included figures to visualize these diagnostics in the appendix section of the paper.

As mentioned above, the development of nuclear weapons is a complex phenomenon influenced by several factors, including political, economic, and strategic considerations. Considering the security concerns, I am considering two niche phenomena that would determine the behavior of the state and the development of nuclear weapons. First, I will consider the Militarized Interstate Dispute Data by Michael R. Kenwick, Matthew Lane Benjamin Ostick, and Glenn Palmer, which covers information from 1816 to 2010 (Michael, 2013).

The first is the 'Hostility level' (measured as continuous) reached by the adversary state, which categorizes one as no militarized action; two as a threat to use force; three as a display of force; four as use of force; and five as war. This level of hostility and whether the state is a target by the other state help understand whether the countries develop nuclear warheads. When the conflict is more severe or at the level of war, there are high chances of a catastrophic outcome. In this case, developing nuclear warheads is the viable solution to either act as a deterrent or use them in a conflict.

The second is the 'Originator conflict' (measured as a dichotomous variable), determining whether the country initiates the conflict with another state. This is categorized as 0 as no conflict initiated and one as conflict initiated. In this case, I will expect that if a country initiates a dispute or a conflict with another adversary, they are more likely to increase the development of nuclear weapons to ensure survival and deterrence capabilities.

To undertake the analyses and examine the relationship, I employed a multiple regression model:

$$\text{Nuclear Warheads} = \beta_0 + \beta_1 (\text{Hostility Level}) + \beta_2 (\text{Originator of Dispute}) + \varepsilon$$

Y is the dependent variable (nuclear warheads); x1 and x2 are the independent variables. β_0 is the intercept or the constant term, and ε is the error term. Lastly, β_1 β_2 are the coefficients of the

independent variables representing the change in the independent variable (y), holding other variables constant.

Overall, this theory suggests that both the originator of the dispute and the level of hostility in a conflict are essential predictors of nuclear weapons development, and they have independent effects on the outcome. By examining the relationship between these variables, we can better understand the complex *'security'* factors that drive nuclear proliferation and their implications for international security.

Results:

The results indicate a weak and negative correlation between hostility level, originator of conflict, and nuclear weapons stockpile, which is -0.1169 for the former and -0.180 for the latter. A negative correlation means that as one variable increases, the other variable decreases; in other words, the result shows that with the increase in hostility, even if the country initiates conflict, it has negative impact development of nuclear weapons. These factors are not directly related to understanding the proliferation efforts suggesting that while hostility level and conflict initiation play a role in a country's decision to develop nuclear weapons, other factors likely have a more significant impact on this decision. Therefore, knowing the level of hostility or the originator of a dispute may not be a reliable predictor of the size of a country's nuclear weapons stockpile.

Table 1: The Relationship between Hostility Level, Originator of Dispute and Nuclear Warheads

	Nuclear Warheads
Hostility Level	-6,316.23*
	(1,468.079)
	t = -3.930
Originator of Dispute	-1,059.596
	(375.906)
	t = -2.693
Constant	16,036.060*
	(1,819.720)
	t = 8.034
Observations	536
R2	0.047
Adjusted R2	0.043
Residual Std. Error	10,144 (df = 533)
F Statistic	13.078* (df = 2; 533)

Notes	Significance level: * p-value < 0.001 Standard errors are in parentheses.

The multiple regression model shows that there is a significant relationship between hostility level and nuclear warheads development. The negative coefficient (-6.316) indicates that as the hostility level increases, the development of nuclear warheads does not necessarily increase. The statistically significant relationship between hostility level and nuclear warheads shows that there is a meaningful association between these variables. However, the low R-squared value of 0.047 indicates that the model explains only a small portion of the variation in nuclear warheads, indicating that other variables may potentially influence the development of nuclear warheads.

Whereas the relationship between the originator of the dispute and the development of nuclear warheads is not statistically significant, indicating that there may not be a significant relationship between them or that other variables could potentially influence the relationship between the

originator of conflict and nuclear warheads development. The negative coefficient indicates that if a state originates a conflict with an adversary, the state is less likely to be associated with developing nuclear warheads than states that do not initiate the conflict. Hence, the regression analysis does not provide strong evidence to support both my hypotheses.

To better understand the relationship between the hostility level, the originator of conflict, and the nuclear warheads, I created a post-estimation dot plot showing each group's mean and 95% confidence interval.

Figure 1
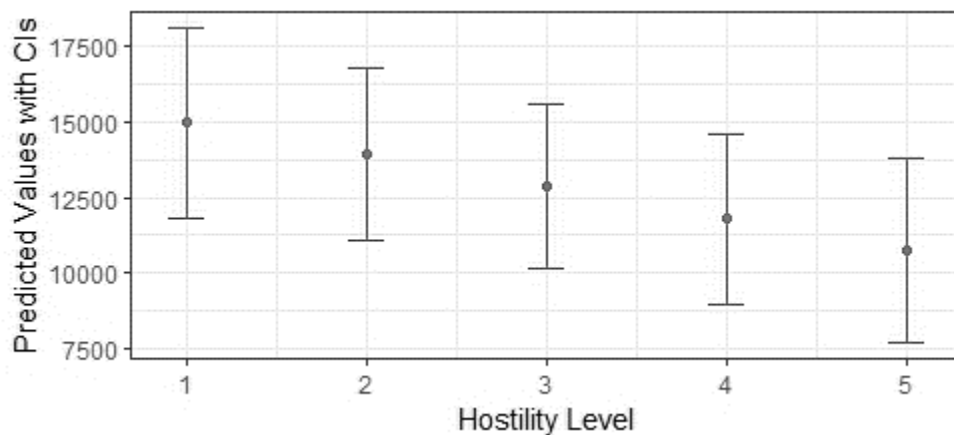
Figure 1 shows a weak and negative relationship between the level of hostility and the development of nuclear warheads. This indicates that countries are less likely to develop nuclear warheads as the hostility level increases. The figure tells us that at the lowest hostility level, the predicted probability of developing nuclear weapons is high and lowest when the hostility level increases. If we look at level five, the probability of developing nuclear weapons is around 10000 to 12500, with a 95% confidence interval ranging from approximately 7700 to 14000. On the other hand, at the lowest level of hostility, the probability of developing nuclear weapons is around

15000, with a 95% confidence interval ranging from approximately 12000 to 18000. This plot suggests that as the level of hostility increases, the countries are less likely to develop nuclear weapons than when the hostility decreases. The likelihood of developing nuclear weapons increases as the country becomes less hostile towards each other. The analysis explains how a country's hostility level determines nuclear proliferation worldwide, with lower levels of hostility associated with higher levels of nuclear proliferation.

Figure 2
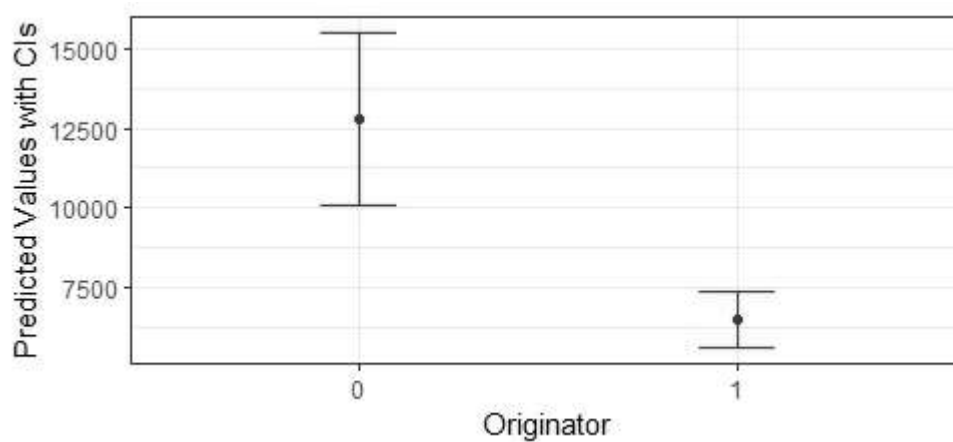
Figure 2 visualizes the relationship between the originator of the dispute and the development of nuclear warheads. The plot demonstrates that when the country does not initiate a conflict with an adversary, they are more likely to develop nuclear warheads than when they initiate the conflict. The plot tells us that the probability of developing nuclear weapons is around 7000 when the country initiates the conflict with its adversary. A 95% confidence interval ranging from approximately 5000 to 7400 is the lowest compared to when a state initiates the conflict with its adversary. Therefore, we can infer that states refrain from developing nuclear warheads or increasing their nuclear stockpiles where there is a security issue. In fact, where there is a security issue, the countries are less likely to behave offensively or build nuclear weapons which would

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threaten their existence or security. In other words, they might ensure their survivability in the international sphere by not engaging in nuclear weapons development when they initiate the conflict compared to when they do not.

Conclusions

With the dawn of the atomic era and as nuclear weapons become more and more essential to ensure peace and security, by deepening diver into the security sphere, we can see that the more the sensitive security environment, the fewer countries are likely to engage in the development of nuclear weapons.

First, the results demonstrate that nuclear proliferation decreases as hostility increases. This means that states are more likely to develop nuclear weapons at the lowest level of hostility than at the highest level (war). This is an interesting finding as one would expect that during the highest hostility level (war), they would proliferate rapidly to maintain their survival. Just as the level of hostility has a significant relationship with the development of nuclear weapons, it is essential to investigate the other factors and variables associated with proliferation and influence the relationship. Just as the proliferation concern increases, an urge to find the reason also increases.

For the second hypothesis, the results demonstrate that states are more likely to proliferate when they do not initiate conflict with their adversary than when they initiate it. This infers that states might see nuclear weapons as a defensive rather than an offensive tool; in this case, they might develop nuclear weapons to prevent the other states from attacking. However, when they initiate conflict with their adversary, the state might already have enough weapons to survive in the conflict, and hence they might not feel the need to develop more.

Though scholarly literature has provided nuanced insights on proliferation debates, with the ever-changing international relations, it is essential to continue exploring different causal factors explaining the proliferation efforts. Having important implications for international security, these findings suggest that it is essential to understand and investigate the states' underlying security concerns and intentions. This investigation would help policymakers to maintain international peace and harmonic relations among states.

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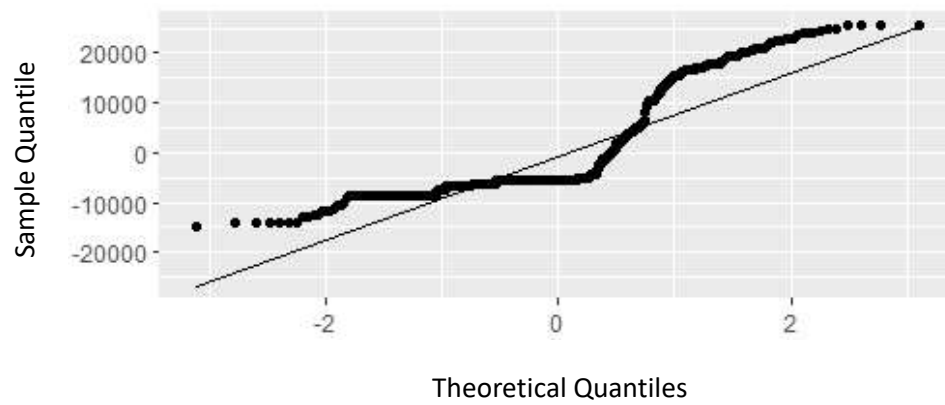
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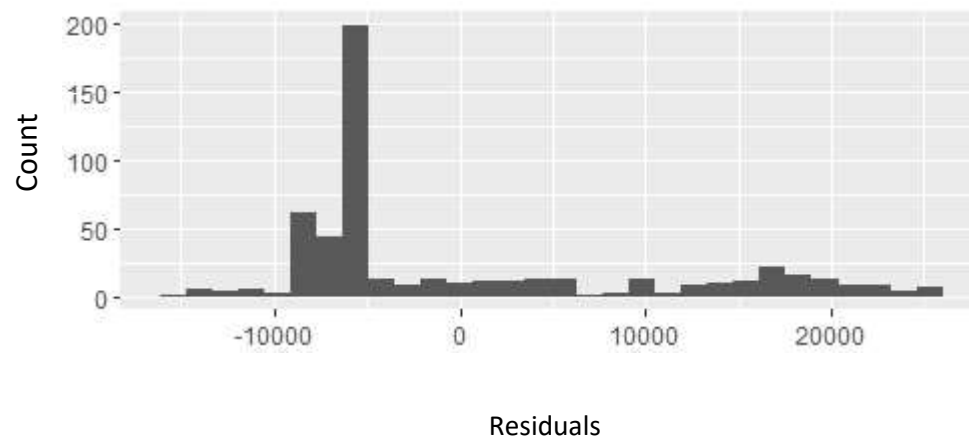[Accessed March 2022].

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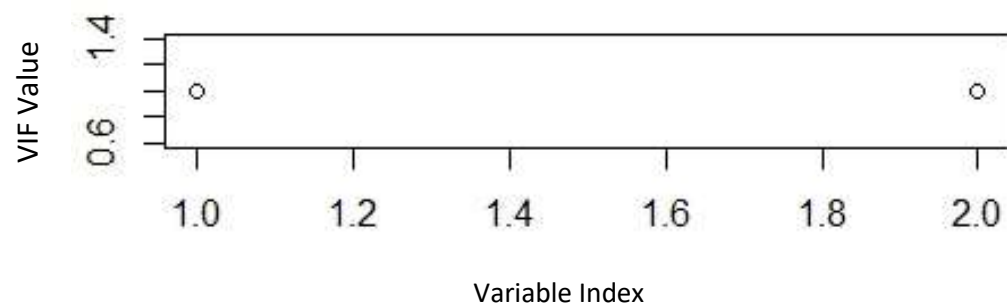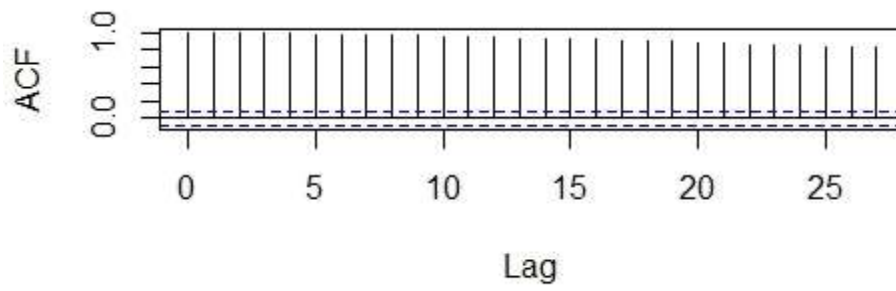
Linearity of Residuals

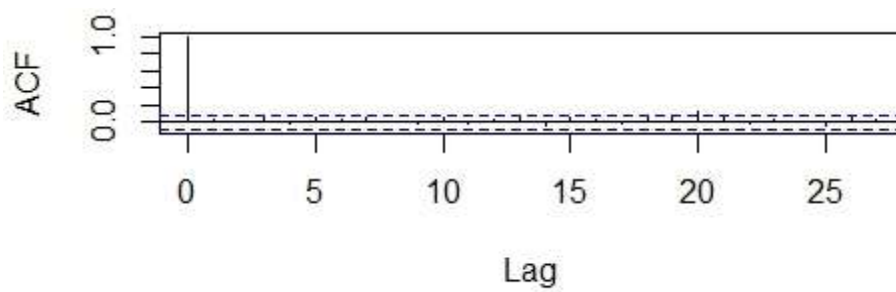## Distribution of Residuals

Variance Inflation factor

Autocorrelation

Nuclear Weapons

Hostility Levels

Originator of Conflict