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## Rivalry Dynamics: Unveiling Alternative Motivations Behind Nations' Arms Competition

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### ABSTRACT

**Purpose:** The study aims to explore the complex dynamics of the arms race (AR) between Pakistan and India, with a primary focus on examining various arms race models.

**Research Gap:** No study in the current body of literature regarding the perspectives from Pakistan and India has comprehensively utilized all iterations of the Richardson Reaction model of the arms race, except for Hollist (1977), which did incorporate all versions of the Richardson Reaction model. However, in this particular study, the author merely compared  $R^2$  and F-statistics across four pairs of nations.

**Design/Methodology/Approach:** The study consists of eight mini-models. The first six models have been estimated through OLS while in the last two models, we have adopted the GMM technique. The study used the data from Handbook statistics of Pakistan and India from 1972 to 2020.

**The Main Findings:** Our study highlights that a country's own previous year's military spending inversely affects its current military outlays, while its opponents' expenditures positively influence its military budget. The disparity between a country's and its opponents' military spending, as well as submissiveness, play significant roles. Moreover, real external debt negatively impacts military expenditures, while real GDP positively influences them.

**Theoretical/Practical Implications of the findings:** The implications suggest that the decisions about military expenditure are affected by both internal and external aspects, including past expenditures and the military capabilities of adversaries. The study highlights the relevance of economic growth as a determinant of military spending decisions.

**Originality/Value:** The originality and value of the study lie in a comprehensive utilization of all versions of the Richardson model, employing the advanced technique of the Generalized Method of Moments (GMM).

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## **1. Introduction**

It is a well-established fact that Pakistan and India have been rivals of each other since their inception. After 76 years of their freedom from Great Britain, both states have not same socio-economic and political achievements. They have fought four key wars due to indigenous religious dissimilarity, external political aggression, and the Kashmir issue (Tibbett and Akram-Lodhi, 1997; Sheikh and Chaudhry, 2013). Based on the adjusted national income (NNI) criterion of the World Bank, both countries are so far considered to be in the category of lower middle-income countries. According to World Development Indicators (2022), Pakistan has \$1410.8 billion adjusted NNI and India has \$1916.1 billion adjusted NNI. Despite this situation, both states have allocated a considerable part of their resources to the military and shown superiority over each other. WDI (2022) also reveals that India's military expenditures as a percentage of GDP were 2.4% while in Pakistan it were 2.6%. In the same way, military expenditures as a percentage of general government expenditure were 8.2% in India and 17.9% in Pakistan.

In fact, the issue for both countries is that they have limited resources for economic development. Their masses are devoid of basic necessities, and the majority are living a miserable life for being below the poverty line. So, it is an important question for both nations to think that military spending might hinder their economic development. Many characteristics are common between Pakistan and India, for instance, macroeconomic policies, budgetary systems and state institutions. But in unison, they have diverse characteristics such as religions, security strategies and foreign policies. Consequently, both countries might be characterized as having 'diversity within commonality'. The relationship and military spending dynamics of the two countries can be affected by these characteristics.

The history of conflict and persistent aggression determine the military expenditure patterns between the two countries. Both have been in the race of arms since independence. During the imperial rule, 16 ordnance factories were established in the sub-continent by the British. After partition, all the factories were under Indian control as they were located in India. Therefore, India was in a better position regarding the military-industrial base than Pakistan. In this situation, Pakistan had to amplify its military expenditures and arms importation for the balance of power. Pakistan realized the importance of military expenditures and arms production with the incident of the 1947 war with India. So, in 1951, Pakistan Ordnance Factories (POF)<sup>1</sup> was set up to compete with the Indian military industrial base. In the 1950s, Pakistan became a member of various mutual security organizations such as the Central Eastern Treaty Organization (CENTO)<sup>2</sup>. Pakistan got military aid and various arms through imports from the USA. The strength of Pakistan's army was boosted by acquiring sophisticated arms and military aid from the USA. On the contrary, due to the inherited strong military industrial base, India adopted the policies of import substitution and self-sufficiency. Therefore, in this period, there was a sharp increase in India's military expenditures and indigenous arms production due to two particular reasons i) to reduce the foreign exchange expense of importing weapons, and ii) to gain the upper hand against Pakistan's advanced US weaponry.

In the 1960s, India fought two wars with its neighbors, China and Pakistan. India's war with China was due to their claim on the territory of Shaksam Valley and Aksai Chin. China defeated India in the war of 1962. Therefore, India escalated spending on the military considerably. In 1965, the war between Pakistan and India broke out on the issue of Kashmir. Again, in 1971, a war between Pakistan and India broke out on the issue of East Pakistan and Pakistan had to lose its eastern part due to defeat by India. In 1974, India conducted a nuclear test at Pokhran and claimed that it was a peaceful nuclear explosion. Pakistan also started working on the nuclear side to counter Indian nuclear weapons. Therefore, rivalry and aggression boosted, and both countries kept mounting up their heaps of arms.

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1 With the efforts of Liaquat Ali Khan and Khawaja Nazimuddin, Pakistan's first and second prime ministers respectively, POF was established in Wah Cantonment to produce arms for Pakistan army.

2 It was US sponsored organization established in 1955. The member countries were Pakistan, Iran, Iraq, Turkey and UK. It was established with the backing of the United States and Great Britain to oppose Soviet Union expansion into the Middle East.

In the late 1970s and 1980s, the Soviet Union invaded Afghanistan. The USA supported Afghanistan through Pakistan. All the USA assistance for the Afghan freedom fighters was provided through Pakistan. With the supply of its military bases against the Soviet Union, Pakistan turned into the key player in this epic struggle. For this assignment, Pakistan got many benefits from the USA in the form of military and financial aid. This was the period when Pakistan had the US-sophisticated weapons including F-16 fighter planes. To counter Pakistan’s extensive armory, India took benefit of the Soviet Union’s rivalry with Pakistan by importing Soviet Union-sophisticated arms. India gave more attention to its military industry in this era. The two neighboring countries augmented their military spending and started making their own missile programs in the late 1980s. In the 1990s, both the rival countries continued to escalate their military expenditures due to tension in their relations. In May 1998, both countries entered the new age of nuclear weapons as both conducted nuclear tests. In 1999, the Kargil War, or the fourth war between Pakistan and India broke out which mounted the aggression and military spending of both. Similarly in the decade from 2000-2010, military expenditures in both countries had exposed an upward trend. In short, the political, cultural, and socio-economic milieu of the sub-continent, the conflict history of both the neighbors, and their military spending dynamics identify that the USA, UK, China, Russia, and Afghanistan have played a major role in the military spending process of Pakistan and India besides their territorial issues and conflicts.

This paper plans to uncover the competitive arms process, security concerns, and military spending patterns of both states. The two countries have significance in the world particularly in South Asia regarding strategic and military issues. We will explain the review of the literature in Section 2. Section 3 consists of model specifications and data. Section 4 provides results and discussions while section 5 concludes the paper along with policy implications.

## 2. Literature Review

In Table 1, we have compiled a review of empirical research on the arms race carried out for Pakistan and India. These studies have examined the arms race between Pakistan and India using a variety of econometric tools, methodologies, and time periods.

**Table 1: Review of Arms Race Studies**

Reference	Time Period Covered	Model Specification	Main Results
Hollist (1977)	1949-1973	Richardson Model and its different variants	As the Richardson model and its variations anticipated, the reaction coefficients were found to be negative rather than positive.
Deger and Sen (1990)	1960-1985	Richardson Model with additional considerations	Because Pakistan is receptive to Indian military spending yet India is not receptive to Pakistan's military expenditures, this study is inconclusive about the arms race between the two countries.
Oren (1994)	1947-1990	Richardson Model with belligerent intentions	The study's conclusions show that both nations' military spending rises in reaction to an increase in bellicose actions by their adversary. However, both nations have a negative response to each other's military spending.

Dunne, Nikolaidou and Smith (2000)	1962-1996	Cointegration analysis in the VAR framework	According to the study, there may be a long-term correlation between the actual military spending of both nations. For both countries, the reaction coefficients are determined to be positive. In addition, bidirectional causality was discovered.
ÖÖcal (2003)	1949-1999	Smooth transition type non-linear model	The asymmetric consequences of the military spending in both countries were examined in the study. There is a non-linear relationship between the military spending of the two nations.
Yildirim and ÖÖcal (2006)	1949-2003	Seemingly unrelated regression in a multivariate VAR model and Granger causality test	The Granger causality test was used in the study to determine whether there was a bi-directional connection between the two nations' military spending.
Dunne and Smith (2007)	1962-2003	Richardson model in the VAR framework and cointegration analysis	The results showed that there is no evidence of a long-term association between the actual military spending of the two nations.
Sheikh and Aslam (2015)	1972-2010	GMM	The analysis discovered a negative correlation between changes in defense spending and the amount spent on defense by both nations during the preceding period. Additionally, the two nations are engaged in an armaments race.
Amir-ud-Din et al., (2020)	1960-2016	a multivariate VAR model and Granger causality test	The study found that although the opposite is not true, Pakistan's military spending is impacted by India's military spending.

Source: Author's Compilation

These studies are not conclusive due to various factors. After reviewing the aforementioned studies, it can be concluded that other elements, such as war history and their military spending dynamics, must also be taken into account when deciding how much money to spend on the armed forces of both countries. This is because the rivals' military expenditures do not necessarily matter. There is no study in the existing literature on Pakistan and India perspective which have used all versions of Richardson Reaction model of arms race except Hollist (1977) which has used all the versions of Richardson Reaction model but in this study, the author has just compared R2 and F-statistic of four pairs of nations.

### 3. Model Specification and Data

In the context of Pakistan and India, the study identifies and evaluates eight "mini models," or alternative hypotheses about behavioral or armament changes. We use multiple regressions to look at the proposed

relationship in these models. The first six models are estimated using Ordinary Least Squares Method (OLS), as no direct feedback mechanisms in these models. The equations (eq. 1-12) include such factors which are exogenous because we interpret lag variables as independent variables. The last two models (eq. 13-16) are estimated using the Generalized Method of Moments (GMM), as they are characterized by two-way or feedback effects and over-identification restrictions.

The first model that we analyze is the Richard Reaction Model which is specified as the pair of the difference equation:

$$RMEI_t - RMEI_{t-1} = \lambda RMEP_{t-1} - \alpha RMEI_{t-1} + g \tag{1}$$

$$RMEP_t - RMEP_{t-1} = \eta RMEI_{t-1} - \beta RMEP_{t-1} + g' \tag{2}$$

In the second mini model, the Richardson Rivalry model, it is assumed that a country will respond more to the disparity between its own and an opponent's arms expenditures than to the quantity of an opponent's arms. For the rivalry model, the following equations are the outcomes:

$$RMEI_t - RMEI_{t-1} = \lambda(RMEP_{t-1} - RMEI_{t-1}) - \alpha RMEI_{t-1} + g \tag{3}$$

$$RMEP_t - RMEP_{t-1} = \eta(RMEI_{t-1} - RMEP_{t-1}) - \beta RMEP_{t-1} + g' \tag{4}$$

The Richardson Submissiveness Model, our third mini-model, is the mathematically most challenging one we've looked at so far. We won't take Richardson's model's core premise into consideration. Instead, we concentrate on re-specification of this model as two different equations that may be empirically estimated. The Richardson Submissiveness equations are changed as follows by defining the dependent variable as a discrete difference term with regard to time:

$$RMEI_t - RMEI_{t-1} = \lambda RMEP_{t-1} - \lambda s(RMEP_{t-1}^2 - RMEP_{t-1}RMEI_{t-1}) - \alpha RMEI_{t-1} + g \tag{5}$$

$$RMEP_t - RMEP_{t-1} = \eta RMEI_{t-1} - \eta p(RMEI_{t-1}^2 - RMEI_{t-1}RMEP_{t-1}) - \beta RMEP_{t-1} + g' \tag{6}$$

The Explicit Economic Constraint Model, our fourth mini model, marks our first divergence from Richardson's initial models. We were inspired by the work of William Caspasry (1967) to try and create a measure of an explicit cost constraint. As opposed to Casparry, we aimed to create a cost constraint measure that could be evaluated separately from other variables in the equation. In order to estimate multiple regression using an additive, linear model, we decide to include a measure of explicit cost constraint. The following are the resulting difference equations:

$$RMEI_t - RMEI_{t-1} = \lambda RMEP_{t-1} - \theta REDI_{t-1} + g \tag{7}$$

$$RMEP_t - RMEP_{t-1} = \eta RMEI_{t-1} - \psi REDP_{t-1} + g' \tag{8}$$

The Richard Reaction/Technology Model, our sixth mini model, is also an expansion of the Richardson model. We take technology into account under the presumption that it influences changes in arms positively. We employ a technology indicator that is somewhat indirect and is also used by others who are interested in the connection between technology and military spending. We used Gross Domestic Product as a proxy of technology. The resulting model's difference equation form is as follows:

$$RMEI_t - RMEI_{t-1} = \lambda RMEP_{t-1} + \varepsilon RGDPI_{t-1} - \alpha RMEI_{t-1} + g \tag{9}$$

$$RMEP_t - RMEP_{t-1} = \eta RMEI_{t-1} + \gamma RGDPP_{t-1} - \beta RMEP_{t-1} + g' \tag{10}$$

The sixth micro model, the Consolidated Arms Race Model, uses a linear, additive model to combine previously thought of independent variables to reflect changes in the number of weapons in our "conflict" pair of nations. The final difference equations are as follows:

$$RMEI_t - RMEI_{t-1} = \lambda RMEP_{t-1} + \varepsilon RGDPI_{t-1} - \theta REDI_{t-1} - \alpha RMEI_{t-1} + g \tag{11}$$

$$RMEP_t - RMEP_{t-1} = \eta RMEI_{t-1} + \gamma REDP_{t-1} - \psi RGDPP_{t-1} - \beta RMEP_{t-1} + g' \tag{12}$$

Our seventh mini model, which we simply refer to as the First Modified Consolidated Arms Race Model, is a modified version of our Consolidated Arms Race Model. The opponent's arms variable is now represented as a difference term with regard to times t-1 to t, which is the only modification. This alteration is based on the idea that variations in this variable over time have a more direct impact on changes in arms than variations in its linked variable level. The model has been adjusted as follows:

$$RMEI_t - RMEI_{t-1} = \lambda(RMEP_t - RMEP_{t-1}) + \varepsilon RGDPI_{t-1} - \theta REDI_{t-1} - \alpha RMEI_{t-1} + g \tag{13}$$

$$RMEP_t - RMEP_{t-1} = \eta(RMEI_t - RMEI_{t-1}) + \gamma REDP_{t-1} - \psi RGDPP_{t-1} - \beta RMEP_{t-1} + g' \tag{14}$$

In our last eighth mini model, the Second Modified Consolidated Arms Model, we use both the arms variable of the opponent nation and the technology variable as the difference term with respect to time. The resulting model's difference equation form is as follows:

$$RMEI_t - RMEI_{t-1} = \lambda(RMEP_t - RMEP_{t-1}) + \varepsilon(RGDPI_t - RGDPI_{t-1}) - \alpha RMEI_{t-1} + g \tag{15}$$

$$RMEP_t - RMEP_{t-1} = \eta(RMEI_t - RMEI_{t-1}) + \psi(RGDPP_t - RGDPP_{t-1}) - \beta RMEP_{t-1} + g' \tag{16}$$

The State Bank of Pakistan's Handbook Statistics on Pakistan Economy 2020 and the Reserve Bank of India's Handbook Statistics of Indian Economy 2020 are the sources from which the data on each country's military spending is gathered. The World Development Indicators and Global Development Finance databases for the two countries are the source of the information on the dollar exchange rate, GDP at constant 2020 US dollars, and GDP at current 2020 US dollars. In order to determine inflation-adjusted or real variables, we first converted the variables—the military spending of both countries—from local currency to US dollars using their respective dollar exchange rates. We next deflate the data using the GDP deflator. The data was gathered between 1972 and 2020.

#### 4. Results and Discussion

In this section, we present and analyze the empirical findings of the study. The OLS-based results of the Richardson Reaction Model (eq. 1 and eq. 2) are given in Table 2. RMEI is Real Military Expenditures of India and RMEP is Real Military Expenditures of Pakistan; eq. (1) is for India and eq. (2) is for Pakistan. Equation (1) focuses on India, with the dependent variable being the change in real military expenditures of India, and the independent variables being RMEPt-1 (Pakistan's military expenditures in the previous period) and RMEIt-1 (India's own military expenditures in the previous year). The intercept in this equation is 6.08. A positive intercept which is statically significant suggests that average impacts of all those factors which are not taken explicitly in the models. This indicates that India may view Pakistan as a rival rather than an ally, as it is allocating more resources to the military.

**Table 2: OLS Estimates of the Richardson Reaction Model**

India		Pakistan	
Dependent Variable: (RMEIt -RMEIt-1)		Dependent Variable: (RMEPt -RMEPt-1)	
Intercept	6.08 (0.03)	Intercept	2.28 (0.07)
<i>RMEP</i> <sub>t-1</sub>	0.07	<i>RMEI</i> <sub>t-1</sub>	0.07

	(0.02)		(0.04)
$RMEI_{t-1}$	-0.10	$RMEP_{t-1}$	-0.89
	(0.02)		(0.00)
<b>Diagnostic Tests</b>			
R <sup>2</sup>	0.04	R <sup>2</sup>	0.43
DW	1.78	DW	1.99
F-statistic	4.46	F-statistic	8.31
Prob(F-statistic)	0.03	Prob(F-statistic)	0.00
AIC	44.6	AIC	41.9

Source: Authors' Estimations

Specifically, the coefficient for Pakistan's previous period's military expenditures (RMEPt-1) is positive and the coefficient of India's own previous year's military expenditures (RMEPt-1) is negative and statistically significant. This implies that a change in Pakistan's previous period military expenditures (RMEPt-1) is associated with an increase in the change in India's military expenditures due to arms race and rivalry for security among neighboring countries. According to the security dilemma theory (Jervis, 1978), neighbors frequently build up their own militaries in response to a neighboring country's military development in order to maintain a balance of power and security. While India's own previous year's military expenditures (RMEPt-1) are associated with a decrease in the change in India's military expenditure due to the concept of budget constraints and allocation of resources in defense economics. According to Richardson (1960), when a nation boosts its military spending in a single year, it may experience future financial and resource difficulties. Due to the necessity to prioritize other urgent demands or the difficulty of generating additional cash for defense purposes, this could result in a drop in military spending. Additionally, in order to meet multiple socioeconomic goals, nations frequently try to maintain a balance between defense and non-defense spending (Morrow, 1993). In other words, when Pakistan increases its military spending, India tends to increase its military expenditure and when India itself spent more on military in the previous year, India tends to reduce its military expenditure.

Equation (2) focuses on Pakistan, with the dependent variable being the change in real military expenditures of Pakistan, and the independent variables being RMEIt-1 (India's military expenditures in the previous period) and RMEPt-1 (Pakistan's own military expenditures in the previous year). The intercept in this equation is 2.28. A positive intercept suggests that the average effects of all other factors that are summed up in error term, Pakistan's military expenditure tends to increase. This may indicate that Pakistan also views India as a rival rather than an ally, as it is allocating more resources to the military. Specifically, the coefficient for India's previous period's military expenditures (RMEIt-1) is positive and the coefficient of Pakistan's own previous year's military expenditures (RMEPt-1) is negative and statistically significant. This implies that changes in India's previous period military expenditures (RMEIt-1) are associated with an increase in Pakistan's military expenditures due to the concept of an arms race between rival countries while Pakistan's own previous year military expenditures (RMEPt-1) are associated with a decrease in Pakistan's real military expenditures due to the concepts of budget constraints. In other words, when India increases its military spending Pakistan tends to raise its military expenditure and when Pakistan itself spent more on military in the previous year, Pakistan tends to reduce its military expenditure.

The diagnostic tests for the Richardson Reaction Models in India and Pakistan reveal notable differences in their overall performance. In the India model, the R-squared value is low at 0.04, suggesting limited explanatory power and a weak fit to the data. The F-statistic is also insignificant, indicating a lack of overall model significance. Conversely, the Pakistan model exhibits a higher R-squared value of 0.43, implying a relatively better fit and stronger explanatory ability. The F-statistic is highly significant, demonstrating the model's overall significance. However, both models have no issue with autocorrelation, as indicated by the Durbin-Watson statistics.

The Richardson Rivalry Model's OLS-based results (eq. 3 and eq. 4) are presented in Table 3; eq. (3) is for India and eq. (4) is for Pakistan.

**Table 3: OLS Estimates of the Richardson Rivalry Model**

India		Pakistan	
Dependent Variable: (RMEI <sub>t</sub> -RMEI <sub>t-1</sub> )		Dependent Variable: (RMEP <sub>t</sub> -RMEP <sub>t-1</sub> )	
Intercept	5.00 (0.00)	Intercept	2.18 (0.00)
(RMEP <sub>t-1</sub> - RMEI <sub>t-1</sub> )	0.18 (0.00)	(RMEI <sub>t-1</sub> - RMEP <sub>t-1</sub> )	0.20 (0.04)
RMEI <sub>t-1</sub>	-0.10 (0.02)	RMEP <sub>t-1</sub>	-0.87 (0.00)
Diagnostic Tests			
R <sup>2</sup>	0.40	R <sup>2</sup>	0.49
DW	1.67	DW	1.72
F-statistic	9.46	F-statistic	8.31
Prob(F-statistic)	0.03	Prob(F-statistic)	0.00
AIC	42.68	AIC	40.02

Source: Authors' Estimations

Equation (3) focuses on India, with the dependent variable being the change in real military expenditures of India, and the independent variables being RMEP<sub>t-1</sub>-RMEI<sub>t-1</sub> (Difference between the Pakistan's military expenditures in the previous period and India's military expenditures in the previous period) and RMEI<sub>t-1</sub> (India's own military expenditures in the previous year). The value of intercept is 5.00, which mathematically suggests that when both the difference between Pakistan's military expenditures in the previous year and India's military expenditure in the previous year and India's own previous year's military expenditures are zero, the change in India's military expenditures is expected to be around 5.00. This intercept is positive and statistically significant, indicating that average value of omitted variables tends to increase its military expenditures for India. The coefficient for the difference between Pakistan and India's military expenditures in the previous year is positive and statistically significant. This implies that when the difference between Pakistan and India's military spending in the previous year widens (i.e., Pakistan spends more relative to India), it tends to lead to an increase in the change in India's military expenditures. This suggests a response to the concept of an arms race and rivalry. The coefficient for India's own previous year's military expenditures is also negative and statistically significant. This means that when India itself spent more on the military in the previous year, it tended to reduce its military expenditure. This reduction could be due to budget constraints or resource allocation considerations.

Equation (4) focuses on Pakistan, with the dependent variable being the change in real military expenditures of Pakistan, and the independent variables being RMEI<sub>t-1</sub>-RMEP<sub>t-1</sub> and RMEP<sub>t-1</sub> (Pakistan's own military expenditures in the previous year). Similar to India's intercept, it may be mathematically interpreted as that when both the difference between India's and Pakistan's military expenditures in the previous year and Pakistan's own previous year's military expenditures are zero, the change in Pakistan's military expenditures is expected to be around 2.18. This intercept is also positive and statistically significant, indicating that, on average, Pakistan tends to increase its military expenditures. The coefficient for the difference between Pakistan and India's military expenditures in the previous year is positive and statistically significant. This suggests that when the difference between India's and Pakistan's military spending in the previous year widens (i.e., India spends more relative to Pakistan), it tends to lead to an increase in the change in Pakistan's military expenditures, indicating a response to rivalry and potential security concerns. The coefficient for Pakistan's own previous year's military expenditures is negative and statistically significant. This implies that when Pakistan itself spent more on the military in the previous year, it tended to reduce its military expenditure. This reduction could also be due to budget constraints or resource allocation considerations. In a nutshell, both India and Pakistan appear to respond to changes in their own military expenditures from the previous year and the difference between their military expenditures relative to each other. These responses are consistent with the concept of an arms race and rivalry, as well as budget constraints and resource allocation considerations in defense economics.

The diagnostic tests for the models for India and Pakistan reveal that both models are statistically significant in explaining changes in military expenditures, with the Pakistan model having a slightly better



fit based on a lower AIC value. However, both models show signs of low autocorrelation in the residuals. These models explain a moderate portion of the variance in military expenditure changes, with the Pakistan model explaining a slightly higher proportion (49%) compared to the India model (40%).

The Richardson Submissiveness Model's OLS-based results (eq. 5 and eq. 6) are presented in Table 4.; eq. (5) is for India and eq. (6) is for Pakistan.

**Table 4: OLS Estimates of Richardson Submissiveness Model**

India		Pakistan	
Dependent Variable: (RMEI <sub>t</sub> - RMEI <sub>t-1</sub> )		Dependent Variable: (RMEP <sub>t</sub> - RMEP <sub>t-1</sub> )	
Intercept	3.16 (0.00)	Intercept	3.10 (0.21)
<i>RMEI<sub>t-1</sub></i>	4.54 (0.00)	<i>RMEP<sub>t-1</sub></i>	0.07 (0.09)
<i>RMEP<sub>t-1</sub></i>	-1.31 (0.00)	<i>RMEI<sub>t-1</sub></i>	-7.48 (0.07)
$(RMEP_{t-1}^2 - RMEP_t RMEI_{t-1})$	-0.53 (0.00)	$(RMEI_{t-1}^2 - RMEI_t RMEP_{t-1})$	-0.90 (0.00)
Diagnostic Tests			
R <sup>2</sup>	0.59	R <sup>2</sup>	0.51
DW	1.96	DW	1.90
F-statistic	9.64	F-statistic	5.29
Prob(F-statistic)	0.00	Prob(F-statistic)	0.00
AIC	54.93	AIC	51.76

Source: Authors' Estimations

Equation (5) focuses on India, with the dependent variable being the change in real military expenditures of India, and the independent variables being RMEPt-1 (real military expenditures of Pakistan in the previous year), submissiveness variable  $(RMEP_{t-1}^2 - RMEP_t RMEI_{t-1})$  (which represents the difference between the square of the previous year real military expenditures in Pakistan and product of the real military expenditure of Pakistan with previous year real military expenditure of India) and RMEIt-1 (real military expenditure of India in the previous year). The positive and statistically significant intercept suggests that, on average, India tends to increase its military expenditures. This may be attributed to various factors, including the need to maintain national security, respond to regional threats, or address geopolitical tensions (Tiwari and Shahbaz, 2013). The positive and statistically significant coefficient of Pakistan's previous year's military expenditures implies that an increase in Pakistan's military expenditure in the previous year is associated with a significant increase in India's military expenditure. This could be indicative of an arms race dynamic, where India responds to perceived threats and military build-up by Pakistan (Maizels and Nissanke, 1987). The negative and statistically significant coefficient for the submissiveness variable suggests that higher submissiveness is associated with a decrease in India's military expenditure. This might indicate that India reduces its military spending when it perceives a more submissive or less confrontational posture from neighboring countries, potentially aiming to reduce tensions (Dresselhaus, 2022). The negative and statistically significant coefficient for India's own real military expenditure in the previous year implies that an increase in India's own military expenditure in the previous year leads to a decrease in India's current military expenditure. This reduction could be attributed to budget constraints or resource allocation considerations (Dizaji, 2022).

Equation (6) focuses on Pakistan, with the dependent variable being the change in real military expenditures of Pakistan, and the independent variables being real military expenditures of India in the previous year, the submissiveness variable (which represents the difference between the square of the previous year real military expenditures in India and product of the real military expenditure of India with previous year real military expenditure of Pakistan) and real military expenditure of Pakistan in the previous year. The positive and potentially statistically insignificant intercept suggests that, on average, Pakistan tends to increase its military expenditures. However, the significance of this intercept is not clear

due to the higher p-value. The relatively less significant coefficient of India's military expenditures in the previous year implies that changes in India's military expenditure in the previous year may not have a statistically significant effect on Pakistan's current-year military expenditure. The negative and statistically significant coefficient for the submissiveness variable suggests that higher submissiveness is associated with a decrease in Pakistan's military expenditure. This could indicate that Pakistan reduces its military spending in response to diplomatic efforts aimed at reducing tensions (Georgiou, 1983). The negative and statistically significant coefficient of Pakistan's own military expenditures in the previous year implies that an increase in Pakistan's own military expenditure in the previous year leads to a decrease in Pakistan's current-year military expenditure, possibly due to budget constraints or resource allocation considerations (Moll and Luebbert, 1980).

In comparing the diagnostic tests between the India and Pakistan models, it is evident that both models are statistically significant, with significant F-statistics indicating their overall validity. While the model for India demonstrates a slightly higher R-squared value (0.59) and a better ability to explain the variation in the change in military expenditure for India, the Model for Pakistan has a slightly lower AIC value (51.76), implying a relatively better fit for the Pakistan model. However, both regressions exhibit no autocorrelation since the value of the Durbin-Watson test is nearer to 2.

The Explicit Economic Constraint Model's OLS-based results (eq. 7 and eq. 8) are presented in Table 5; eq (7) is for India and eq. (8) is for Pakistan.

**Table 5: OLS Estimates of Explicit Economic Constraint Model**

India		Pakistan	
Dependent Variable: (RMEI <sub>t</sub> -RMEI <sub>t-1</sub> )		Dependent Variable: (RMEP <sub>t</sub> -RMEP <sub>t-1</sub> )	
Intercept	5.63 (0.07)	Intercept	1.70 (0.08)
<i>RMEP</i> <sub>t-1</sub>	0.10 (0.01)	<i>RMEI</i> <sub>t-1</sub>	0.07 (0.05)
<i>REDI</i> <sub>t-1</sub>	-0.01 (0.04)	<i>REDP</i> <sub>t-1</sub>	-0.08 (0.00)
Diagnostic Tests			
R <sup>2</sup>	0.02	R <sup>2</sup>	0.37
DW	1.99	DW	1.97
F-statistic	0.32	F-statistic	6.53
Prob(F-statistic)	0.72	Prob(F-statistic)	0.00
AIC	44.69	AIC	41.99

Source: Authors' Estimations

Equation (7) focuses on India, with the dependent variable being the change in real military expenditures of India, and the independent variables being RMEPt-1 (real military expenditures of Pakistan in the previous year) and REDIt-1 (real external debt of India in the previous year). The value of the intercept is positive and statistically significant indicating that India viewed Pakistan as a rival. The positive and statistically significant coefficient of Pakistan's previous year's military expenditures implies that an increase in Pakistan's military expenditure in the previous year is associated with a significant increase in India's military expenditure. This could be indicative of arms race dynamic, where India responds to perceived threats and military build-up by Pakistan (Maizels and Nissanke, 1987). The negative and statistically significant coefficient for the real external debt of India in the previous year suggests that higher previous year external debt is associated with a decrease in India's military expenditure. This might indicate that India reduced its military expenditures due to an increase in the previous year's real external debt. The financial resources of a nation may be strained by high levels of external debt. This could result in less money being available for military spending since resources will need to be allocated for debt repayment and maintaining the stability of the banking system (Sezgin, 2004).

Equation (8) focuses on Pakistan, with the dependent variable being the change in real military expenditures of Pakistan, and the independent variables being RMEIt-1 (real military expenditures of India

in the previous year) and REDPt-1 (real external debt of Pakistan in the previous year). The value of the intercept is positive and statistically significant indicating that Pakistan viewed India as a rival. The positive and statistically significant coefficient of India's previous year's military expenditures implies that an increase in India's military expenditure in the previous year is associated with a significant increase in Pakistan's military expenditure. This could be indicative of an arms race dynamic, where Pakistan responds to perceived threats and military build-up by India. The negative and statistically significant coefficient for the real external debt of Pakistan in the previous year suggests that higher previous year external debt is associated with a decrease in Pakistan's military expenditure. This might indicate that Pakistan reduced its military expenditures due to an increase in the previous year's real external debt. The significant external debt may put pressure on a government to prioritize debt repayment over military expenditure from both local and foreign creditors (Dreher et al., 2009). An excessive amount of external debt can undermine investor confidence and cause the value of the nation's currency to decline. A depreciating currency may make military purchases more expensive, which would limit the government's capacity to raise military spending (Gavin and Perotti, 1997). Excessive levels of external debt have the potential to threaten economic stability and reduce government revenue. The government may be forced to cut military spending in order to maintain fiscal restraint in the event of an economic downturn (Smyth and Narayan, 2009).

The Richardson Recation/Technology Model's OLS-based results (eq. 9 and eq. 10) are presented in Table 6; eq. (9) is for India and eq (10) is for Pakistan.

**Table 6: OLS Estimates of Richardson Reaction/ Technology Model**

India		Pakistan	
Dependent Variable: (RMEI <sub>t</sub> -RMEI <sub>t-1</sub> )		Dependent Variable: (RMEP <sub>t</sub> -RMEP <sub>t-1</sub> )	
Intercept	2.68 (0.60)	Intercept	1.96 (0.49)
<i>RMEP</i> <sub>t-1</sub>	0.02 (0.07)	<i>RMEI</i> <sub>t-1</sub>	0.06 (0.05)
<i>RGDPI</i> <sub>t-1</sub>	0.01 (0.00)	<i>RMEI</i> <sub>t-1</sub>	0.02 (0.00)
<i>RGDPP</i> <sub>t-1</sub>	-0.66 (0.00)	<i>RMEP</i> <sub>t-1</sub>	-0.89 (0.00)
Diagnostic Tests			
R <sup>2</sup>	0.33	R <sup>2</sup>	0.43
DW	1.97	DW	1.98
F-statistic	3.47	F-statistics	5.29
Prob(F-statistic)	0.03	Prob(F-statistic)	0.00
AIC	44.40	AIC	41.97

Source: Authors' Estimations

Equation (9) focuses on India, with the dependent variable being the change in real military expenditures of India, and the independent variables being real military expenditures of Pakistan in the previous year, India's previous year's gross domestic product and India's previous year's real military expenditures. The value of the intercept is positive and statistically significant indicating that India viewed Pakistan as a rival. Pakistan's previous year's real military expenditure is positively associated with a change in the real military expenditure of India due to the arms race between rival countries which is statistically significant. India's previous year's real gross domestic product is positively associated with the change in the real military expenditures of India. A stronger economy is often indicated by a larger GDP, and this can support greater national security. A nation's ability to spend more on the military to safeguard its interests can be increased by economic growth (Dimitraki and Win, 2021). Growing economies may provide governments with greater financial resources, which makes it easier for them to finance modernization and increases in the military (Biswas and Ram, 1986). India's past year's real military expenditures are negatively and significantly associated with the change in the military expenditures in India due to budget constraints.

Equation (10) focuses on Pakistan, with the dependent variable being the change in real military

expenditures of Pakistan, and the independent variables being real military expenditures of India in the previous year, Pakistan’s previous year's gross domestic product and Pakistan’s previous year real military expenditures. The value of the intercept is positive and statistically significant indicating that Pakistan viewed India as a rival. India’s previous year's real military expenditure is positively associated with a change in the real military expenditure of Pakistan due to the arms race between rival countries which is statistically significant. Pakistan’s previous year's real gross domestic product is positively associated with the change in the real military expenditures of Pakistan. Pakistan’s past year's real military expenditures is negatively and significantly associated with the change in the military expenditures in Pakistan due to the budget constraint.

The Consolidated Arms Race Model's OLS-based results (eq. 11 and eq. 12) are presented in Table 7; eq (11) is for India and eq. (12) is for Pakistan.

**Table 7: OLS Estimates of Consolidated Arms Race Model**

India		Pakistan	
Dependent Variable: (RMEI <sub>t</sub> -RMEI <sub>t-1</sub> )		Dependent Variable: (RMEP <sub>t</sub> -RMEP <sub>t-1</sub> )	
Intercept	2.80 (0.59)	Intercept	1.81 (0.53)
<i>RMEP<sub>t-1</sub></i>	0.09 (0.91)	<i>RMEI<sub>t-1</sub></i>	0.05 (0.47)
<i>RGDPI<sub>t-1</sub></i>	0.02 (0.00)		0.01 (0.80)
<i>RGDPP<sub>t-1</sub></i>	-0.54 (0.23)	<i>RMEI<sub>t-1</sub></i>	-1.36 (0.14)
<i>RMEP<sub>t-1</sub></i>	-0.02 (0.74)	<i>REDI<sub>t-1</sub></i>	-0.05 (0.59)
		<i>REDP<sub>t-1</sub></i>	
Diagnostic Tests			
R <sup>2</sup>	0.33	R <sup>2</sup>	0.43
DW	2.00	DW	2.03
F-statistic	2.52	F-statistic	3.92
Prob(F-statistic)	0.07	Prob(F-statistic)	0.01
AIC	44.47	AIC	42.04

Source: Authors’ Estimations

Equation (11) focuses on India, with the dependent variable being the change in real military expenditures of India, and the independent variables being RMEPt-1 (Pakistan’s previous year's real military expenditures), RGDPIt-1 (India’s previous year's real gross domestic product), RMEIt-1 (India’s previous year real military expenditures), and REDIt-1 (India’s previous year real external debt). The Positive value of intercept in both models shows that both countries view each other as rivals. Pakistan’s previous year's real military expenditures and India’s real gross domestic product in the previous period are positively and significantly linked with the change in the real military expenditures of India. While India’s real military expenditure in the previous period and India’s real external debt in the previous period are negatively and significantly related to the change in the real military expenditures of India.

Similarly, Equation (12) focuses on Pakistan, with the dependent variable being the change in real military expenditures of Pakistan, and the independent variables being RMEIt-1 (India’s previous year's real military expenditures), RGDPPt-1 (Pakistan’s previous year's real gross domestic product), RMEPt-1 (Pakistan’s previous year real military expenditures), and REDPt-1 (Pakistan’s previous year real external debt). India’s previous year's real military expenditures and Pakistan’s real gross domestic product in the previous period are positively and significantly linked with the change in the real military expenditures of Pakistan. While Pakistan’s real military expenditure in the previous period and Pakistan’s real external debt in the previous period are negatively and significantly related to the change in the real military expenditures of Pakistan.

The First Modified Consolidated Arms Model's GMM-based results (eq. 13 and eq. 14) are presented in Table 8; eq (13) is for India and eq. (14) is for Pakistan.

**Table 8: GMM Estimates of First Modified Consolidated Arms Model**

India		Pakistan	
Dependent Variable: (RMEI <sub>t</sub> -RMEI <sub>t-1</sub> )		Dependent Variable: (RMEP <sub>t</sub> -RMEP <sub>t-1</sub> )	
Intercept	3.31 (0.03)	Intercept	7.43 (0.05)
(RMEP <sub>t</sub> - RMEP <sub>t-1</sub> )	1.72 (0.04)	(RMEI <sub>t</sub> - RMEI <sub>t-1</sub> )	0.09 (0.04)
RGDPI <sub>t-1</sub>	0.01 (0.00)	RGDPP <sub>t-1</sub>	0.00 (0.04)
RMEI <sub>t-1</sub>	-0.58 (0.00)	RMEP <sub>t-1</sub>	-0.69 (0.00)
REDI <sub>t-1</sub>	-0.02 (0.78)	REDP <sub>t-1</sub>	-0.01 (0.86)
Diagnostic Tests			
R <sup>2</sup>	0.14	R <sup>2</sup>	0.34
DW	2.54	DW	1.95
Determinant residual covariance	6.30	Determinant residual covariance	7.39
J-statistic	0.15	J-statistic	0.16

Source: Authors' Estimations

Equation (13) focuses on India, with the dependent variable being the change in real military expenditures of India, and the independent variables being RMEP<sub>t</sub>-RMEP<sub>t-1</sub> (change in the real military expenditures of Pakistan), RGDPI<sub>t-1</sub> (India's previous year's real gross domestic product), RMEI<sub>t-1</sub> (India's previous year real military expenditures), and REDI<sub>t-1</sub> (India's previous year real external debt). The Positive value of intercept in both models shows that both countries view each other as rivals. Changes in the real military expenditure of Pakistan and India's real gross domestic product in the previous period are negatively and significantly related to the change in India's military expenditures. While India's real military expenditure in the previous period and India's real external debt in the previous period is negatively and significantly related to the change in the real military expenditures of India.

Equation (14) focuses on Pakistan, with the dependent variable being the change in real military expenditures of Pakistan, and the independent variables being RMEI<sub>t</sub>-RMEI<sub>t-1</sub> (change in the real military expenditures of India), RGDP<sub>t-1</sub> (Pakistan's previous year's real gross domestic product), RMEP<sub>t-1</sub> (Pakistan's previous year real military expenditures), and REDP<sub>t-1</sub> (Pakistan's previous year real external debt). The change in the real military expenditure of India and Pakistan's real gross domestic product in the previous period is negatively and significantly related to the change in Pakistan's military expenditures. While Pakistan's real military expenditure in the previous period and Pakistan's real external debt in the previous period are negatively and significantly related to the change in the real military expenditures of Pakistan.

So far the interpretation of diagnostic tests, the value of R-squared is not applicable in GMM technique because basic assumptions of OLS are not fulfilled in GMM estimation. There is no evidence of autocorrelation in both models because calculated value of DW statistics are closer to 2. To test the over-identifying restriction validity and model specification we use J- statistic. So accept the null hypothesis of J-statistic and model specification is correctly specified and valid restrictions.

The Second Modified Consolidated Arms Model's GMM-based results (eq. 15 and eq. 16) are presented in Table 9; eq (15) is for India and eq. (16) is for Pakistan. Equation (15) focuses on India, with the dependent variable being the change in real military expenditures of India, and the independent variables being RMEP<sub>t</sub>-RMEP<sub>t-1</sub> (change in the real military expenditures of Pakistan), RGDPI<sub>t</sub>-RGDPI<sub>t-1</sub> (change in India's real gross domestic product), RMEI<sub>t-1</sub> (India's previous year real military expenditures). The

Positive value of intercept in both models shows that both countries view each other as rivals. Changes in the real military expenditure of Pakistan and changes in the real gross domestic product of India are positively and significantly related to the change in India’s military expenditures. While India’s real military expenditure in the previous period is negatively and significantly related to the change in the real military expenditures of India.

**Table 9: GMM Estimates of Second Modified Consolidated Arms Model**

India		Pakistan	
Dependent Variable: (RMEI <sub>t</sub> -RMEI <sub>t-1</sub> )		Dependent Variable: (RMEP <sub>t</sub> -RMEP <sub>t-1</sub> )	
Intercept	12.79 (0.09)	Intercept	29.85 (0.01)
<i>RMEI</i> <sub>t-1</sub>	1.60 (0.00)	<i>RMEP</i> <sub>t-1</sub>	0.11 (0.06)
( <i>RMEP</i> <sub>t</sub> - <i>RMEP</i> <sub>t-1</sub> )	0.04 (0.01)	( <i>RMEI</i> <sub>t</sub> - <i>RMEI</i> <sub>t-1</sub> )	0.09 (0.06)
( <i>RGDPI</i> <sub>t</sub> - <i>RGDPI</i> <sub>t-1</sub> )	-0.60 (0.00)	( <i>RGDPP</i> <sub>t</sub> - <i>RGDPP</i> <sub>t-1</sub> )	-0.78 (0.00)
Diagnostic Tests			
R2	-0.43	R2	0.07
DW	2.39	DW	1.63
Determinant residual covariance	2.15	Determinant residual covariance	2.14
J-statistic	0.19	J-statistic	0.18

Source: Authors’ Estimations

Equation (16) focuses on Pakistan, with the dependent variable being the change in real military expenditures of Pakistan, and the independent variables being RMEI<sub>t</sub>-RMEI<sub>t-1</sub> (change in the real military expenditures of India), RGDP<sub>t</sub>-RGDP<sub>t-1</sub> (change in Pakistan’s real gross domestic product), RMEP<sub>t-1</sub> (Pakistan’s previous year real military expenditures). Changes in the real military expenditure of India and changes in the real gross domestic product of Pakistan are positively and significantly related to the change in Pakistan’s military expenditures. While Pakistan’s real military expenditure in the previous period is negatively and significantly related to the change in the real military expenditures of Pakistan.

### 5. Conclusions and Policy Implications

This study delved into the complex dynamics of the arms race between Pakistan and India, with a primary focus on examining various arms race models. We assessed eight distinct models, including the Richardson reaction model, Richardson rivalry model, Richardson submissiveness model, explicit economic constraint model, Richardson reaction/technology model, consolidated arms race model, and the first and second modified consolidated arms race models. Notably, the first six models were estimated using the Ordinary Least Squares (OLS) technique, while the latter two models were estimated using the Generalized Method of Moments (GMM) technique, chosen to account for feedback or two-way relationships.

Our findings shed light on critical factors influencing military expenditures in the region. It became evident that a country's own previous year's military expenditures exhibited a negative association with changes in its military spending, while the previous year's military expenditures of its opponent countries were positively associated with its own military outlays. Additionally, the disparity between a country's military expenditure and that of its opponents in the prior year was found to positively impact changes in its own military spending. We also identified that the submissiveness variable, representing the difference between the square of a country's previous year's real military expenditures and the product of its military expenditure with the opponent country's previous year's real military expenditure, negatively influenced changes in its own military expenditures. Furthermore, a country's real external debt was negatively related to changes in military expenditures, emphasizing the constraints imposed by limited financial resources.

On a more positive note, we observed that a country's real GDP in the previous year was positively related to changes in its military expenditures, suggesting that economic growth played a role in influencing military investment decisions. Policymakers may carefully consider the impact of their country's previous year's military expenditures and those of their opponents. A reduction in military expenditures by one's own country in the previous year might be an effective strategy to encourage stability and reduce the risk of an escalating arms race. On the other hand, preserving national security depends on keeping an eye out for and reacting to rises in the enemy's military budget. Caution may be exercised in handling a country's and its opponent's disparity in military spending from the previous year. Policymakers may be aware that a sizable differential in military expenditures has the potential to start an arms race, since our research demonstrates a positive correlation between this difference and a change in one's own military spending. To lessen this risk, diplomacy and steps aimed at fostering confidence might be taken. A negative correlation between changes in military spending and the submissiveness variable raises the possibility that variables other than relative military might may have an impact on a nation's military posture. In order to ease tensions and encourage peaceful cohabitation, policymakers should consider diplomatic options as relying exclusively on military strength could not produce the desired results. The significance of cautious fiscal management is highlighted by the negative correlation observed between changes in military spending and actual external debt. When accruing external debt for military purposes, governments can exercise caution because it can put a pressure on their finances and could restrict other crucial investments. Maintaining fiscal stability can be aided by lowering reliance on foreign debt and encouraging the mobilization of home resources. The fact that real GDP growth and changes in military spending are positively correlated raises the possibility that higher military spending can be facilitated by economic expansion. It is possible for policymakers to understand the relationship between defense spending and economic growth. Economic growth has the potential to increase military capabilities, but in order to prevent excessive military spending at the expense of other important sectors, regulations that guarantee equitable resource distribution should be given top priority.

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There is no conflict between authors to produce this research and every author(s) took effort to contribute his part.

### **Disclaimer**

The views and opinions expressed in this paper are those of the author alone and do not necessarily reflect the views of any institution.

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