ARMS RACE MODELING

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IN PARTIAL FULFILLMENT OF REQUIREMENTS FOR ID 499-HONORS THESIS
THERE HAS BEEN MUCH WRITTEN IN THE ECONOMIC AND POLITICAL SCIENCE LITERATURE CONCERNING THE SO CALLED "ARMS RACE" BETWEEN THE UNITED STATES AND THE SOVIET UNION. THE PURPOSE OF THIS THESIS WILL BE THREE-FOLD. 1) TO DEVELOP A WORKING DEFINITION OF AN ARMS RACE WITH WHICH TO WORK WITH. 2) TO SURVEY THE LITERATURE CONCERNING ARMS RACE MODELING AND WHETHER OR NOT THERE IS AN ARMS RACE BETWEEN THE U.S. AND U.S.S.R. 3) IF SUCH AN ARMS RACE DOES EXIST, TO DETERMINE THE CAUSALITY THROUGH ECONOMETRIC MEANS AND TO POINT OUT THE DIFFICULTY IN DOING SUCH ECONOMETRIC WORK.

BEFORE CONSIDERING AN ARMS RACE IT WILL BE USEFUL TO DEFINE IT. ALBERT WOHLSTETTER (1974a: 4) DEFINES AN ARMS RACE AS A "COMPETITION THAT TAKES ON AN EXPLOSIVE LIFE OF ITS OWN THAT MAY FRUSTRATE THE OBJECTIVES OF BOTH CONTESTANTS. EXPLOSIVE IN TWO SENSES: (1) IT LEADS TO "ACCELERATING" (OR "EXPONENTIAL" OR "UNCONTROLLED" OR "UNLIMITED" OR "UNBRIDLED" OR "INFINITE") INCREASES IN BUDGETS AND FORCE SIZES; (2) IT LEADS INEVITABLY TO WAR, OR AT ANY RATE MAKES WAR MUCH MORE LIKELY."

THE MOST WIDELY USED ARMS RACE MODEL IS THE RICHARDSON DIFFERENTIAL EQUATION MODEL. IN THE CONTEXT OF ARMS RACE BETWEEN TWO OPPONENTS, THE RICHARDSON MODEL CAN BE EXPRESSED BY A SYSTEM OF TWO LINEAR DIFFERENTIAL EQUATIONS:

\[
\begin{align*}
\frac{dx}{dt} &= ky - ax + g (k, a > 0) \\
\frac{dy}{dt} &= lx - by + h (l, b > 0)
\end{align*}
\]

TIME RATE OF CHANGE OF ARMS EXPENDITURES (AS A PROXY OF THE LEVEL OF ARMAMENT BUILD-UP) IN EACH NATION IS DETERMINED BY THREE FACTORS: (A) THE 'DEFENSE' TERM, CAPTURED BY THE PARAMETERS \( k \) AND \( l \), INDICATING THE THREATS BETWEEN TWO ARMS RACE OPPONENTS; (B) THE 'FATIGUE' TERM, CAPTURED BY THE PARAMETERS \( a \) AND \( b \), INDICATING THE ECONOMIC BURDEN OF EACH NATION MAINTAINING ITS OWN ARMAMENT LEVEL; AND (C) THE 'GRIEVANCE' TERM, CAPTURED BY THE CONSTANT TERMS \( g \) AND \( h \), INDICATING THE LEVEL OF HOSTILITY OF ONE NATION TOWARD ITS OPPONENT NATION. IN THIS MODEL RICHARDSON ASSUMED THAT THE CAUSES OF ARMS EXPENDITURES ARE LINEARLY ADDITIVE.

REVIEW OF LITERATURE

BEFORE TRYING TO CONSIDER AN ARMS RACE AND WHETHER OR NOT ONE EXISTS ONE MUST TRY TO DETERMINE AN APPROPRIATE MODEL. WE CAN ASK WHAT WE THINK AN ARMS RACE MODEL SHOULD ACCOMPLISH. ACCORDING TO ANDERTON (1989: 347) THE "WORTH OF AN ARMS RACE MODEL DOES NOT NECESSARILY DEPEND ON ITS TRUTH OR FALSENESS, ITS RIGOR, OR ITS EMPIRICAL FIT. THE TEST OF AN ARMS RACE MODEL IS ITS USEFULNESS AND THAT, OF COURSE, DEPENDS ON THE USE TO WHICH IT IS PUT."

ARMS RACE MODELING MAY BE USEFUL IN THREE MAJOR WAYS, ACCORDING TO ANDERTON (1989: 347), FIRST THEY CAN "DESCRIBE AND SUMMARIZE THE COMPLEX REALITY OF ARMS RACES." SECOND, THEY CAN BE USEFUL TO BETTER "UNDERSTAND AND PREDICT" THE COMPLEXITY OF ARMS RACES. THIRD, ARMS RACE MODELING CAN BE USEFUL IF THEY HELP
"PRESCRIBE A TREATMENT THAT WILL ACHIEVE A DESIRED END."

According to Anderton (1989: 347) many models of arms races point to the conclusion that nations should pursue efforts to subside the negative effects of arms races. "Beyond this, however, most arms race models are not used to shed insight into specific policies for reducing the cost and danger of arms races. The arms race modelers that use their models to make specific policy prescriptions rarely rely on Richardson-type models in their work, presumably because they are not useful for the task."

Instead, analysts use arms race models that focus on gross behavior and strategies of parties involved in arms races. Intriligator and Brito (1985) and McGuire (1965: Chap. 7) make specific arms control policy recommendations based on their models.

Richardson Models

Anderton (1989: 348) makes note that "description, summarization, understanding, prediction, and prescription" are what an arms race analyst would like to be able to do when studying an arms race. There are various types of arms race modeling approaches available to the analyst. Richardson models have a comparative advantage in describing and summarizing arms races. "They are a tool of first cut", according to Anderton (1989: 348). For greater understanding, prescription, and prediction, Richardson-type models are often at a comparative
DISADVANTAGE RELATIVE TO MODELS THAT PERTAIN TO STRATEGIC CONSIDERATIONS AND GROSS BEHAVIOR.

KENNETH BOULDING (1962) AND ANATOL RAPPOPORT (1957, 1961) QUESTIONED THE APPLICABILITY OF RICHARDSON-TYPE (DIFFERENTIAL EQUATION) MODELS IN ANALYZING ARMS RACES WHEN ARMS RACE MODELING WAS IN ITS EARLY STAGES. THEIR ARGUMENT WAS THAT CLASSICAL MATHEMATICS LACKED NECESSARY CONCEPTS FOR THE STUDY OF ARMS RACES.

"IT IS NO WONDER THAT MUCH CONTEMPORARY RESEARCH IN INTERNATIONAL CONFLICT HAS BEEN DIRECTED TOWARD EXPLAINING THE DYNAMICS OF ARMS RACES. AN EXHAUSTING COMPILATION OF ARMS RACE RESEARCH IS PROVIDED BY CIDIFFI-REVILLA (1979). MUCH OF THIS RESEARCH CAN BE TRACED TO LEWIS F. RICHARDSON'S PIONEERING WORK ON MATHEMATICAL MODELS OF COMPETITIVE ARMAMENTS PROCESSES. 

UNFORTUNATELY, EMPIRICAL APPLICATIONS OF THIS MODEL OFTEN HAVE BEEN DISAPPOINTING. IN PARTICULAR, ESTIMATES OF THE RICHARDSON MODEL IN SITUATIONS WHICH ARE INTUITIVELY CONVINCING AS ARMS RACES ARE, NONETHELESS, GENERALLY UNSATISFACTORY."


ACCORDING TO ANDERTON (1989:348),

"THE MATHEMATICS OF RICHARDSON'S EQUATIONS AND RICHARDSON-PROCESS MODELS IN GENERAL (EVEN THOSE WITH STOCHASTIC ELEMENTS) IS OF THE SAME NATURE AS THE MATHEMATICS THAT DESCRIBES THE MOTION OF PLANETS, THE PROBLEM WITH CLASSICAL MATHEMATICS IS THAT IT CANNOT ADEQUATELY DESCRIBE CONCEPTS SUCH AS BLUFFING, COOPERATION, PLOTTING OF ONE NATION AGAINST ANOTHER, TAKING ACCOUNT OF STRATEGIC INTERACTION, AND SO ON. PLANETS DO NOT DO THESE THINGS, BUT NATIONS DO."

THIS IS PERHAPS THE REASON THAT BOULDING (1962: 24) CONCLUDES THAT "THE CLASSICAL APPARATUS OF PHYSICAL MECHANICAL SYSTEMS ... HAS ONLY A VERY LIMITED APPLICABILITY TO SOCIAL SYSTEMS". RAPPOPORT (1957: 295) CONCURS BY STATING THAT "NO AMOUNT OF THE DEVELOPMENT OF THE TECHNIQUES OF CLASSICAL ANALYSIS WILL BREAK THE BARRIER WHICH SEPARATES ITS RANGE OF APPLICABILITY FROM
THAT OF HUMAN BEHAVIOR".

Boulding (1962: 23) stated that "One answer to the failure of mechanical dynamics in social systems" would be to "look for bigger and better differential equations." This was what happened in the arms race modeling literature following the popularization of Richardson-type models. There are over one hundred Richardson-process arms race models in the literature. One might argue that this is a reflection of the popularity and success of Richardson-type modeling. "I believe, however, that the search for bigger and better differential equations is a reflection of frustration over the limited applicability of Richardson-type models. This is a sign, not of a successful research program, but of a degenerating one". (Anderton, 1989: 349).

Anderton goes on to discuss some of the empirical problems with arms race modeling. This topic will be discussed later in the text of this paper.

While Anderton commented on the broad subject of arms race models, Majeski and Jones (1991) focus on twelve actual pairs of arms expenditures that are commonly proposed as arms races. Majeski and Jones find that the Richardson differential equation model is unsatisfactory at explaining anything statistically significant as far as correlation between pairs of arms expenditures for the twelve 'arms races'. Majeski and Jones consider two potential sources for the failure of the Richardson model. "First, they may not constitute arms races. Second, for those which do, the Richardson model specification may not be
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THE METHODOLOGY WHICH ENABLED MAJESKI AND JONES TO FURTHER EXPLORE THE TWELVE SUPPOSED ARMS RACES IS "STATISTICAL CAUSALITY ANALYSIS, AS RECENTLY PROMULGATED IN TIME SERIES RESEARCH, USING THIS METHODOLOGY, WE FIND THAT ARMS EXPENDITURES ARE INDEPENDENT IN A MAJORITY OF THE TWELVE CASES EXAMINED. FOR THOSE CASES WHERE INTERDEPENDENCE IS FOUND, THOSE WHICH EXHIBIT ARMS COMPETITION, THE TRADITIONAL RICHARDSON MODEL SPECIFICATION IS NOT EMPIRICALLY SUPPORTED. FINALLY, WE PROVIDE A SPECIFIC METHODOLOGY FOR IMPROVED MODEL SPECIFICATION DERIVED FROM A GENERAL DISTRIBUTED LAG MODEL FOR ANY PROPOSED ARMS RACE."


U.S.-U.S.S.R.


SURVEY OF U.S.-U.S.S.R. LITERATURE

States and the Soviet Union." Ayanian (1986: 202). In Section Three 
...an asymmetrical nuclear stockpiling model is presented
in which U.S. activity is exogenous, determined as a by-product
of domestic interest group politics, with little reference to
Soviet activity, while Soviet stockpiling displays rationality
given American nuclear-relevant decisions. The correspondence of
this model to observed changes in U.S./Soviet nuclear force
ratios is striking," Ayanian (1986: 202). Section Four discusses
SALT I and SALT II. In Section Five Ayanian discusses nuclear
opportunism and the prospective for the U.S. to survive. Section
Six is a summary.

According to Ayanian (1986: 220),

There is no evidence of a nuclear arms race between the United
States and the Soviet Union. On the contrary, there is clear
evidence of Soviet 'nuclear opportunism' and American 'nuclear
drift' over this period. During these decades the U.S. welfare
system has expanded in two directions: into the federal budget;
crowding-out defense, and into the private sector, reducing the
untaxed taxable capacity of the nation. This process has rendered
the U.S. nuclear force levels unresponsive to changes in Soviet
nuclear force, while allowing the Soviets to pursue political
dominance through nuclear superiority as American 'latent
strength' has declined...It is difficult to see how democracy and
the West are to survive without a reallocation of resources
toward defense.

For other authors suggesting there is no strategic arms
race between the United States and Soviet Union, see Tullock
(1974), and Wohlstetter (1974a) and (1974b).

In his 1984 paper titled "The Political Economy of Arms
Races and International Tension", Michael Ward

"developed, measured and tested a continuous time model which
exists between the U.S. and U.S.S.R. an arms race is shown to
exist, albeit a race concerned most directly with weapons
ACQUISITIONS, NOT WITH BUDGETS. THE SENSITIVITIES OF THIS SYSTEM WERE EXPLORED, AND THEY SUGGESTED THAT THE SYSTEM IS HIGHLY SENSITIVE BOTH TO THE WAYS IN WHICH COMPARISONS OF WEAPONS GET TRANSLATED INTO EXPENDITURES BY THE SOVIET UNION AND THE U.S., AND TO THE LEVEL OF SUPERPOWER TENSION WHICH IS PERCEIVED TO EXIST IN THE INTERNATIONAL POLITICAL CLIMATE...THE MAJOR GOAL IS TO ILLUSTRATE IN A RIGOROUS AND AND VERIFIABLE FASHION THAT THE ARMS RACE BETWEEN THE U.S. AND SOVIET UNION DOES EXIST AND IS NOT A NEW PHENOMENON.


IT IS INTERESTING TO NOTE THAT AYANIAN USED AN INDEX OF NUCLEAR FORCE IN HIS PAPER, WHILE WARD USED AN INDEX OF NUCLEAR AND CONVENTIONAL FORCES. ACCORDING TO ANDERTON (1989: 353), "WHILE THE CASE FOR INCLUSION OF SOME MEASURE OF WEAPONS STOCKS IN ARMS RACE STUDIES IS PERSUASIVE, THERE IS NO CLEAR CONSENSUS AMONG ARMS RACE MODELERS AS TO WHAT TYPE(S) OF MEASURE(S) SHOULD BE EMPLOYED."


IN TANG AND YANG'S PAPER, 'CAUSALITY' IS REFERRED TO IN THE SENSE OF GRANGER CAUSALITY. (GRANGER CAUSALITY REFERENCES TO THE FACT THAT ONE VARIABLE ADDS TO THE ABILITY TO FORECAST ANOTHER VARIABLE. SEE ZELLNER (1979).) THE PAPER EXAMINED THE EMPIRICAL

COMMENTS

MY FIRST COMMENT WILL RELATE TO THE RICHARDSON MODEL ITSELF, AND THUS TO MANY OTHER PAPERS IN THE ARMS MODELING LITERATURE. ACCORDING TO GORDON TULLOCK (1974), "THE MOTIVATING FORCES IN THE RICHARDSON MODEL ARE ESSENTIALLY EMOTIONAL, RATHER THAN RATIONAL EFFORTS TO OBTAIN GAIN OR AVOID LOSS." THIS LEADS TO SOME RATHER DRASIC DIFFERENCES BETWEEN THE RESULTS OF TULLOCK'S REASONING AND THE RESULTS OF RICHARDSON'S. "IN PARTICULAR, IT IS ALWAYS RATIONAL TO START A WAR IF YOUR ENEMY IS BOTH RICH ENOUGH AND WEAK ENOUGH." TULLOCK (1974: 92). THIS POINT OF VIEW WAS EXPANDED UPON BY MR. TULLOCK IN PRIVATE CONVERSATION. THIS MIGHT GIVE A VALID REASON WHY THE RICHARDSON MODEL FAILED TO GIVE SATISFACTORY RESULTS IN ANY OF THE TWELVE "ARMS RACES"

THE NEXT COMMENT REFERS NOT JUST TO TANG AND YANG (1988), BUT TO VIRTUALLY EVERY ARMS RACE STUDY IN THE LITERATURE. THIS COMMENT REFERS TO MEASUREMENT ERROR.

"THE TWO MAJOR SOURCES OF MEASUREMENT ERROR IN ARMS RACE STUDIES ARE INACCURACIES IN THE COLLECTION AND PUBLICATION OF DATA AND THAT AVAILABLE DATA DO NOT REFER TO THE VARIABLE AS SPECIFIED. WHILE THESE PROBLEMS CAN AFFECT ALL ARMS RACE DATA AND VARIABLES, THE MOST FREQUENTLY CITED EXAMPLES IN THE LITERATURE ARE (1) THE POOR QUALITY OF ARMS AND MILITARY EXPENDITURE DATA AND (2) THE DIFFICULTY IN CHOOSING A MEASURE OF DEFENSE...FACTORS THAT REDUCE DATA RELIABILITY INCLUDE INFLATION AND EXCHANGE RATE CORRECTIONS, DIFFERENT MODES OF DATA PREPARATION BY INSTITUTIONS, AND DIFFERENT INSTITUTIONAL PURPOSES FOR PRODUCING INFORMATION...THE VARIABLES IN ARMS RACE MODELS ARE PERCEIVED VARIABLES. IF POLICYMAKERS IN THE (U.S.) USE CIA ESTIMATES OF SOVIET MILITARY EXPENDITURES WHEN FORMULATING THEIR POLICY, THEN CIA DATA ARE THE BEST MEASURE OF U.S. POLICYMAKERS' PERCEPTIONS OF SOVIET MILITARY EXPENDITURES...IRONICALLY, UPDATED (MORE ACCURATE) ESTIMATES OF SOVIET MILITARY SPENDING FOR PREVIOUS YEARS ARE INFERIOR MEASURES...OF U.S. POLICYMAKER'S PERCEPTIONS OF SOVIET MILITARY EXPENDITURES IN THOSE YEARS.

ARMS RACE MODELERS STUDYING THE BEHAVIOR OF POLICYMAKERS MUST IDENTIFY THE DATA THAT THE POLICYMAKERS USED, NOT THE DATA THEY (THE ARMS RACE MODELERS) THINK IS MOST ACCURATE...IF U.S. PERCEPTIONS OF SOVIET MILITARY SPENDING ARE DIFFERENT FROM SOVIET PERCEPTIONS OF MILITARY SPENDING, TWO MEASURES OF SOVIET MILITARY SPENDING MIGHT BE NEEDED. SIMILAR REASONING MAY IMPLY THE NEED FOR TWO MEASURES OF U.S. MILITARY SPENDING. IF WE HAVE A THREE NATION ARMS RACE (OR AN N-NATION RACE), THE COMPLICATIONS COULD BE QUITE SEVERE.

THERE IS A MILD CONSENSUS THAT MILITARY EXPENDITURES ARE
A GOOD MEASURE OF DEFENSE, OR AT LEAST THE BEST AVAILABLE....
HOWEVER, SOME ANALYSTS ARGUE THAT MILITARY EXPENDITURES CAN BE A
MISLEADING MEASURE OF DEFENSE THAT SHOULD BE REPLACED OR
SUPPLEMENTED BY CAPABILITY DATA. MCCUBBINS (1983) ARGUES THAT THE
MILITARY EXPENDITURES OF TWO NATIONS INVOLVED IN AN ARMS RACE
COULD BE UNCHANGED WHILE INTENSE ARMS COMPETITION IS OCCURRING
BETWEEN ONE OR TWO (OR MORE) WEAPONS TYPES."

ECONOMETRIC ANALYSIS

I HAVE CONSIDERED TWO MODELS OF ARMS RACE BEHAVIOR
BETWEEN THE UNITED STATES AND THE SOVIET UNION. IN BOTH MODELS I
HAVE USED STATISTICS ON LEVELS OF RUSSIAN AND AMERICAN WARHEADS
FOR YEARS 1963-1985. (BOMBER WARHEADS WERE EXCLUDED BECAUSE OF
AMBIGUITIES.) THE STATISTICS WERE OBTAINED WITH PERMISSION FROM
THE HUDSON INSTITUTE. IN BOTH MODELS I USED OLS (ORDINARY LEAST
SQUARES).

RICHARDSON MODEL

THE RICHARDSON MODEL I TESTED IS A SYSTEM OF TWO LINEAR
DIFFERENTIAL EQUATIONS: (THIS IS THE RICHARDSON MODEL IN ITS MOST
BASIC FORM.)

(1) \[ FDRW = K(AWH) - A(RWH) + G \]
(2) \[ FDAW = L(RWH) - D(AWH) + H \]

\[ FDRW \] (FIRST DIFFERENCE RUSSIAN WARHEADS)
FD AW (FIRST DIFFERENCE AMERICAN WARHEADS)
RWH (RUSSIAN WARHEADS)
AWH (AMERICAN WARHEADS)
G AND H (CONSTANTS)

THE FIRST (1) OLS REGRESSION FAILED TO PROVIDE ANY SIGNIFICANT t-STATISTICS. THE SECOND (2), HOWEVER, DID AS FOLLOWS:

\[ F D A W = -0.23583(R W H) + 0.25954(A W H) + 46.828 \]
\[ (-3.3270) \quad (2.9119) \quad (0.21869) \]

R-SQUARE=.3737 R-SQUARE=.3078 DURBIN-H=1.5493028
WHERE THE NUMBERS IN PARENTHESES ARE t-STATISTICS.

ACCORDING TO THESE RESULTS, F DAW CORRELATES NEGATIVELY WITH RWH AND POSITIVELY WITH AWH. THIS IS THE EXACT OPPOSITE OF WHAT RICHARDSON ORIGINALLY PROPOSED IN HIS MODEL. MY RESULTS CONFIRM MAJESKI AND JONES (1981: 261) FINDINGS OF NEGATIVE INTERACTION TERMS IN THEIR RESEARCH.

DISTRIBUTED LAG MODEL

THE DISTRIBUTED LAG MODEL I PURPOSE IS A SYSTEM OF TWO LINEAR EQUATIONS:

(1) \[ R W H = R i \ (i=1 \ to \ m) + A i \ (i=1 \ to \ m) + C \]
(2) \[ A W H = A i \ (i=1 \ to \ m) + R i \ (i=1 \ to \ m) + C \]
RWH (RUSSIAN WARHEADS)

AWH (AMERICAN WARHEADS)

R1 (RUSSIAN WARHEADS LAGGED 1 YEARS)

A1 (AMERICAN WARHEADS LAGGED 1 YEARS)

C (CONSTANT)

The method for obtaining \( n \) and \( m \) was provided from Tang and Yang (1988). (In brief, lags are added to the models until significant t-statistics were obtained for all \( R1 \) and \( A1 \)).

The second (2) equation failed to provide any significant t-statistics. The first (1), however, did as follows: \((n=1, m=3)\)

\[
\begin{align*}
RWH &= 0.58848(R1) + 0.95856(A1) + 1.3695(A2) + 0.98040(A3) + 79.717 \\
   &= (4.1760) \quad (2.9362) \quad (-2.7472) \quad (3.0704) \quad (2.9744)
\end{align*}
\]

\[ R-\text{SQUARE} = 0.7777 \quad \text{R-BAR \ SQUAR} E = 0.9718 \quad \text{DURBIN-H} = -1.5590 \]

Thus levels of Russian warheads correlate well with Russian warhead levels lagged one year and American warhead levels lagged one, two, and three years. American warhead levels did not correlate significantly with any lagged values of Russian warheads, implying that changes in yearly levels of Russian warheads have little to do with yearly changes in American warhead levels. The results of this model imply that American warhead build-up preceded Russian warhead build-up in a statistically significantly manner: it took the U.S.S.R. one to three years to catch up with the United States, (from 1963-1985).
OF THE TWO MODELS I HAVE PRESENTED, I PREFER THE DISTRIBUTED LAG MODEL, FOR REASONS STATED EARLIER IN THIS PAPER CONCERNING RICHARDSON MODELS, AND FOR REASONS STATED BY TULLOCK (1974). IT WOULD BE INTERESTING TO SEE HOW BOTH MODELS HOLD UP WHEN MILITARY EXPENDITURES ARE USED INSTEAD OF WARHEAD LEVELS, BUT DATA WERE NOT READILY AVAILABLE.

CONCLUSIONS

REFERENCES


BOULDING, K.E. (1962) CONFLICT AND DEFENSE. NEW YORK: HARPER AND ROW.


McGUIRE (1965) SECRECY AND THE ARMS RACE. CAMBRIDGE: HARVARD UNIV. PRESS.

OSTROM (1977) "EVALUATING ALTERNATIVE FOREIGN POLICY DECISION MAKING MODELS: AN EMPIRICAL TEST BETWEEN AN ARMS RACE MODEL AND AN ORGANIZATIONAL POLITICS MODEL." J. CONFLICT RESOLUTION. 21: 235-266.


