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From War to War to War

Arms Races in the Middle East

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In this article two simple Richardson-type arms race models are applied to the military build-ups of Egypt, Iraq, Jordan, Syria, and Israel. Time-series data on major weapon system inventories and capabilities of these nations and on their military manpower were collected for this study, and measurement procedures are discussed briefly. The periods from 1956 to 1967 and from 1967 to 1973 are analyzed separately to detect changes of reaction patterns from one arms race to the other. Ordinary and generalized least squares regression are used as estimation techniques. Empirical findings are compared across arms races, nations, armed services, weapon systems, models, and indicators. Many reaction patterns which initially look significant are wiped out if autocorrelation of residuals is taken into account by generalized least squares regression. Thus, the first period is shown to be more of a mutual arms "race," whereas in the second period only Israel is seen as reacting to Arab inventories, capabilities, and manpower. The only exception is an Israeli-Syrian missile-boat race between 1967 and 1973. Generally it can be concluded that by disaggregating overall military postures into individual services for which multiple indicators are available, it is possible for arms race research to identify reaction processes which not only would have gone unnoticed in aggregate data but also come closer to real-world decision processes.

The Middle East is at present regarded by many as that part of the world in which large-scale conflict between the superpowers is most likely to originate. One event in support of that view was the worldwide alert of American forces during the

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Arab-Israeli war of October 1973. Not the least important factor in establishing the Middle East as the world's primary trouble spot is the sheer mass of sophisticated weaponry available to Israel and her Arab enemies. Should fighting break out again on a level of intensity comparable to that of 1973, superpower involvement—at least to supply replacement of losses, spare parts, ammunition, and expert advice—would be unavoidable from the first hour of combat. Since rearmament after the war took place in a matter of weeks rather than months in Israel as well as in Iraq, Syria, and Egypt, and since these countries now command more formidable arsenals than ever before (Kemp, 1975; Tahtinen, 1974), all this is even more relevant today than it was in 1973.

In this situation it is not surprising that a number of studies have been devoted to conflict interactions in the Middle East (Wilkenfeld et al., 1972; Burrowes and Garriga-Pico, 1974; McCormick, 1975) and specifically to the arms race characteristics of the military build-ups in the interwar periods. In a study of military spending before 1967, Lambelet (1971) finds the effects of reactivity to be comparatively low when contrasted with those of economic growth. Controlling for the high correlation of real armament expenditures with time by de-trending linearly, Rattinger (1974a) found fairly high interaction between Israeli and total Arab defense expenditures between the wars of 1956 and 1967; for the period from 1967 to 1973 no significant results were obtained.

The major weakness of these studies is their focus on aggregate defense expenditures. For most nations in the area, military spending is a rather meaningless indicator of capability because of the complex interplay of military aid, regular arms procurement, gifts and nonmaterial forms of payment by political allegiance to arms donors, and the like. This fact—together with the high degree of hostility and comparatively good information on hardware levels—makes defense spending less important as a perceptual variable in the Middle East context.

These limitations on the use of budgetary data have led Mihalka (1975) to fit a modified Richardson model to capability data on Arab and Israeli combat aircraft inventories from 1949 to 1968. The restriction to aircraft assumes that arms races take place in "dominant" weapon systems (Huntington, 1958) and that combat aircraft fill that role in the Middle East. While Mihalka's work is highly innovative with respect to capability measurement, his interpretation of empirical results is afflicted by some serious shortcomings. Most important is that his major conclusion that arms accumulation in the Middle East is mainly a product of bureaucratic incrementalism does not follow from his data analysis.[1]

The purpose of the present article is to explore the extent to which military build-ups in the Middle East can be explained by action-reaction processes as expressed in Richardson's model and in a modification of this model which is introduced below. Its analysis goes beyond previous research by fitting these two models not to budget data but to a comprehensive set of inventory, capability, and manpower data on the armies, air forces, and navies of Israel and her main Arab opponents, Egypt, Iraq, Jordan, and Syria. To avoid blurring possible historical breakpoints in reaction patterns, the periods leading up to the wars in 1967 and 1973 will be analyzed separately. Their short duration imposes severe constraints on the complexity of modeling so that some important determinants of military expansion in Middle East countries—like internal developments in these nations, inter-Arab rifts and rivalries, and external stimuli and constraints—cannot be incorporated in the two models to be presented now.

1. Mihalka determines the extent of incrementalism by inspecting the estimated coefficient of the lagged endogenous variable in the unrestricted reduced form of his model. This coefficient stands for $(1 - a_i + c_i)$ in the restricted reduced form, where c_i is the incrementalist growth constant and a_i is the reaction coefficient (Mihalka, 1975: 25). By confounding both effects Mihalka might interpret as strong incrementalism what in fact is low incrementalism coupled with low reactivity, and as low incrementalism the strong presence of both reactivity and incrementalism. Another weakness of Mihalka's study is the use of data from 1949 to 1968 without allowing for a breakpoint in 1956. The virtual absence of Arab-Israeli reaction might thus simply be a statistical artifact. My impression from a conversation with the author is that he is aware of these points, even though this is not documented in his study.

Models of Arms Accumulation

No extensive analytical discussion of arms race models will be provided here, as at least the first model to be applied in this article is well known and its heuristic utility is generally accepted. Our first model is adapted from Richardson's (1960) basic two-nation model. It states that each state in an arms race would want to increase its military capability from one year to the next in proportion to the accumulated capability of the other side but is restrained by the cost of its own weaponry:[2]

$$X_t - X_{t-1} = k_1 Y_{t-i} - a_1 X_{t-1} + e_1 \ (i = 1, 2, \ldots) \qquad [1]$$

X_t denotes the military strength of one side to the arms race in time t, Y_{t-i} that of its opponent in $t - i$. k_1 is a reaction constant (the "defense coefficient"), a_1 corresponds to Richardson's "expense and fatigue" coefficient, e_1 is a random error term with mean zero and finite standard deviation, and i stands for the time lag of reaction to the opponent's capability. In keeping with the econometric literature (e.g., Kmenta, 1971: 539) the coefficients k_1 and a_1 will not be estimated directly from equation 1. Instead, equation 1 is solved for X_t to yield the multiple regression equation 2 which is the first model to be estimated.

$$X_t = b_1 X_{t-1} + b_2 Y_{t-1} + e_2 \ (i = 1, 2, \ldots). \qquad [2]$$

Equations 1 and 2 share one fundamental shortcoming with most arms race models in attributing the "fallacy of the last move" to arms racing nations. Only current and past—but not projected—force levels are assumed to enter into a state's decision concerning the amount to increase its capability. The only effort to cope with this problem in the context of arms races is the model advanced by Lagerstrom (1968). Unfortunately, this model cannot be applied to the Middle East arms competition

2. Difference equations are used instead of the original differential equations because of the discrete character of the data.

as it requires the estimation of more parameters than is feasible with our short series of data.

Projections of force levels can be allowed for in a simpler way by treating the change of one side's capability as dependent upon the corresponding increment for the adversary at the same or at some previous time, as is formally done in equation 3:[3]

$$X_t - X_{t-1} = k_2 (Y_{t-i} - Y_{t-i-1}) - a_2 X_{t-1} + e_3 \quad (i = 0, 1, \ldots) \qquad [3]$$

The generality of equation 3 is restricted by the implicit assumption that the effect of the enemy's arms vanishes if and only if their levels remain constant from $t - i - 1$ to $t - i$. This restriction can be overcome by respecifying equation 3 to the effect that not the change in $t - i$ of the opponent's capability but its deviation from an "acceptable" increment is the crucial variable producing a behavioral reaction. If the "acceptable" growth rate of the opponent's capability is $(k_4 - 1)$ model 3 becomes:[4]

$$X_t - X_{t-1} = k_3 (Y_{t-i} - k_4 Y_{t-i-1}) - a_3 X_{t-1} + e_4 \quad (i = 0, 1, \ldots) \qquad [4]$$

3. It should be noted, incidentally, that behavior according to model 3 on the part of all participants in an arms race would lead to the second type of dynamic equilibrium the author has analyzed elsewhere (Rattinger, 1974b: 498-504).

4. With $k_4 - 1$ as the "acceptable" growth rate, $(k_4 - 1)Y_{t-i-1}$ is the "acceptable" increment of the enemy's arms from $t - i - 1$ to $t - i$. As the observed increment is $Y_{t-i} - Y_{t-i-1}$, its deviation from "acceptable" change is

$$Y_{t-i} - Y_{t-i-1} - (k_4 - 1)Y_{t-i-1} = Y_{t-i} - k_4 Y_{t-i-1}.$$

In highly competitive situations $k_4 - 1$ is likely to be negative so that k_4 will be below unity. This implies that one side would have to disarm unilaterally to prevent the other side from increasing its armaments in response.

By solving for X_t we have as our second regression equation:

$$X_t = b_3X_{t-1} + b_4Y_{t-i} + b_5Y_{t-i-1} + e_5 \quad (i = 0, 1, \ldots) \tag{5}$$

Before proceeding to measurement and data, three further points concerning our models will be made. First, one might argue for an exclusion of "expense and fatigue" terms from equations 1, 3, and 4, as the real "restraining" factors in the Middle East might be the (un)willingness of suppliers to deliver hardware desired by their clients (see Milstein, 1970) as well as disagreement between both on what political "prices" should be paid (SIPRI, 1971: 506-559). In spite of the heavy load of military preparations on the economies of Israel and the Arab nations (see Askari and Corbo, 1974; Gottheil, 1974), a simple cost constraint in the style of Richardson's model might thus be inappropriate.[5] This issue can be clarified by inspecting the estimated values of $\hat{b}_1$ and $\hat{b}_3$. If Richardson's perspective is borne out by the data, b_1 and b_3 should be well below unity as $b_1 = 1 - a_1$ and $b_3 = 1 - a_3$.

A second point concerns the interpretation of equations 2 and 5 as incrementalist models. Both are autoregressive as the lagged endogenous variable X_{t-1} is part of their right-hand sides. In his recent study of the Middle East, Mihalka treats similar autoregressive terms as representations of an incrementalist bureaucratic drive towards the expansion of armaments. This interpretation is open to some doubts. Even though theoretical arguments—for which there is also some empirical evidence (Crecine, 1971; Rattinger, 1975b, 1975c)—attribute defense spending to bureaucratic incrementalism (Wildavsky, 1964; Crecine, 1969), their extension to capability data in high-conflict situations is

5. An elaborate "expense and fatigue" term of the kind proposed by Caspary (1967) might be more appropriate to the situation in the Middle East. Its introduction would, however, aggravate the degrees of freedom problem even further.

anything but straightforward, since these data typically exhibit discontinuous growth patterns. It is therefore necessary to distinguish conceptually, theoretically, and empirically between "arms races" in military spending on the one hand, and in inventories, capabilities, and manpower on the other. A model which proves valid for the one type of arms race is not automatically the best approach for the other type. The Richardson model probably possesses least validity for "expenditure races," whereas the bureaucratic model is probably least useful in explaining the growth of capability.

This implies that autoregressive terms cannot, in all reduced forms of difference equation models (and by extension, differential equation models), be regarded as markers for incrementalism if substantial considerations do not warrant this interpretation. With the outbreak of war as an imminent and permanent contingency, as it is in the Middle East, applying the model of bureaucratic incrementalism to capabilities makes little sense as it assumes that the defense apparatus has been able to settle down to a comfortably monotonous pace (Crecine, 1969). In this article the growth of capabilities will therefore not be ascribed to bureaucratic momentum even if the reaction component is absent.

Finally, it should be explained why the increasingly popular approach of specifying arms race models together with their parameter values a priori on the basis of historical information about the specific case (Moll, 1974; Lambelet, 1974) is not pursued here, even though it seems attractive with our short series of data. The first reason is that this approach is too far to the one extreme of a continuum ranging from purely theoretical exercises to entirely descriptive and atheoretical—though historically well informed—post festum curve fitting. The second reason underlines the first one in that the pertinent information is simply unavailable for the Middle East. There has generally been little declaratory policy as to whose armaments a given state has regarded as the major threat at a given time and what its standards for comparing forces have been.

TABLE 1
Inventories 1957-1973

	YEAR	*1957*	*58*	*59*	*60*	*61*	*62*	*63*	*64*	*65*	*66*	*67*	*68*	*69*	*70*	*71*	*72*	*73*
TANKS	EGYPT	330	340	365	380	410	520	660	790	940	970	370	710	925	1425	1650	2060	1955
	IRAQ	125	155	245	280	325	345	395	430	450	480	500	575	575	685	925	925	1055
	JORDAN	120	150	150	150	150	150	150	150	200	300	100	230	309	300	290	344	420
	SYRIA	150	250	400	435	435	435	435	435	435	435	400	430	450	780	800	1190	1270
	ISRAEL	320	340	360	380	420	450	500	570	640	800	990	800	1020	1050	1075	1430	1700
COMBAT AIRCRAFT	EGYPT	38	170	170	170	240	270	305	355	355	430	225	400	352	463	553	568	570
	IRAQ	31	55	69	80	97	104	117	136	154	183	150	193	193	207	209	194	224
	JORDAN	16	16	18	18	12	12	14	16	20	20	0	16	23	30	35	47	50
	SYRIA	34	64	64	64	64	64	71	71	71	76	25	145	145	200	210	240	334
	ISRAEL	120	130	152	169	179	207	220	236	257	250	220	235	275	330	368	426	482
SHIPS	EGYPT	42	64	66	67	69	73	73	78	78	90	94	100	108	106	105	106	100
	SYRIA	13	15	15	15	15	15	15	15	17	23	23	26	26	26	26	25	29
	ISRAEL	23	23	23	25	25	25	24	24	24	26	23	20	20	31	33	35	41
MAJOR SHIPS	EGYPT	10	14	16	17	19	23	25	30	30	40	44	50	55	54	54	52	52
	SYRIA	3	3	3	3	3	3	3	3	3	7	7	9	9	9	9	11	14
	ISRAEL	7	7	6	8	7	7	6	6	6	8	7	7	6	16	16	14	15

SOURCES: Table 1 has been compiled by aggregation from the inventory tables in Rattinger (1975d). In preparing those tables, data from 1966 onward have been taken from *Military Balance*. Data for previous years have been derived from statistics on arms transfers to the Middle East (SIPRI, 1971, 1975), allowing for depreciation of inventories according to Leiss and Kemp's (1970: 366) formula. All data have been checked against Dupuy (1974), *Jane's Aircraft*, *Jane's Fighting Ships*, *Jane's Weapon Systems*, *Statesman's Year-Book*, and *Weyers Flottentaschenbuch*. Whenever sources were incongruous, information from the latter group of sources has been preferred.

Measurement and Data

INVENTORIES

In a previous research effort annual weapons inventories for Israel, Egypt, Iraq, Jordan, and Syria for the period from 1957 to 1974 were derived from a variety of sources (Rattinger, 1975d). Data collection had to be restricted to major weapon systems like tanks, combat aircraft, and fighting ships, because data on lesser systems are unavailable or contradictory or unreliable. In measuring the capability of a state's army by counting its number of tanks, one assumes, of course, that it maintains a force mix within its army allowing it to employ its tank force with a reasonable degree of effectiveness, and similar assumptions have to be made about air force and navy inventories. These assumptions seem realistic for Middle East countries, since the generally high probability of war has prevented them from stocking up on major weapon systems without taking care of their integration into the remainder of their forces.

Table 1 gives annual inventories of tanks, combat aircraft, fighting ships, and major ships for the five countries in this study. Armored personnel carriers and self-propelled artillery are not counted as tanks, regardless of armor and armament. "Combat aircraft" includes armed trainers in the case of Israel and aircraft in storage in the case of Egypt, but consistently excludes helicopters. "Fighting ships" do not include landing craft. Numbers of "major ships" are given, as it might be suspected that these vessels (particularly missile boats) have played an important role of their own in the second race. Numbers of "major ships" are arrived at by excluding minesweepers, torpedo boats, and all patrol boats not armed with missiles from the totals.

CAPABILITIES

For deriving the time series of capability indices in Table 2, capability indices for all major weapon systems in the inven-

TABLE 2

Capabilities 1957-1973

	YEAR	*1957*	*58*	*59*	*60*	*61*	*62*	*63*	*64*	*65*	*66*
TANKS	EGYPT	1390.6	1416.2	1480.0	1518.4	1738.4	2173.4	3803.4	3380.9	4168.4	4325.9
	IRAQ	352.0	447.8	875.3	1036.6	1205.6	1385.3	1385.8	1740.8	1815.0	1927.5
	JORDAN	415.6	607.0	607.0	607.0	607.0	607.0	607.0	607.0	926.0	1564.0
	SYRIA	483.0	858.0	1645.5	1735.1	1735.1	1735.1	1735.1	1735.1	1735.1	1735.1
	ISRAEL	838.0	899.2	960.4	1021.6	1144.0	1235.8	1388.8	1769.0	2215.8	3000.5
COMBAT AIRCRAFT	EGYPT	46540	138200	138200	138200	161300	380500	684300	809300	809300	1003200
	IRAQ	19870	78900	83170	103600	219540	220650	281490	360260	427410	520880
	JORDAN	8320	27280	47280	47280	44160	44160	51520	58880	73600	73600
	SYRIA	10720	19720	19720	19720	19720	19720	33300	33300	33300	67800
	ISRAEL	66800	85700	109760	122470	123470	203700	282630	359500	438570	428260
SHIPS	EGYPT	11.68	16.46	18.86	19.19	20.71	23.42	23.99	25.18	25.18	31.56
	SYRIA	.80	.95	.95	.95	.95	.95	.95	.95	1.02	2.40
	ISRAEL	5.46	5.46	4.68	5.04	4.33	4.33	3.55	3.55	3.55	5.11
MAJOR SHIPS	EGYPT	9.78	13.06	15.46	15.79	17.31	20.02	20.64	21.84	21.84	28.05
	SYRIA	.06	.06	.06	.06	.06	.06	.06	.06	.06	1.30
	ISRAEL	4.70	4.70	3.92	4.28	3.50	3.50	2.73	2.73	2.73	4.29

TABLE 2 (Continued)

	YEAR	*1967*	*68*	*69*	*70*	*71*	*72*	*73*
TANKS	EGYPT	1427.5	2977.9	4079.3	6189.3	7415.0	9549.5	9813.8
	IRAQ	2130.1	2556.7	2556.7	3194.2	4566.2	4566.2	5203.7
	JORDAN	472.0	1063.6	1440.3	1416.0	1385.4	1767.6	2004.4
	SYRIA	1645.5	1939.8	2137.5	3789.3	3821.3	5733.8	5861.8
	ISRAEL	4125.5	3006.1	4119.9	4167.9	4394.7	6009.1	7390.5
COMBAT AIRCRAFT	EGYPT	324250	666400	753940	969170	1156960	1197760	1306500
	IRAQ	440600	542510	542510	546710	618380	584060	621240
	JORDAN	0	48680	80920	106680	124150	168310	178420
	SYRIA	19800	202200	202200	312600	337600	346600	600060
	ISRAEL	379750	381350	520000	1556370	2662560	3239800	3519750
SHIPS	EGYPT	32.61	35.77	37.18	36.31	36.22	35.98	35.48
	SYRIA	2.41	3.11	3.11	3.11	3.11	3.11	4.71
	ISRAEL	4.33	4.19	4.03	9.65	9.70	8.91	9.43
MAJOR SHIPS	EGYPT	29.10	32.33	33.36	32.67	32.67	32.04	32.04
	SYRIA	1.31	1.93	1.93	1.93	1.93	2.56	3.73
	ISRAEL	3.60	3.60	3.42	9.01	9.01	8.12	8.59

SOURCES: Rattinger (1975d); capability scores for individual weapon systems available from the author.

tories of Middle East countries between 1956 and 1973 had to be available along with the detailed inventory tables from which Table 1 was compiled. Since the capability indices used in this study have received extensive discussion elsewhere (Rattinger, 1975a: 234-310), only a brief overview will be given.

From the judgments of military experts on the effectiveness of a large number of ground weapon systems and combat aircraft over a wide variety of missions, the properties of speed, combat radius, and payload were identified as the most frequently applied criteria. This finding coincides with the results of an independent factor analytic study on the dimensions of the technical characteristics of combat aircraft (Mihalka, 1975). In this latter study, factor scores for an offensive and a defensive component were combined to yield overall capability indices. In contrast, the simple product of speed, payload, and combat radius will be used here as an index.[6]

Preliminary tests of validity against expert judgments suggest that this index might be a reasonable alternative to factor scores, which are heavily influenced by the composition of the sample from which they are derived. The main problem in applying this capability index in the present case was the difficulty in obtaining meaningful data on "payload" for naval vessels. In keeping with the general thrust of the index, all ships were therefore rank-ordered on a scale from 1 (for lowest) to 8 according to main armament, and the rank of each ship was treated as its payload score. This does not impair the generality of the index, since it is not meant for comparing sea, air, and ground systems.[7] Aggregated annual capability scores for tanks, combat aircraft, fighting ships, and major ships are contained in Table 2.

6. The intercorrelation between the two indices for all combat aircraft in Middle East inventories from 1957 to 1973 is .89. A list with technical characteristics and index values of all major weapon systems operated by Middle East nations since 1957 is available from the author.

7. The trade-off between weapon systems of different services is probably the most severe obstacle to a general approach to the measurement of capability. A good illustration of all the problems involved is the study of Weiner (1968).

MANPOWER

Manpower data for the total armed forces of our five countries and for their individual services from 1967 to 1974 are given in Table 3. Paramilitary forces, police forces, and reserves are excluded. Manpower data for the first arms race will not be analyzed for two reasons. First, these data are available from the same set of sources only back to 1961, and combining data from different sources in time series is always a risky enterprise since they might be biased differently. Second, data obtained from other sources (Stateman's Year-Book; Hurewitz, 1969) suggest that the major changes in manpower levels in the Middle East have taken place before 1957 or after 1967.

Some Empirical Findings

Models 2 and 5 were estimated for all five countries for the periods from 1956 to 1967 and from 1967 to 1973 by ordinary least squares (OLS) regression. The two arms races were analyzed separately because it seems unrealistic to expect that reaction patterns before and after 1967 have been identical. Lumping races together could lead to spurious findings or wash out reaction patterns that are significant but different in both races.[8]

Both models were estimated for each of the four Arab countries individually reacting to Israel's arms and force levels. In addition, total Arab inventories, capabilities, and manpower were treated as being dependent upon those of Israel. For Israel, five variants of each model were estimated from each set of data with the forces of Egypt, Iraq, Jordan, and Syria, as well as aggregated Arab strength as explanatory variables. Aggregate

8. Indiscriminately lumping together different races between different parties is the decisive problem with Milstein and Mitchell's (1969) naval simulation. See also footnote 1.

TABLE 3

Manpower (in 1000) 1967-1973[a]

	YEAR	1967	68	69	70	71	72	73
ARMY	EGYPT	154	184	184	254	279	285	260
	IRAQ	70	70	70	85	85	90	90
	JORDAN	30	53	53	58	58	65	68
	SYRIA	50	50	60	75	100	100	120
	ISRAEL	60	61.5	61.5	61.5	61.5	61.5	94.5
AIR FORCE	EGYPT	15	15	15	20	25	25	23
	IRAQ	10	10	6	7.5	8.25	9.8	9.8
	JORDAN	1.75	1.75	1.75	2	2	4	4.6
	SYRIA	9	9	9	10	10	10	10
	ISRAEL	9	9	9	9	9	11	16
NAVY	EGYPT	11	12	12	14	14	15	15
	SYRIA	1.5	1.5	1.5	1.75	1.75	1.95	2
	ISRAEL	4	4.5	4.5	4.5	4.5	4.5	4.5
TOTAL	IRAQ	82	82	78	94.5	95.25	101.8	101.8
	JORDAN	32	55	55	60.25	60.25	69.25	72.85

SOURCES: *Military Balance,* USACDA (1972, 1975).

a. For Egypt, Syria, and Israel, total military manpower naturally is equivalent to the sum of their army, air force, and navy manpowers. Because of their small sizes, the navies of Iraq and Jordan have been excluded from the analysis and their numbers of personnel are not contained in this table. Instead, total military manpower for these two countries is given in the row headed "TOTAL" which includes Iraq's and Jordan's small navies.

Arab figures are included in the analysis because it can be safely assumed that they are an important input into Israel's defense decision-making. However, since there is little military coordination among Arab nations (Evron and Simantov, 1975), we do not expect a good fit for aggregate Arab strength as a *dependent* variable. The navies of Iraq and Jordan were excluded because of their minimal sizes. In addition to the five simple variants, models combining the individual effects of the military strength of the four Arab nations on Israeli force levels were estimated.

Time lags in equation 2 were varied from one to three years, and all models corresponding to equation 5 were estimated with lags from zero to two years. Longer lags were not estimated as they would have reduced degrees of freedom below the required minimum. But in a situation characterized by the imminence of war,[9] long lag times certainly are a luxury no one can afford. Since we have three sets of data for the second race (two for the first), three lags, two general models with 11 interpretations for army and air force, and seven interpretations for total navy and major fighting ships, 432 equations had to be estimated for the first race and 648 equations for the second race. These numbers were slightly increased by estimating the models for Israel by combining the individual effects of the Arab countries' forces with different lags for different countries.

A major problem in the study of time-series data is the danger of autocorrelation in the residuals from OLS regression. It is aggravated by the fact that the routine Durbin-Watson test is, strictly speaking, not appropriate for autoregressive models like 2 and 5 (Kmenta, 1971: 295). In place of the Durbin-Watson ratio, first-order autocorrelation coefficients for OLS residuals are therefore given in Tables 4 and 5 together with the results of OLS estimation. Since these coefficients tend to underestimate true autocorrelation (Hibbs, 1974: 292), a stringent criterion for estimation by generalized least squares (GLS) regression was applied, and GLS reestimation with the standard transformation

9. There are those who argue that Egypt's decision to go to war with Israel again was taken as early as 1970 (Monroe and Farrar-Hockley, 1975: 5).

TABLE 4
Estimation Results on Reaction Patterns in the First Period, 1957-1967[a]

No.	*Equation*
1.1	$TANKJO_t = 2.12\,TANKJO_{t-1} + .21\,TANKIS_{t-2} - 245$ (.45) (.09) (109) (2), N = 8, R^2 = .95, F = 45.3, SE = 14.5, A = –.03
1.2	$CTANKJO'_t = 1.70\,CTANKJO'_{t-1} + 2.06\,CTANKIS'_{t-1} - 2.61\,CTANKIS'_{t-2} - 117$ (.26) (.23) (.37) (96) (5), N = 8, R^2 = .99, F = 171.0, SE = 89.1
1.3	$PLANSY_t = .48\,PLANSY_{t-1} + .26\,PLANIS_{t-1} - .20\,PLANIS_{t-2} + 21.7$ (.46) (.13) (.15) (17.9) (5), N = 8, R^2 = .91, F = 12.7, SE = 1.9, A = .03
1.4	$CPLANSY'_t = -.06\,CPLANSY'_{t-1} + .21\,CPLANIS'_{t-3} + 6555$ (.52) (.06) (9288) (2), N = 7, R^2 = .93, F = 25.5, SE = 7521
1.5	$CPLANIS_t = -.66\,CPLANIS_{t-1} + .45\,CPLANAR_{t-1} + 59259$ (.75) (.12) (40187) (2), N = 9, R^2 = .98, F = 79.3, SE = 23529, A = –.01
1.6	$PLANIS'_t = -.03\,PLANIS'_{t-1} + .43\,PLANEG'_{t-1} + 85.4$ (.17) (.06) (56.2) (2), N = 9, R^2 = .99, F = 115.5, SE = 3.3
1.7	$CSHIPEG'_t = .86\,CSHIPEG'_{t-1} + 2.34\,CSHIPIS'_t - 1.87\,CSHIPIS'_{t-1} + 3.47$ (.20) (1.09) (1.32) (3.79) (5), N = 9, R^2 = .93, F = 23.4, SE = 1.7
1.8	$CSHIPSY'_t = 1.30\,CSHIPSY'_{t-1} + .61\,CSHIPIS'_t - .55\,CSHIPIS'_{t-1} - .44$ (.67) (.17) (.14) (1.07) (5), N = 9, R^2 = .83, F = 8.2, SE = .3
1.9	$CSHIPAR'_t = .89\,CSHIPAR'_{t-1} + 2.97\,CSHIPIS'_t - 2.25\,CSHIPIS'_{t-1} + 1.91$ (.23) (1.24) (1.50) (3.83) (5), N = 9, R^2 = .92, F = 20.4, SE = 2.0
1.10	$CSHIPIS_t = -.74\,CSHIPIS_{t-1} + 1.59\,CSHIPSY_t - 1.06\,CSHIPSY_{t-1} + 5.80$ (.37) (.50) (.45) (2.93) (5), N = 9, R^2 = .95, F = 17.3, SE = .2, A = –.10

TABLE 4 (Continued)

1.11 $CSHIPIS_t = .01\ CSHIPIS_{t-1} + .17\ CSHIPAR_t - .26\ CSHIPAR_{t-1} + 5.91$

(.55) (.07) (.10) (4.72)

(5), N = 9, R^2 = .80, F = 6.5, SE = .4, A = .07

a. The following conventions are used in this table: Standard errors of parameter estimates are given in parentheses. Variable labels are self-explanatory; the prefix "C" denotes capabilities. All variables in equations estimated by GLS are marked by a prime. The first information in the line of summary statistics is whether a given equation is a variant of model 2 or of model 5. Then follow number of cases (N), R^2, F, standard error of estimate (SE), and first-order autocorrelation of residuals in the case of equations estimated by OLS (A).

of data (Theil, 1971: 253; Hibbs, 1974: 268 f.) was performed whenever the autocorrelation coefficient for OLS turned out to be above .15.[10] This was done regardless of the size of reaction terms in the OLS results because autocorrelation of residuals might conceal significant reactivity.

As the purpose of this article is to identify reaction patterns in the Middle East, the discussion of empirical results will focus on best fitting models among those equations with a significant reaction term. Since degrees of freedom differ greatly between equations—due to varying numbers of cases and of explanatory variables—the significance of overall F-ratios and of regression coefficients has been used as a criterion for selecting best fitting models instead of the values of R^2. Reactivity will only be said to prevail when *both* are significant at the .05 level.

The use of these conventional criteria could be criticized on two accounts. First, arms race data might be considered as popu-

10. There is, of course, some disagreement within the discipline on the use of OLS versus GLS regression. In this discussion, proponents of the classic linear regression model have the procedural simplicity and the least variance properties of OLS estimates on their side. If, on the other hand, the assumptions of the classical model are violated by the presence of autocorrelated disturbances—as is often the case in the analysis of dynamic models—OLS results and the causal inferences derived from them tend to be heavily distorted as has been amply demonstrated by Hibbs (1974). Since first-order autocorrelation was above .15 in more than three-fourths of the OLS regressions run with the Middle East data, the application of GLS is clearly indicated in the present case. It should be noted, incidentally, that GLS transformations were performed without ignoring scalars so that the summary statistics for OLS and GLS results are comparable (Hibbs, 1974: 269).

lation rather than sample data, and second, there might be a probabilistic problem if several hundred equations are estimated. However, these arguments overlook the fact that capabilities can be measured, at least in principle, at arbitrary intervals, and the fact that no more than three equations (which are identical except for the lag parameter) are estimated from the same subset of data. Standard statistical criteria therefore seem adequate.

THE FIRST RACE: 1956 TO 1967

The general format in presenting an overview of reaction processes in the Middle East will be to proceed from one service to the next. For each service, OLS results on reactivity will be reported and their modification by GLS reestimation afterwards discussed. Best fitting equations with significant reaction terms are reproduced in Table 4 and graphically summarized in Figure 1.

For tank inventories and capabilities, OLS regression shows two nations to have reacted to other countries with the build-up of their tank forces. Israel is seen as reacting to tank capabilities of Egypt and Jordan and to the inventory of Jordan. Inventory and capability of Jordan's tank forces have been influenced by those of Israel. Equation 1.1, which links Jordan's tank inventory to that of Israel, holds up under GLS estimation as autocorrelation of residuals is very low.

Whereas the reaction process manifested by Jordan's tank inventory is better described by model 2, 5 is superior for tank capabilities. Because of strong autocorrelation (—.74), GLS transformation has to be performed, which leads to equation 1.2. This equation might suggest that Jordan did not feel very much threatened by the capability of Israel's armored forces since she would accept an annual increase in CTANKIS up to about 27% ($\hat{k}_4 = 1.27$) without upgrading her own tank force in response. A more sensible explanation is probably found in the constraints on the supply of modern armor that Jordan experienced through the late fifties and early sixties (SIPRI, 1971: 539-545).

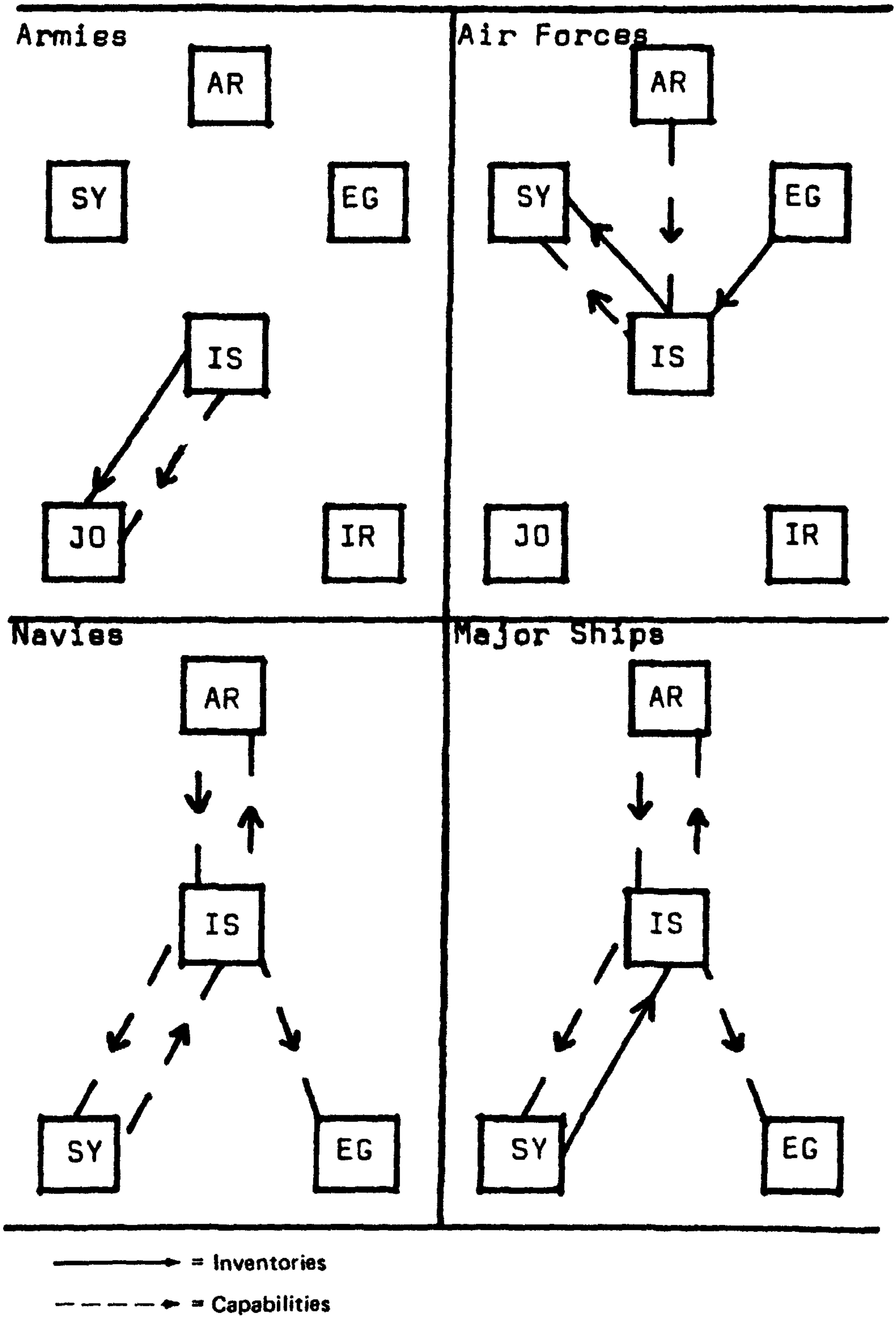

Figure 1: GLS and Stable OLS Relationships, 1957-1967

A high degree of autocorrelation in all OLS regressions with Israel's tank inventories and capabilities calls for GLS reestimation which virtually wipes out all significant coefficients in the equations for Israel's tank inventory. With Israeli tank capabilities, the only significant coefficient is that of the autoregressive term. As has been stressed earlier, one should not jump to conclusions about bureaucratic momentum.

For the air force component of the first Middle East arms race, we find the number of Syrian combat aircraft depending primarily upon the increase in Israel's aircraft inventory. Equation 1.3 suggests that the number of Syrian combat aircraft would have declined sharply had it not been for the Israeli air force build-up. It moreover reveals the drastic extent of Syrian reactivity to Israel, since only an annual reduction of Israel's inventory by about 22% could have brought the Syrian response down to zero.

The capability of Syria's air force has likewise increased as a reaction to that of the Israeli air force. This increase is shown by equation 1.4 which was obtained from a GLS transformation of variables because of strong autocorrelation (−.41) in its OLS equivalent. A plausible reason for the long lag in the Syrian response is the difficulty which she had experienced in obtaining weaponry from the late fifties to the mid-sixties owing to her oscillations towards and away from the Soviet Union.

For Syria's adversary, OLS analysis reveals only one significant relationship; namely, that the capability of Israel's air force is a response to the combined capability of the air forces of Egypt, Iraq, Jordan, and Syria (equation 1.5).[11] The negative sign of $\hat{b}_1$ certainly leaves a discomforting impression, but since this coefficient is not significant this matter will not be pursued here. GLS reestimation leads to the discovery of an additional interesting feature of Israel's air force build-up by establishing

11. In his study of aircraft capabilities from 1949 to 1968, Mihalka (1975) detects virtually no Arab-Israeli reaction patterns from 1949 to 1968. As has been pointed out earlier, this might well be due to the fact that he lumps data from two races together.

a highly visible link between the numbers of combat aircraft in the Israeli and the Egyptian inventories (equation 1.6).[12]

Turning now to the naval race, three remarkable observations have to be reported. The first is that reaction patterns for total navies and for "major ships" are almost identical. Capability scores for the total Egyptian navy (equation 1.7), for the Syrian navy (equation 1.8), and for their combined navies (equation 1.9) display significant reactivity to the capability of the Israeli navy, which, in turn, is a response to the capabilities of the Syrian (equation 1.10) and of the combined Arab navies (equation 1.11). For major ships the pattern is exactly the same—with the exception that the Syrian inventory is more important for Israel's reaction than for its capability. The separation of "major ships" from total navies thus is not meaningful for the first race, and equations for "major ships" are not reproduced in Table 4.

The second noteworthy point is the complete identity of OLS and GLS results. In the case of Israel, there is little autocorrelation, but for the capability scores of the Egyptian, Syrian, and combined Arab navies first-order autocorrelation of OLS-residuals is strong, so that reestimation by GLS could have led to very different findings.

Finally, equations 1.7 through 1.11 all are of the general form 5 which suggests that changes in naval strength have been a more salient and sensitive feature than absolute capabilities. Furthermore, equations for Egypt, Syria, and their combined navies are of the "runaway" type, since Israel would have had to disarm by from 10% to 30% annually to force their reaction down to zero.

12. Hibbs (1974: 302) maintains rather apodictically that GLS reestimation of dynamic models would generally decrease the importance of autoregressive terms and increase that of other variables. The case of Israel's and Egypt's aircraft inventories is the only spectacular empirical evidence I could find to support this assertion. Generally, however, GLS reestimation eliminates many significant OLS findings on reactivity together with those on "momentum."

13. For a more extensive treatment of the estimation of arms race models from very short series of data, see Rattinger (1976).

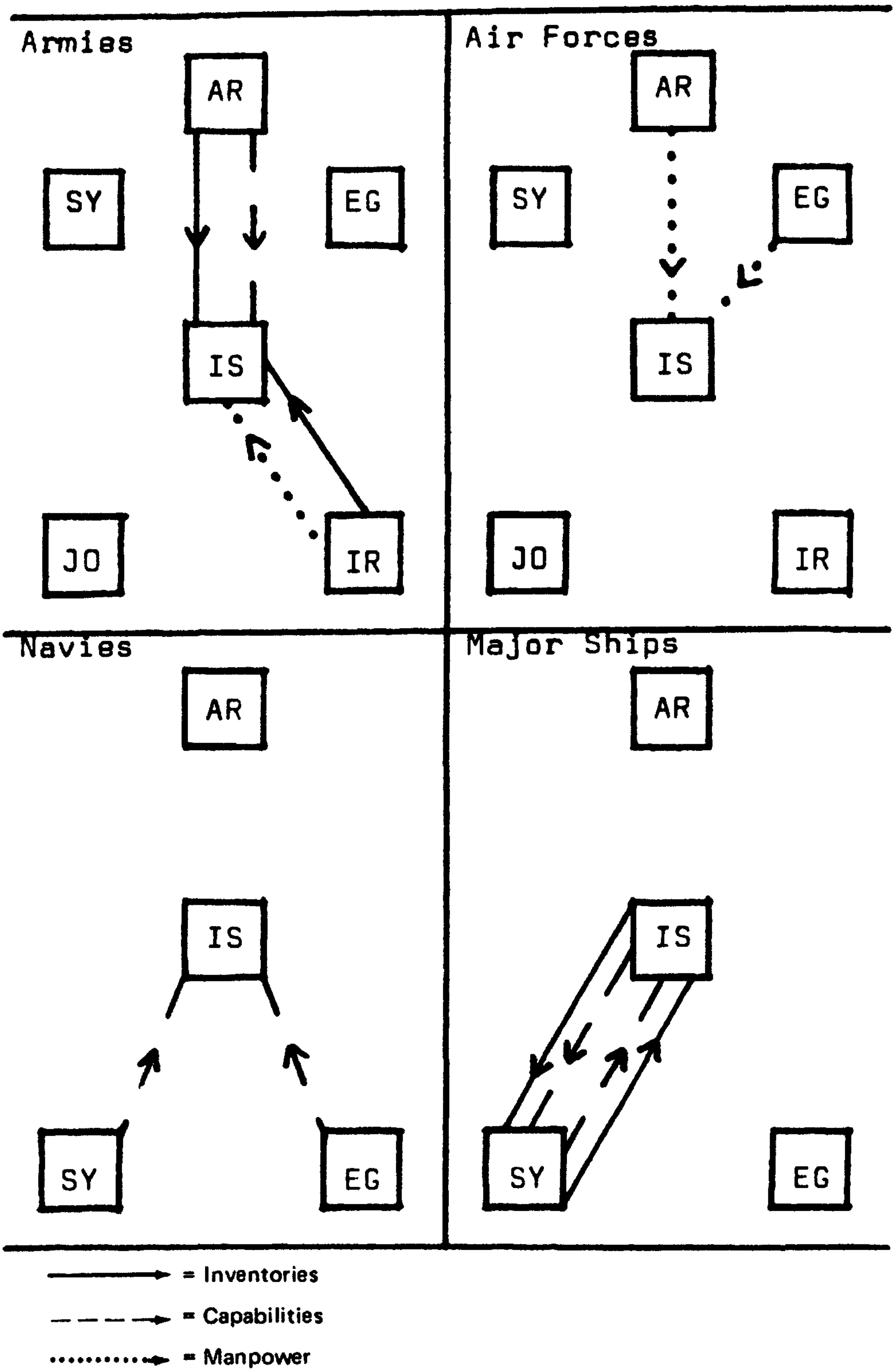

Figure 2: GLS and Stable OLS Relationships, 1967-1973

The same is true for Israel's response to Syria's naval strength. As to the combined capabilities of Arab navies, however, Israel appears to have been willing to accept quite substantial increases without its own countermoves.

THE SECOND RACE: 1967 TO 1973

In the second race, we will look for reaction patterns not only in inventory and capability, but also in manpower data. The major problem with the period from 1967 to 1973 is the low number of cases.[13] Values of R^2 are therefore less meaningful than for the first race, and we will have to rely even more on F-ratios, regression coefficients, and their standard errors to discern reactivity. Best fitting equations with significant reaction terms are reproduced in Table 5 and graphically summarized in Figure 2.

With OLS regression we find that Iraq is the only Arab country that—in the manpower data—shows some response to Israel's ground forces, but this exception vanishes with GLS. Israel, on the other hand, seems to have been especially concerned about the inventories (equation 2.1) and the qualitative upgrading (equation 2.3) of the combined Arab tank forces. Isolating the four Arab countries surprisingly reveals the Iraqi tank inventory (equation 2.2) and the manpower of Iraq's army (equation 2.4) as particularly strong determinants for the expansion of the Israeli army.

For air force capabilities and inventories a strange finding emerges. In contrast to the first race, there is only one significant reaction term for post-1967 air force inventories and none for capabilities. This only exception, moreover, which sees Israel responding to the aircraft inventory of the Jordanian air force, vanishes when GLS regression is applied. We are thus left with the impression that Israeli responses to the air force build-up of her adversaries show up only in manpower data. GLS reestimation eliminates a significant OLS finding on Israeli reactivity to Syrian air force manpower, whereas the relationships to

TABLE 5
Estimation Results on Reaction Patterns in the Second Period, 1967-1973[a]

No.	*Equation*
2.1	$TANKIS_t = .15\ TANKIS_{t-1} + .24\ TANKAR_{t-1} + 338$
	(.49) (.09) (355)
	(2), $N = 6, R^2 = .90, F = 14.2, SE = 130, A = -.11$
2.2	$TANKIS_t = .41\ TANKIS_{t-1} + 1.34\ TANKIR_{t-1} - 184$
	(.35) (.39) (261)
	(2), $N = 6, R^2 = .93, F = 19.9, SE = 111, A = -.03$
2.3	$CTANKIS_t = .10\ CTANKIS_{t-1} + .24\ CTANKAR_{t-1} + 1278$
	(.43) (.07) (1198)
	(2), $N = 6, R^2 = .92, F = 16.8, SE = 582, A = -.06$
2.4	$ARMIS_t = .00\ ARMIS_{t-1} + 2.20\ ARMIR_{t-3} - 94.5$
	(.22) (.01) (49.5)
	(2), $N = 4, R^2 = 1.00, F = 408.4, SE = .6, A = .05$
2.5	$AIRIS'_t = -.01\ AIRIS'_{t-1} + .28\ AIRAR'_{t-1} - 1.74$
	(.64) (.12) (4.36)
	(2), $N = 6, R^2 = .93, F = 20.9, SE = 2.7$
2.6	$AIRIS'_t = .11\ AIRIS'_{t-1} + .59\ AIREG'_{t-2} - 1.23$
	(.49) (.15) (1.35)
	(2), $N = 5, R^2 = .98, F = 48.4, SE = .9$
2.7	$CSHIPIS_t = -.29\ CSHIPIS_{t-1} + 1.68\ CSHIPEG_{t-2} + 49.4$
	(.15) (.25) (13.3)
	(2), $N = 5, R^2 = .97, F = 33.5, SE = .6, A = .10$
2.8	$CSHIPIS'_t = .13\ CSHIPIS'_{t-1} + 3.44\ CSHIPSY'_{t-2} - 4.85$
	(.12) (.49) (2.92)
	(2), $N = 5, R^2 = .99, F = 98.9, SE = .9$
2.9	$BIGSHIPSY_t = 1.51\ BIGSHIPSY_{t-1} + .21\ BIGSHIPIS_{t-2} - 5.98$
	(.09) (.02) (4.36)
	(2), $N = 5, R^2 = 1.00, F = 632.6, SE = .1, A = .01$

TABLE 5 (Continued)

2.10 $CBIGSHIPSY_t = 1.89\ CBIGSHIPSY_{t-1} + .11\ CBIGSHIPIS_{t-2} - 2.12$
(.03) (.01) (.29)
(2), N = 5, R^2 = 1.00, F = 883.5, SE = .01, A = .05

2.11 $BIGSHIPIS'_t = .02\ BIGSHIPIS'_{t-1} + 2.48\ BIGSHIPSY'_{t-2} - 11.52$
(.13) (.35) (8.01)
(2), N = 5, R^2 = .99, F = 65.8, SE = 1.3

2.12 $CBIGSHIPIS'_t = .01\ CBIGSHIPIS'_{t-1} + 5.74\ CBIGSHIPSY'_{t-2} - 4.16$
(.10) (.65) (3.97)
(2), N = 5, R^2 = .99, F = 116.6, SE = .6

a. The following conventions are used in this table: standard errors of parameter estimates are given in parentheses. Variable labels are self-explanatory; the prefix "C" denotes capabilities. All variables in equations estimated by GLS are marked by a prime. The first information in the line of summary statistics is whether a given equation is a variant of model 2 or of model 5. Then follow number of cases (N), R^2, F, standard error of estimate (SE), and first-order autocorrelation of residuals in the case of equations estimated by OLS (A).

Egyptian (equation 2.6) and total Arab air force manpower (equation 2.5) survive.

In the first race, OLS and GLS produce similar results for the categories of ships and major ships. This is quite different for the second race. OLS regression shows total Arab navy manpower to be a response to Israeli navy manpower. The number of Israel's ships is seen as a reaction to Egyptian and to total Arab inventories, and the capability score of Israel's navy is determined by the capabilities of the Egyptian and Syrian navies and by their combined capability. Only the relationship between Israeli and Egyptian naval capabilities (equation 2.7), however, is close to being undistorted by autocorrelation, and, with one further exception, all reaction patterns disappear in GLS reestimation. This exception views the qualitative upgrading of Israel's navy as the result of a similar build-up of Syrian naval forces (equation 2.8).

Turning to "major ships," we again find a very "dense" pattern of interaction in OLS results. The Syrian and combined

Arab navies respond to the number and capability of Israel's major naval units. Israel in turn reacts to the capabilities of Egyptian and Syrian major ships and to their combined capability as well as to the number of Syrian major ships. Apart from Syria's reactions to Israel (equations 2.9 and 2.10), all findings are heavily distorted by autocorrelation and have to be reestimated. This eliminates all reactive relationships but Israel's response to the major ship inventory (equation 2.11) and capability (equation 2.12) of Syria. Hence separation of major ships from the remainder of the Middle Eastern navies has enabled us to identify a missile-boat race between Syria and Israel as the "hard core" of the post-1967 naval race.

Conclusion

In addition to summarizing, the purpose of this concluding section is to compare the structure of action-reaction processes in both Middle Eastern arms races and to point to some substantive implications of the analysis and to areas of interest for future research. Comparisons of results can be made across arms races, countries, services and weapon systems, indicators, and models. Let us begin with the first two issues.

The term "arms race" is more appropriate for the period from 1956 to 1967 than for the years preceding the Yom Kippur war. In this latter period only Israel is seen as reacting to the Arab nations' armaments, whereas Arab reaction occurs only in the Israeli-Syrian missile-boat race. One reason for the absence of reactivity in the Arab camp after 1967 might have been the early decision to go to war again so that at least Egypt and Syria and probably Iraq took whatever weaponry they could get—regardless of Israeli behavior. In that sense the absence of reactivity might foreshadow aggression.

For the individual Arab countries a number of interesting results emerge. Apart from the navy build-up in the first period, Egypt never reacted to Israel, whereas Israel felt challenged throughout by at least some part of Egyptian armaments. Iraq was entirely isolated from interaction patterns in the first period. The same held true for Jordan in the second period when Iraq's armored contingents were of major concern to Israel. As predicted, Israel did in fact in some cases respond to aggregate Arab inventories, capabilities, and manpower, whereas all findings on reactivity in the opposite direction vanish when the effects of autocorrelation are removed.

Turning to services and major weapon systems, we can examine Huntington's (1958) assertion that arms races will focus on "dominant" weapon systems. Empirical evidence in the Middle Eastern case seems ambiguous. Depending upon the definition of a "dominant" weapon system, we should expect either the first race to be for tanks and the second for combat aircraft or both races to be for aircraft. What we find is that aircraft inventories and capabilities are more reaction-prone before 1967, whereas in the post-1967 period tanks are more likely to give rise to reactivity than aircraft. For naval forces, however, Huntington's hypothesis seems to be borne out by the data. Before 1967 no single system dominates the naval race, but afterwards the main object of competition is clearly the missile-equipped fast patrol boat. These results might be taken as some indication that the more we disaggregate overall military postures the more likely we are to come up with reaction patterns that are not only statistically significant but also correspond to the decisional calculus of the relevant political and military elites.

As to different indicators of military power, we can conclude that capability and manpower data help identify reaction patterns that would have gone unnoticed in inventories. The largest number of significant interactive processes is discernible in the capability data. In this context a promising development of the present approach should be the combination of inventory or manpower with capability indices in the same model. In this way frequently heard hypotheses about Israel's attempting to offset quantitative Arab superiority by quality could be empirically assessed.

Not even a preliminary judgment is possible on the relative confirmation of our two models. For the first race there is a rough balance. The "blind" model (2) is more appropriate for tanks and combat aircraft; the "anticipating" model (5) proves superior for the naval race. Just like the longer lags this might be due to the comparatively long time elapsing between the decision to acquire a new naval system and its operational status. For the second race, however, model 5 is either inferior or inapplicable because it eliminates degrees of freedom.

It seems possible, on the other hand, to answer the question whether the treatment of economic constraints and the exclusion of Richardson's "grievance" term in models 1, 3, and 4 are adequate. With respect to "grievance" we are on safe ground since almost no regression constant is significantly different from zero. The coefficients of the autoregressive terms vary from negative to far above unity, but there seems to be a systematic pattern. With one exception, $\hat{b}_1$ and $\hat{b}_3$ are well below one for Israel which suggests the presence of strong economic constraints. For her Arab adversaries $\hat{b}_1$ and $\hat{b}_3$ are consistently in the neighborhood of one or markedly higher. It might be that the growth of their armaments is not so much constrained by economic than by other factors. It might also be that the burden of the arms race affects them in a more complex way than expressed in our models.

Just like the empirical determination of lag structures—instead of a priori specification—and the presence in some cases of more than one equally well fitting equation for Israel, this reliance on data analysis might draw criticism for being atheoretical and purely descriptive. Since there is, however, no substantive theory of Middle East arms races—and it is doubtful whether such a "theory" would deserve the name—this criticism is exaggerated.

If one wants to write a comprehensive descriptive history of interactive armament policies in the Middle East there is no need for arms race models. If one is interested in the extent to which the general notion of systematic reactive armaments behavior can help to explain the military build-ups in the Middle East, the present study should be of some use.

Whether the Richardsonian hypothesis can claim some explanatory value or just leads to useless curve-fitting exercises might be ascertained by tracking beyond 1967 and 1973 those equations with a significant interaction term. Together with investigations of the role of intraorganizational and intrasocietal factors and the influence of constraints and stimuli external to the Middle East subsystem, this matter has to be reversed for future research. As of now we can only say that reaction processes in the Middle East as modelled here are but one of many determinants of armament levels and that they are not very stable. Maybe some of the reaction patterns identified in this study are irrelevant or spurious, and maybe in reality there are others which are not adequately grasped by either model. Unfortunately, the constraints on more complex modelling are so severe in the case of the Middle East that we will probably have to live with rather rudimentary knowledge of the driving and restraining forces behind the accumulation of arms in that part of the world.

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