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VARIABILITY OF EMPLOYMENT BETWEEN DEFENSE AND

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by

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TABLE OF CONTENTS

TABLE OF CONTENTS

I. INTRODUCTION

The economic value of the resources devoted to satisfying defense demand in the United States is considerable. In a static sense, the income generated from expenditures made by the Department of Defense is of a substantially high magnitude. Thus, from an economic point of view we might be prone to conclude that military preparedness constitutes an asset to economic growth. Such a view, however, ignores completely the dynamic properties of defense demand.

While these expenditures have remained a constant proportion of Gross National Product over the past 15 years, they have undergone substantial change. The most notable change has been in the purchase of goods for military use. Military hardware has undergone a radical transformation such that it is now a very sophisticated and highly specialized set of equipment. This change of form began after World War II but has become most noticeable in the Post Korean War period.

One consequence of specialization in military hardware is that its production now requires special facilities and no longer can be accomplished by converting or adapting civilian production processes. In response to this unique demand, firms have come into existence with the sole function of satisfying these limited requirements. In a sense these firms have been fostered by the defense purchaser to satisfy his very special needs. In doing so, however, the resources utilized by these producers have become isolated from producing for the civilian sector of the economy. Consequently, the intensity of utilization of these resources is intimately associated with the dynamic requirements of providing a defense capacity.

Following from this structural shift in defense requirements and the special purpose firms it has fostered is a change in the geographical distribution of defense expenditures. When production for military purposes was accomplished by adapting civilian facilities to defense needs, expenditures went wherever the facilities were located. This is no longer so, and these expenditures have become more concentrated.

Both of the above embrace a long-term dynamism upon which we must superimpose changes in defense demand brought about through current activities. Like the elements of an individual's consumption set, the elements in the defense bundle shift about in terms of preference ranking. The preference ranking in the defense bundle is a consequence of a changing concept of national defense and military preparedness. The form of this concept at any particular time is an image of our evaluation of the world force structure.

This rapidly changing concept of military preparedness coupled with the unique structure and distribution of defense suppliers comprises an unusual economic situation. On one side of this market is the defense supplier with relatively immobile resources, while on the other is the purchaser with a highly dynamic set of demand requirements. Thus, a situation is possible where, due to shifts in defense demand and the lack of alternative applications, significant quantities of productive resources are idled. The consequence, of course, is that economic growth falls short of its potential.

The purpose of this study is to examine the dynamic aspects of defense output. This is to be done by concentrating on the level of employment over time. The structure of the study is to contrast the dynamic aspects of employment in the set of industries that are particularly involved in defense production with a set of civilian-oriented industries. The purpose of this contrast is to examine the behavior of employment levels in the defense-oriented industries *vis-a-vis* the nondefense industries.

More concretely, the study first outlines, in Chapter II, the structural change in defense hardware requirements. This is elaborated at some length to show the locked-in or dependent feature of the modern defense firm. Chapter III then reports a previous attempt by another author at relating defense spending to economic growth. The study cited in this section developed a correlation coefficient relating growth in per capita personal income to growth in defense income. The resulting statistic was strikingly weak. The present study, however, argues that for reasons of variability in defense spending, and the dependent nature of defense suppliers, this is to be expected.

This argument is placed in the form of an hypothesis in Chapter IV. In addition, Chapter IV discusses the data to be used in an empirical test of this hypothesis at the national level of geographic aggregation, along with the data reductions required to put these in a usable form. The later sections of Chapter IV present the statistical technique employed at the national level and the set of variables the study concentrates on.

The results derived from the application of this statistical technique are presented in detail in Chapter V. At this time a connection is formed between the elements of the argument leading up to the hypothesis and the subsequent empirical findings.

Chapter VI discusses an attempt at examining the regional dimensions of defense procurement. The same industry employment and group format used earlier is maintained, with the added dimension of geographic regions. Due to data limitations, the statistical technique presented in Chapter IV is not suitable at the regional level. Therefore, the second section of this chapter is devoted to formulating an appropriate statistical model. The third section reports the results of the regional analysis.

Chapter VII concludes the study with a brief review of the more salient features of the analyses and their outcomes.

II. THE STRUCTURAL CHANGE IN DEFENSE SPENDING

A. General Aspect of Structural Change

The quantity of goods and services consumed by the United States Department of Defense has been the subject of considerable discussion over the past several years.[1] Of late, much of this discussion has centered around the question of what would be the economic consequences of a major disarmament program. Quite aside from this, however, there are several reasons why defense expenditures have occupied the thoughts of many men. Superficially, we might argue that defense expenditures are of little economic interest, since they have been relatively stable over the past fifteen years, or that this type of expenditure as a percentage of Gross National Product has not changed significantly over the period.[2]

Such an argument, however, obscures two very important points. First, the current pattern of defense expenditures differs markedly from that of either World War II or the Korean conflict. There has been a geographical shift in prime contract awards and the regional distribution of payrolls. The second and possibly more important aspect of the problem is the very specialized nature of the resources used by the major companies supplying defense demands. In contrast with the situation of World War I and World War II, a far greater share of defense production today is conducted in

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[1]For example, see (5, 30, 39).

[2]There was a slight tapering off during the 1950's, a more or less constant rate through the mid-1960's, and a slight rise as the Viet Nam build-up began to take on significance. Table A-1 in the Appendix exhibits defense purchases both in absolute and relative terms for the years 1945-1965.

highly specialized facilities. In many instances these facilities have been specifically built, often at the initiative of the military establishment, to serve a certain very limited requirement.[1]

To illustrate this last point, roughly 80 percent of the equipment of the armies that entered the field in the early stages of World War I consisted of standard peacetime goods produced in ordinary peacetime production facilities. By 1941, this had changed such that about one-half of the materiél consisted of special-purpose equipment. It was, however, still possible to produce the bulk of this equipment through conversion of ordinary peacetime facilities. By contrast, the current requirements for defense consist of about 90 percent specialized equipment produced in special facilities built for these limited purposes.[2]

As a consequence of the high degree of specialization which prevails today, the problem of mitigating the adverse economic aspects of a shift in the composition of the defense budget is quite different from that dealt with at the end of the Korean War or World War II. The experience after these two conflicts suggests that the United States economy can cope with rather serious changes in defense expenditures through proper use of fiscal and monetary policy. It must be recognized, however, that the favorable

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[1]An example of one such specialized facility is the Denver, Colo. plant of the Martin Marietta Corp. This facility was organized and designed to produce the Titan II missile. Moreover, this plant was originally designed to handle 120-inch diameter missiles or vehicles only, and the feasibility of adapting to a larger weapon is questionable. See (26).

[2]Derived from statements by Deputy Secretary of Defense Roswell L. Gilpatric presented before the Subcommittee on Employment and Manpower, Senate Committee on Labor and Public Welfare, United States Senate, Nov. 6, 1963 (29, pp. 2401-2402).

results obtained from the use of a particular set of fiscal and monetary instruments to help smooth out the economic impact of former changes in defense expenditures need not imply that these will work similarly in the future. To make such an inference implicitly assumes that the base conditions of the problem have not changed. On the contrary, these conditions have changed significantly. The post World War II economic adjustment was one of adapting to a reduced magnitude of expenditures. With respect to the ongoing cold war, the problem is to cope with a different composition of expenditures for a given volume or total.

As an example of how these policies have worked in the past and why they may not work in the future, consider what happened in the midwestern states of Ohio, Michigan, Illinois, and Indiana in the period between fiscal years 1953 and 1957. The value of production of tanks, conventional ordnance, and commercial types of military hard goods dropped from $11 billion in 1953 to about $2 billion in 1957. The result was a massive loss of defense business in this area where such production had been concentrated; but since the resources released were not highly specialized, they were reabsorbed in the economy by keeping aggregate demand high. Since that time, an increasing proportion of military purchases from private industry has been for electronics, propulsion, and other technologically advanced and specialized components of weapons systems rather than for metal and other fabricated structures. Thus, we cannot presume that simply by keeping total demand at a high level a similar transition from defense production to civilian production could be effected at present. The distinct possibility exists that a change in defense procurement may free resources which do not have a ready application in non-defense production, and consequently the policy instruments used in former situations may well be inapplicable in the present.

The two difficulties set out individually above come together quite rapidly in a kind of imperfect cause-effect relationship in the sense that the more specialized requirements have caused defense demand to become more concentrated in certain geographical areas. The increase in defense concentration follows from the fact that formerly defense production was carried on in plants and with equipment which was simply diverted from civilian production into producing for military requirements. Production, therefore, took place wherever the appropriate facilities were located, and concentration was not in fact caused by defense procurement.

As mentioned previously, many firms of today have come into existence in response to certain very specific inducements from military establishments, and most of these are specially designed and staffed to fulfill a unique function. Often these firms either move towards an area with a similar industrial complex, or an area characterized by a high level of defense demand where there is an abundant and properly qualified labor force with an above average amount of research personnel and facilities. Favorable climatic conditions, proximity to academic institutions, and a well developed transportation system are often important inducements to modern defense-oriented industries; many of these are not attracted to any particular area because of significant material requirements. A large portion of the modern defense producing facilities are independent of location-specific input requirements and are free to move towards more amicable physical settings. The growing dependence on travel by air reinforces the gravitational movement toward the Southwest where atmospheric conditions are favorable and land is available.

In contradistinction with a decade ago, defense purchases from private industry involve a very different bundle of goods and come from different industries. While formerly defense needs were fulfilled by modifying existing production schemes to satisfy defense specifications, the present arrangement involves many firms in the defense industries which have never produced for nonmilitary markets. As a consequence of this shift, the economic impact of a change in the structure or magnitude of defense demand may be, at least in the short run, quite different from anything witnessed in the past.

B. Regional Aspect of Structural Change

The preceding pages provide a general description of the material change in defense requirements. This change is in many respects responsible for a shift in the geographical distribution of defense expenditures. The following pages establish the specific magnitude of these disbursements on a state and regional basis. The figures presented are broken down by period and type of expenditure to show how these changes have affected certain areas.

The defense expenditures to be concentrated on are the purchases of goods and services in the United States by the Department of Defense, especially purchases of goods. In the present context, reference to the Department of Defense includes the three military services or departments and unified procurement agencies such as the Defense Supply Agency. Nonpurchase expenditures, such as retirement pay and certain outright grants, are excluded. Also excluded are expenditures by other agencies under the broader Major National Security title for stockpiling and atomic energy development.

For the purpose of the present discussion, it is important that defense expenditures for goods and services, referred to above, be subdivided. This breakdown is done under three headings: Military Payrolls, Civilian Payrolls, and Procurement Purchases.

Figures for military payrolls are published by the Office of Business Economics, but, due to the arbitrariness involved in allocating these payments to the state of residence and not state of duty station, these are not measured without some error. The allocating mechanism utilized is that the national total of net pay is distributed among states according to the distribution of military strength. Furthermore, the Office of Business Economics excludes the net pay of personnel overseas, but does make the appropriate adjustment of further subtracting dependents' allowances from overseas military pay. These are allocated to the various states according to the sum of the distributions of military strength and civilian population.

The figures for civilian wages and salaries are much more reliable than are those for military. These are taken directly from Department of Defense reports based on Federal income tax withholding reports (W-2 statements). Consequently, they cover actual disbursements allocated to or classified by state of residence.

The allocation of annual procurement purchases to states involves problems of estimation which are considerably more complex than those encountered in treating military payrolls. The complications are both conceptual and practical. It is, thus, not surprising that in previous regional studies of defense purchases a variety of techniques and approaches for its estimation have been applied.

Procurement information on a state-by-state basis is available only in the form of prime contract awards. These data are published, since fiscal year 1951, by the Department of Defense under the title Military Prime Contract Awards by Region and State (32).

The value of prime contracts awarded in a state in a given year has two serious shortcomings as a measure of the value added in defense production by a state. First, a time lag of an irregular period occurs between the awarding of the contract and the completion of production; the production precipitated by a contract may be forthcoming during years subsequent to the one in which the contract was let. The nature and form of this lag is as varied as are the items in any procurement bundle. Although attempts have been made, little dependable information has been extracted on the general structure or duration of the lag. Consequently, any attempt to develop annual estimates of defense procurements by state contains a degree of arbitrariness.

The second complication grows out of the fact that while prime contract awards are reported for each state, extensive subcontracting and other purchasing by prime contractors from supply sources in other states means that value added by state is not equal to the dollar value of the contract award. This matter of correctly allocating all of the value added components of any given contract award to the state responsible for production becomes rather impractical since any one prime contract may undergo several rounds of subcontracting. Moreover, there is also a kind of hierarchy of contracting arrangements in that prime awards are subcontracted and then these subawards are subjected to further tiers of subcontracting.

As a consequence of the discrepancy between the value of prime contract award and the actual value added by any one state in any given year, the published award figures must be adjusted with respect to both timing and dispersion (subcontracting).[1] A significant attempt at handling the two problems was made by Roger Bolton (4) in a study of the regional effects of defense purchases.[2] Bolton's estimates of procurement were made by estimating annual percentage shares for each state, and then multiplying them by the national purchases total. The shares referred to are prime contract shares adjusted for the lag of purchases in time and for the dispersion of value added due to contractors' out-of-state purchases.

To get an indication of the absolute magnitude of defense expenditures for each state and to get some idea of how these magnitudes have behaved over time, the prime contract awards, adjusted for both timing and dispersion, can be added to military and civilian defense payrolls. The figure that results is an estimate of annual purchases of goods and services, by the Department of Defense, for each state. These estimates may be subject to a high degree of error in states where extreme or unusual circumstances prevail. They will, however, serve the immediate purpose of giving some indication of what has happened to defense spending in the past several

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[1] *An alternative approach has been utilized wherein national defense* purchase totals were allocated to the respective states through use of input-output analysis. A difficulty in this method is that input-output coefficients refer to shipments and not to value added. See Mushkin (18, 19).

[2] Similar studies of a more limited scope are Labovitz (16), Pfister (22), and (37).

years with respect to geographical density and distribution. In addition, these estimates provide a means for measuring the relative importance of defense expenditures to the level of income in a state.

Table 1 shows defense purchases of goods and services for each state and region for the selected years 1952, 1956, and 1962.[1] As may be seen from Table A-1 in the Appendix, 1951 was the year the Korean Conflict build-up began to show its effect. This increase in purchase activity reached its peak in 1953 both in absolute dollars spent and as a percent of GNP. This particular year is not, however, representative of the peak in production for the Korean Conflict, since a significant number of contract cancellations occurred during the first half of 1953. These are not reported separately and, as a consequence of the specific estimation technique used, tend to distort the true distribution of awards. For purpose of comparison with other years, 1952 appears to most accurately represent the peak in production activity for the Korean situation. By contrast, 1956 is beyond the direct and subsequent adverse effects of the post-Korean cutback which began in 1953 and carried through 1954 and part of 1955. The year 1956 predates the mild economic recession of 1957-1958 when the Gross National Product fell from a level of $452 billion in 1957 to $447 billion in 1958; both are in terms of 1958 prices. It is not, however, to be construed that

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[1]This and the next table were extracted from more detailed tables contained in the appendix to Bolton's book (4). Some degree of completeness is lost since these do not cover the years since 1962. Since the Viet Nam build-up is too recent to be reflected in the currently available data and otherwise no surprising or unusual changes occurred since 1962, the informational value of the years omitted does not appear to justify the time and expense involved in calculating the required estimates.

Table 1. Estimated annual defense purchases and percentage shares, by state and region, 1952, 1956, and 1962[a]

State or Region	1952 Purch. (Millions of Dollars)	1952 Per Capita (Dollars)	1952 %[b]	1956 Purch.	1956 Per Capita	1956 %[b]	1962 Purch.	1962 Per Capita	1962 %[b]
Maine	169	185		177	189		217	219	
New Hampshire	108	202		96	170		179	284	
Vermont	58	155		31	82		40	102	
Massachusetts	1,255	270	3.13	1,010	207	3.01	1,728	332	3.86
Connecticut	1,077	518	2.69	1,137	491	3.39	1,290	489	2.88
Rhode Island	281	350		213	254		247	283	
New England	2,944	315	7.36	2,668	269	7.97	3,701	345	8.27
New York	4,318	284	10.79	3,038	189	9.08	3,729	214	8.33
New Jersey	1,918	374	4.79	1,526	272	4.56	1,977	310	4.41
Pennsylvania	2,206	210	5.51	1,708	156	5.10	2,191	193	4.89
Middle Atlantic	8,442	274	21.11	6,272	192	18.74	7,897	224	17.65
Ohio	2,410	291	6.02	1,812	197	5.41	2,101	211	4.69
Indiana	1,431	345	3.57	768	172	2.29	958	203	2.14
Illinois	2,154	241	5.38	1,729	181	5.16	1,718	167	3.84
Michigan	2,967	446	7.42	894	120	2.67	1,401	177	3.13
Wisconsin	699	202	1.74	370	99	1.10	530	132	1.18

[a]Bolton (4, Appendix).

[b]All states for which no percentage share figure is reported had less than 1% of the national total in each of the three years included.

Table 1 (Continued)

State or Region	1952 Purch. (Millions of Dollars)	1952 Per Capita (Dollars)	%[b]	1956 Purch.	1956 Per Capita	%[b]	1962 Purch.	1962 Per Capita	%[b]
E.N. Central	9,660	307	24.16	5,571	162	16.65	6,708	182	14.99
Minnesota	346	114		260	801		394	113	
Iowa	265	101		193	71		277	100	
Missouri	814	205	2.03	687	165	2.05	868	199	1.94
North Dakota	15	25		20	33		82	129	
South Dakota	46	71		45	67		97	138	
Nebraska	152	116		125	90		197	135	
Kansas	489	247	1.22	653	308	1.95	654	290	1.46
W.N. Central	2,126	150	5.31	1,983	133	5.92	2,569	164	5.74
Kentucky	418	143	1.04	308	106	.92	425	137	.94
Tennessee	372	111		305	89		427	116	
Alabama	441	144	1.10	470	153	1.40	579	173	1.29
Mississippi	184	86		182	87		284	125	
E.S. Central	1,412	123	3.53	1,267	110	3.78	1,715	138	3.83
Arkansas	153	83		147	86		194	103	
Oklahoma	403	187	1.00	385	169	1.15	446	183	.99
Louisiana	374	132	.93	342	113	1.02	440	131	.98
Texas	1,773	213	4.43	1,847	209	5.52	2,254	223	5.03
W.S. Central	2,702	178	6.75	2,722	172	8.13	3,334	187	7.45

Table 1 (Continued)

State or Region	1952 Purch. (Millions of Dollars)	1952 Per Capita (Dollars)	1952 %[b]	1956 Purch.	1956 Per Capita	1956 %[b]	1962 Purch.	1962 Per Capita	1962 %[b]
Delaware	128	375		82	201		118	253	
Maryland	1,062	425	2.65	1,074	382	3.21	1,222	377	2.73
D. C.	403	501	1.00	346	456	1.03	374	479	.83
Virginia	1,284	366	3.21	1,122	301	3.35	1,555	371	3.47
West Virginia	125	64		95	51		172	94	
North Carolina	625	152	1.56	612	142	1.82	810	171	1.81
South Carolina	410	188	1.02	340	153	1.01	465	190	1.03
Georgia	745	208	1.86	705	190	2.10	944	230	2.11
Florida	515	163	1.28	639	158	1.90	1,099	204	2.45
S. Atlantic	5,295	239	13.24	5,012	210	14.98	6,759	249	15.10
Montana	36	60		48	73		100	144	
Idaho	47	80		41	65		64	92	
Wyoming	43	147		51	163		72	217	
Colorado	249	182	.62	318	196	.95	658	349	1.47
Utah	143	198	.35	140	173	.41	448	468	1.00
Nevada	38	210		54	216		61	176	
Arizona	136	162		244	232		338	231	
New Mexico	143	195		170	211		218	223	
Mountain	834	157	2.08	1,064	173	3.18	1,959	266	4.37

Table 1 (Continued)

State or Region	1952 Purch. (Millions of Dollars)	1952 Per Capita (Dollars)	%[b]	1956 Purch.	1956 Per Capita	%[b]	1962 Purch.	1962 Per Capita	%[b]
Washington	1,055	431	2.63	965	362	2.88	1,378	468	3.08
Oregon	192	121		132	78		169	93	
California	5,061	435	12.65	5,412	395	16.17	7,988	470	17.85
Pacific	6,305	402	15.76	6,508	360	19.45	9,535	438	21.31
Hawaii	125[c]	241		186[d]	333		351	505	
Alaska	137[c]	724		206[d]	920		220	905	1.27
U.S.	39,983	255		33,457	199		44,738	241	

[c]Includes military payrolls only.

[d]Military payrolls and estimated procurement.

changes in GNP have an effect, direct or indirect, on the level and distribution of defense expenditures. That such a dependent relationship exists is neither obvious nor well established, and any theory or argument to the effect that a connection exists should take the form of a hypothesis which is to be subjected to empirical testing. This word of caution is injected at this point to prevent any unintended inference that the general level of economic activity would or should alter the magnitude and pattern of defense spending. The matter of a relationship between these two macroeconomic quantities will be studied in detail later.

What is important about choosing a representative year which is to be compared and contrasted with other years is that certain comparisons are to be made on a relative basis requiring that all the components of any particular measure be free from unusual or ephemeral disturbances. To get an idea of how important defense-generated income is to the various states, we may want to examine the proportion of a state's personal income which is contributed by defense purchases of goods and services.[1] Unless the national levels of both figures move in a proportionate manner, we may get a distorted view due to some unusual and unwanted changes in one or the other quantity. For example, defense spending in 1957 and 1958 was roughly constant in dollars magnitude. Gross National Product, on the other hand, dipped slightly in 1958 and recovered to surpass the 1957 level during 1959. The choice of 1958 as a representative year would have involved a distorting component in which we have no interest at this time, since our purpose

[1] Defense purchase totals somewhat overstate income derived since depreciation allowances and certain taxes are not netted out.

is only to judge the importance of defense expenditures at the state level and see how these have shifted geographically in the post-Korean War years.

As a third choice of representative years, 1962 seems to serve well, in that no undesirable shocks were experienced in either GNP or defense spending. As a matter of fact, defense purchases of goods and services as a percent of GNP are the same for the years 1956 and 1962, which make these two years of additional interest in tracing through the changes in the geographical mix of this type of spending.

Looking at the percentage share of the national total for the various regions outstanding changes have occurred in only three of them: Middle Atlantic, East North Central, and Pacific. In the remaining regions, purchases have changed only moderately, both in absolute dollar volume and in relative shares.

The Middle Atlantic and East North Central regions have experienced a decline, both in absolute and relative terms, over the period considered. The Middle Atlantic's change in absolute terms is slight. Its percentage share, on the other hand, has fallen considerably, showing a decline from 21.11 percent of the national total in 1952 to 17.65 percent in 1962. The East North Central region has suffered an even more serious decline, with its absolute share dropping nearly $3 billion and its relative share falling from 24.16 percent to 14.99 percent over the 1952-1962 period. It appears that the 1953-1954 cutback after the Korean War and the subsequent shift in the nature of the items procured by the Department of Defense set in motion a series of circumstances from which these two regions never recovered. The first event was the shock to production brought about by post-Korean contract cancellations; the second was a shift in military hardware type. Other regions were affected by the contract cancellations in a similar manner, i.e., their absolute dollar volume in 1956 was less than in 1952, but each was able to recover its position and none was quite as significant in terms of total share held and degree of initial shock as were these two. Of all the states included in these two regions, Michigan was most adversely affected, having its dollar volume reduced some $2 billion and its share of the total fall from 7.42 percent to 2.67 percent between 1952 and 1956.

The Pacific region, and especially California, has fared well over the whole period under consideration. That is, the post-Korean cutback did not hit this region nearly as hard as *it* did the two regions singled out above, and the shift in the nature of defense procurement has been exceptionally beneficial to it. The state of Washington experienced a reversal in absolute terms between 1952 and 1956, but California realized an absolute gain of almost $400 million in the same period. In terms of shares, California benefited significantly over the 1952-1956 period of reduced defense spending. This latter point gives some indication of the regional impact brought about by the currently more specialized military hardware requirements. The historically industrialized regions have experienced a decline in their share of defense spending since the Korean conflict, while those regions containing the aerospace and electronics industries have appreciated a sizable gain. These geographical shifts become even more noticeable if defense procurement is isolated from total purchases.

Table 2 shows defense procurement broken out in a form identical with Table 1. Again, the regions to be isolated for consideration are Middle

Table 2. Estimates of annual procurement purchases and percentage shown by state and region, 1952, 1956, and 1962[a]

State or Region	1952 Proc. (Millions of Dollars)	%[b]	1956 Proc.	%[b]	1962 Proc.	%[b]
Maine	113		100		108	
New Hampshire	68		53		101	
Vermont	50		23		34	
Massachusetts	886	3.28	686	3.30	1,336	4.52
Connecticut	1,025	3.80	1,077	5.18	1,208	4.08
Rhode Island	147		67		95	
New England	2,286	8.47	2,009	9.66	2,879	9.73
New York	3,642	13.49	2,409	11.58	3,091	10.45
New Jersey	1,531	5.67	1,193	5.74	1,533	5.18
Pennsylvania	1,650	6.11	1,209	5.81	1,584	5.35
Middle Atlantic	6,823	25.27	4,811	23.13	6,208	20.97
Ohio	2,039	7.55	1,434	6.90	1,681	5.68
Indiana	1,252	4.64	644	3.10	811	2.74
Illinois	1,706	6.32	1,320	6.34	1,270	4.29
Michigan	2,781	10.30	742	3.57	1,163	3.93
Wisconsin	624	2.31	317	1.52	468	1.58

[a]Bolton (4, Appendix).

[b]All states for which no percentage share figure is reported had less than 1% of the national total in each of the three years included.

Table 2 (Continued)

State or Region	1952 Proc. (Millions of Dollars)	%[b]	1956 Proc.	%[b]	1962 Proc.	%[b]
E.N. Central	8,402	31.12	4,456	21.42	5,390	18.21
Minnesota	302	1.12	210	1.01	334	1.13
Iowa	235		149		227	
Missouri	645	2.39	495	2.38	635	2.15
North Dakota	4		10		34	
South Dakota	11		11		59	
Nebraska	95		47		85	
Kansas	346	1.28	469	2.25	452	1.53
W.N. Central	1,638	6.07	1,391	6.69	1,826	6.17
Kentucky	128		106		142	
Tennessee	239		166		278	
Alabama	185		197		234	
Mississippi	73		68		121	
E.S. Central	622	2.30	539	2.59	773	2.61
Arkansas	69		44		83	
Oklahoma	166		142		146	
Louisiana	184		165		233	
Texas	778	2.88	841	4.04	1,122	3.79
W.S. Central	1,196	4.43	1,193	5.73	1,585	5.36

Table 2 (Continued)

State or Region	1952 Proc. (Millions of Dollars)	%[b]	1956 Proc.	%[b]	1962 Proc.	%[b]
Delaware	113		46		75	
Maryland	551	2.04	539	2.59	588	1.99
D. C.	129		72		124	
Virginia	279	1.03	205	.98	485	1.64
West Virginia	99		72		151	
North Carolina	308	1.14	300	1.44	400	1.35
South Carolina	138		91		150	
Georgia	336	1.24	296	1.42	417	1.41
Florida	115	.42	165	.79	577	1.95
S. Atlantic	2,066	7.65	1,783	8.57	2,970	10.04
Montana	14		22		53	
Idaho	19		19		33	
Wyoming	6		7		51	
Colorado	68	.25	101	.49	406	1.37
Utah	27	.10	34	.17	305	1.03
Nevada	8		11		10	
Arizona	46		126		204	
New Mexico	34		41		62	
Mountain	221	.82	359	1.72	1,122	3.79

Table 2 (Continued)

State or Region	1952 Proc. (Millions of Dollars)	%[b]	1956 Proc.	%[b]	1962 Proc.	%[b]
Washington	617	2.28	566	2.72	948	3.20
Oregon	136		85		112	
California	2,996	11.10	3,531	16.98	5,704	19.27
Pacific	3,746	13.88	4,181	20.10	6,764	22.85
Hawaii	-		21		36	
Alaska	-		63		50	
U.S.	27,000		20,800		29,600	

Atlantic, East North Central, and Pacific. The Middle Atlantic's change in percentage share of procurement is roughly the same as for total purchases in this region over the 1952-1962 period.

The deterioration in the East North Central's share is more significant when examined in the present manner. Its share fell from 31.12 percent in 1952 to 18.21 percent in 1962, with the State of Michigan receiving the brunt of the deterioration. As was the case in the comments about Table 1, the post-Korean cutback was a severe setback from which the region never recovered. Michigan's share of total spending fell 9 percent between 1952 and 1962, while its share of procurement dropped almost 13 percent.

Making this type of comparison for the Pacific region, its relative share of defense procurement displays a growth which overshadows rather significantly this region's growth in overall defense spending. The gross measure grew by some 5.5 percent between 1952 and 1962, while procurement alone grew nearly 9 percent.

It was previously argued that production for military purposes prior to and including the Korean War was characterized by a process of converting the existing productive facilities from their civilian orientation to producing for military requirements. Since that time the military requirements have changed in such a manner that it is no longer desirable to continue this adaptive procedure. Now special purpose industries are originated and designed to produce for military needs. The manifestation of the change in military needs was a shift in procurement away from the historically industrialized states. Specifically, the concentration of defense procurement has undergone a shift away from the Middle Atlantic and East North Central regions to the Pacific, and in a lesser sense, Mountain and

South Atlantic regions (see Tables 1 and 2). Within these recipient areas, certain states have shown sizable gains over the ten-year period considered.

The connection between the modern-day military requirements and the shift of production activity away from the older industrial states can be seen by examining the value added by industry in a selected group of militarily-procured hardware items. The representative quality of this value-added breakdown is that we can focus on the industries responsible for significant contributions to these final products. The point of interest is to concentrate on the relative contribution made by industries classified in the primary metals group, since these are largely located in the regions which have been hurt by the structural change in the bundle of goods purchased. Those items which represent a sizable proportion of the current procurement expenditure have shifted emphasis in terms of relative contributions to the final product of the aerospace and electronics industries.[1]

Beckler, et al. (2) have attempted to estimate the percentage distribution of value added by the ten largest industries in the production of fighter aircraft, missiles, and surface ships.[2] The allocation was done on the basis of four-digit Standard Industrial Classification (SIC) codes. Table 3 shows the percentage distribution and identifies the industries covered.

The industries to notice in the table are SIC 33, major group: Primary Metals, and to a somewhat lesser extent, SIC 34, major group:

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[1]A more detailed discussion of these changes is given in (31).

[2]The estimation technique used was that of tracing a sample of prime contract awards through its tiers of subcontracts and assigning value added to the appropriate industry.

Table 3. Percentage distribution of 1963 value added, by industry, for selected procurement groups[a]

Industry	Fighter aircraft SIC	Fighter aircraft %	Missiles SIC	Missiles %	Surface ships SIC	Surface ships %
10 largest, by SIC	3721	29	3662	27	3731	30
	3662	10	1925	17	3511	14
	3679	9	3722	15	3662	8
	3722	7	3621	10	3443	4
	3729	6	3729	4	3621	3
	3811	5	3721	2	3519	3
	3011	4	2892	2	3323	3
	3599	2	7391	2	3312	2
	3511	1	3679	1	1999	2
	3621	1	3674	1	3571	2
Subtotal		74		79		71
Other identified industries		13		10		8
Unallocated		13		9		21
Total		100		100		100

Legend:

SIC code	Industry title
3721	Aircraft
3662	Electronic transmission and detection equipment
1925	Guided missiles
3722	Aircraft engines and parts
3721	Shipbuilding and repairing
3679	Electronic components and accessories, n.e.c.
3729	Aircraft parts and auxiliary equipment, n.e.c.
3621	Electric motors and generators
7391	Research, development, and testing labs
3811	Engineering, laboratory, and scientific equipment
3674	Semiconductor (solid state) devices
3511	Steam engines, turbines, generator set units
3599	Nonelectrical machinery, n.e.c.
1999	Ordnance and accessories, n.e.c.
3312	Blast furnaces, steel works, and rolling mills
3011	Tires and inner tubes
2892	Explosives
3323	Steel foundries
3443	Fabricated plate work (boiler shops)
3519	Internal combustion engines, n.e.c.

[a]Beckler (2, p. 24).

Fabricated Metal Products (except ordnance), Machinery, and Transportation Equipment. The point to be made is that the three procurement items exhibited account for a significant proportion of the total defense bundle, but the industry groups SIC 33 and 34 figure only incidentally in the production of these items while the aerospace, SIC 37, and the electronics industry's, SIC 36, share is large indeed. This shift away from primary metals explains in part the rather severe relative losses suffered by the East North Central region. The Middle Atlantic region has been able to avoid the brunt of the change in defense procurement through its inclusion of an appreciably sized electronics industry and its shipbuilding facilities.

The tone of the argument heretofore implies rather strongly that draconic changes have befallen the East North Central and Middle Atlantic regions, with their losses being the Pacific region's gains. It must be recognized, however, that even though these regions have experienced rather sizable changes in their percentage shares, they are still important in the sense that each region's share of the total is significant in all years considered. Even the East North Central, which has had its share eroded over the ten-year period exhibited in the tables, still accounts for nearly one-fifth of the national total of defense procurement. Looked at differently, if we ordinally arrange the top five regions according to their share of the national total, we see immediately that membership in this array does not change over the three annual periods considered. Table 4 exhibits this. Also Table 4 arrays the top six states by the same criterion; the choice of six was based on no state having less than 6 percent in any of the years included. A good deal of stability is present in this array

Table 4. Partial rank ordering of states and regions, by share of national total, 1952, 1956, and 1962

1952 Region	%	1956 Region	%	1962 Region	%
E.N. Central	31.12	Middle Atlantic	23.13	Pacific	22.85
Middle Atlantic	25.27	E.N. Central	21.42	Middle Atlantic	20.97
Pacific	13.88	Pacific	20.10	E.N. Central	18.21
New England	8.47	New England	9.66	So. Atlantic	10.04
So. Atlantic	7.65	So. Atlantic	8.57	New England	9.73
State	**%**	**State**	**%**	**State**	**%**
New York	13.49	California	16.98	California	19.27
California	11.10	New York	11.58	New York	10.45
Michigan	10.30	Ohio	6.90	Ohio	5.68
Ohio	7.55	Illinois	6.34	Pennsylvania	5.35
Illinois	6.32	Pennsylvania	5.81	New Jersey	5.18
Pennsylvania	6.11	New Jersey	5.74	Illinois	4.29

as well; however, a few surprises are present. After 1952 Michigan drops from third place in the rank ordering out of the top six altogether and is replaced by New Jersey. The other item of interest is to note the spread or range between the states occupying the first and sixth position in the three years covered. In 1952, the number one state's share was a bit over twice as large as the sixth place state; by 1956, number one's share was three times that of number six; and in the last year, the spread between them is nearly fivefold.

III. DEFENSE SPENDING AND THE LEVEL OF ECONOMIC ACTIVITY

The preceding tables and the attendant discussions have established, on a regional basis, the areas where defense spending in general, and defense procurement in particular, is concentrated most heavily. In addition, these tables show how the changing nature of defense requirements has affected the density of defense spending in the various regions, resulting in shifts in the geographical distribution of this type of expenditure. Also shown in the tables is the fact that the absolute dollar volume of expenditures in many regions and states is indeed large, in many cases several billions of dollars. The interesting economic question posed by this consideration is: How important are defense expenditures to the income level of a region or state? More specifically, how important is this class of expenditure for supporting a certain level of economic activity, as measured by the income generated, and how much do these contribute to economic growth and the rate of growth of a region, and through aggregation, the nation as a whole? The point of interest, therefore, is not simply how large relative to a state or region's income these expenditures are, but how strong are their impacts on the level of economic activity generated or supported by them. To be sure, the relative volume of this type of spending is significant, but to draw inferences about its contribution to economic activity levels from this measure alone is myopic in that it may obscure the dynamic properties and variable effects which might be present.

Through proper specification and identification of the variables included, the usual Keynesian income-determination type macroeconomic model of an open economy can be adapted to an arbitrarily delimited subdivision of a country. Such an adaptation allows certain components of interest to be isolated for the purpose of estimation and examination. Interest in national income models is usually focused on examining the income-multiplier effects brought about through changes or perturbations which are autonomous or exogenous to the system. From the national point of view, autonomous investment, purchases of goods and services by various governmental agencies at all levels, and net exports to foreign countries are the exogenous elements, with domestic consumption expenditures and induced investment designated as being endogenous. For a region of a country, the exogenous and endogenous elements are quite different; the exogenous elements of income are receipts for goods and services produced within the region but sold beyond its borders, while the endogenous items are those which are local in both productive scope and market area.

When applying an income determination model to the economy of a particular region, the exogenous components are of the greatest significance, inasmuch as the fundamental premise of such an inquiry is that the reason for the existence and growth of a region lies in the goods and services it produces locally but sells elsewhere. In other words, the receipts flowing into a region not only provide the means of payment for the purchase of goods and materials it cannot provide for itself but also supports those service and productive activities which are local or internal to the region. Each region defined will have a set of activities which are subdivided with respect to the geographical destination of its output, i.e., the configuration of exogenous and endogenous income components peculiar to a specific region; however, defense purchases can correctly be considered as almost completely exogenous to any region. Supposedly then, the larger this type expenditure is as a proportion of a region's total exogenous income, the more dependent this region will be on the level of defense spending.

Several applications of the economic base type macro model have been made in an attempt to quantify the economic impact of defense spending. The reference base to which the models have been applied has varied from single cities, to complex industrial centers comprising a Standard Metropolitan Statistical Area (SMSA), to a state-by-state analysis of the whole United States.[1] Quite aside from these, several studies have attempted to focus on the intersectoral flows of commodities to isolate the contribution made by defense purchases, and to estimate the degree to which certain regions are dependent on this type of spending.[2]

The most comprehensive study of the first type was that done by Bolton (4), cited in Chapter II. He first postulated a simple regional income determination model linearly relating endogenous income to total exogenous income for each state and region; Bolton then estimated the "exogenous income multipler" in each case using time-series data. Defense spending was accounted for as it contributed to income received by industry. Except for those industries which, on an a priori basis, can be classified as producing for export demand, for example, SIC 19, Ordnance, or on the other hand, those which are clearly endogenous, all industries were allocated to one or the other category, endogenous or exogenous, through use of a location

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[1]For example, see Bolton (4), Hildebrand and Mace (11), and Park (21).

[2]One such study is Hansen and Tiebout (9).

coefficient.[1]

A least-squares estimate was performed using sixteen annual observations on the two components of income expressed in per capita terms.[2] In all states but one, North Dakota, the estimate of the multiplier was statistically significant at at least the 5 percent level of significance. However, the Durbin-Watson statistic indicated the presence of some positive autocorrelation in many cases, which implies that the standard errors of the estimates may be seriously understated.

No separate estimate of a so-called "defense spending multipler" was attempted. The importance of this portion of exogenous income to the level of economic activity in each state was measured indirectly as it contributed to total exogenous income. This measure of relative importance was made by forming the ratio of estimated defense purchases, after being adjusted downward to account for that portion of spending which does not become personal income, to total exogenous income for the state.[3] A large value for

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[1] For a definition and discussion of this, see Isard (13).

[2] The postulated model was of the following form:

(1) $Y_n = a + bY_p$;

(2) $Y_p = Y_n + E$;

where; Y_n is endogenous personal income, Y_p total personal income, E exogenous income, and a and b are constants. The model fit was a reduced form equation of (1) and (2), namely:

(3) $Y_n = \frac{a}{1-b} + \frac{b}{1-b} E$

[3] Procurement figures were adjusted downward by 30 percent to get an estimate of personal income. This value is arrived at by averaging over time the product of the following fractions:

$$\frac{\text{National Income}}{\text{Gross National Product}} \qquad \frac{\text{N.I. - (Corp. profit taxes, undist. corp. profits, supplements to wages and salaries)}}{\text{N.I.}}$$

The first fraction is available for all (footnote continued on next page)

this ratio coupled with a sizable multiplier would indicate that the income level in any state is tied rather closely to defense spending. In other words, a certain amount of dependency on defense spending exists.

Table 5 exhibits the percentage share of total exogenous income which is contributed by defense income for each state and region and the estimate of the exogenous income multiplier, that is, the numerical coefficient showing the multiplied effect exogenous income has on personal income for each state and region. The percentage figures are, of course, only approximations, since the dichotomy between the two classes of income was arbitrarily formed and the defense purchases figures are only estimates.

Bolton then attempts to analyze further the magnitude of impact which defense spending has on personal income by measuring the correlation between the growth in personal income and the growth in defense purchases. In estimating this correlation, each state represents an observation. The results are surprisingly insignificant, especially if personal income is put on a per capita basis. The relative contribution that defense income makes to growth in total exogenous income was correlated with growth in total personal income, expressed as a gross measure and on a per capita basis. To ensure that the measure would be sensitive to defense income, the rates of growth in the two income components weighted by the importance of defense income in some base year was used to represent the relative

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(footnote continued from previous page) manufacturing, the second by major industry. For a more detailed discussion, see Marimont (17).

Table 5. Defense income as a percentage of total exogenous income and the numerical value of the exogenous income multiples, by state and region[a]

State or Region	1952 % of Exog.	1956 % of Exog.	1962 % of Exog.	Multipliers
Maine	19.9	19.7	19.5	1.96
New Hampshire	22.4	17.4	23.8	2.44
Vermont	17.7	9.2	9.7	2.94
Massachusetts	28.2	19.9	23.9	2.50
Connecticut	37.3	32.9	28.5	2.63
Rhode Island	33.7	24.9	24.4	2.70
New England	31.0	24.6	25.3	2.63
New York	27.3	16.5	14.8	2.63
New Jersey	41.7	27.8	26.8	3.23
Pennsylvania	24.7	16.5	17.1	2.70
Middle Atlantic	31.6	20.0	18.5	2.70
Ohio	29.2	18.9	17.0	2.70
Indiana	36.8	17.8	16.3	2.63
Illinois	25.7	17.6	13.3	3.03
Michigan	40.2	10.5	13.2	2.70
Wisconsin	20.4	10.1	10.4	2.63
E.N. Central	32.6	16.5	15.0	2.86
Minnesota	13.1	9.0	10.1	3.13
Iowa	9.0	7.4	8.5	2.23
Missouri	25.2	18.9	17.4	2.78
North Dakota	3.6	3.6	8.7	-
South Dakota	10.0	9.4	10.3	1.59
Nebraska	10.9	11.1	10.7	2.22
Kansas	22.6	31.7	23.0	2.22
W.N. Central	16.5	15.4	14.1	2.86
Kentucky	25.2	17.7	18.1	3.03
Tennessee	20.5	15.2	14.8	3.03
Alabama	26.7	25.6	21.8	2.63
Mississippi	16.8	16.7	18.9	2.70
E.S. Central	24.0	19.8	19.2	3.03

[a]Extracted from more detailed tables in Bolton (4, pp. 48 and 88).

Table 5 (Continued)

State or Region	1952 % of Exog.	1956 % of Exog.	1962 % of Exog.	Multipliers
Arkansas	14.5	13.4	13.2	2.50
Oklahoma	24.7	22.4	19.6	2.50
Louisiana	20.6	16.3	15.8	2.86
Texas	28.9	26.4	23.3	2.86
W.S. Central	25.8	23.4	21.0	2.94
Delaware	24.5	11.6	12.5	1.79
Maryland	48.4	39.3	30.8	2.27
D. C.	29.4	24.9	19.5	1.22
Virginia	46.8	38.0	37.4	2.44
West Virginia	7.2	5.2	8.1	2.33
North Carolina	21.8	18.4	18.1	2.63
South Carolina	29.5	22.4	22.3	2.33
Georgia	33.8	28.6	27.5	2.63
Florida	25.8	20.9	20.1	2.44
S. Atlantic	33.8	27.4	25.6	2.56
Montana	5.7	6.9	10.5	2.00
Idaho	8.4	7.0	8.7	2.70
Wyoming	13.8	15.5	14.8	2.17
Colorado	22.6	24.9	31.0	2.94
Utah	27.4	23.7	41.3	2.50
Nevada	17.6	18.5	13.4	2.86
Arizona	18.3	24.6	22.2	2.78
New Mexico	25.8	28.7	24.8	2.86
Mountain	18.6	20.7	24.2	3.13
Washington	41.8	34.0	33.2	2.27
Oregon	12.0	7.8	7.7	2.56
California	41.9	35.3	33.9	2.63
Pacific	39.5	33.0	32.7	2.63
Hawaii	25.4[b]	31.3[c]	44.7	2.50
Alaska	48.8[b]	59.7[c]	58.7	4.00

[b]Includes military payrolls only.

[c]Military payrolls and estimated procurement.

contribution.[1] This relative measure correlated with total personal income growth rate yielded a coefficient of correlation of .36; correlated on a per capita basis the coefficient dropped to .16 (4, p. 105).

The numerator of the relative contribution variable when taken by itself provides a measure of absolute contribution to growth. The correlation of this variable with the growth rates in total personal income yielded a coefficient of correlation of .57. On a per capita income basis, the coefficient was .19 (4, p. 102). This indicates that states with large absolute gains in defense income tended to grow more rapidly, but that this tendency is weak. Relating the benefit of defense income growth to income growth on a per capita basis, the effect is almost completely offset by population growth.

If we recall from Tables 1 and 5 that defense spending is both large in absolute dollar volume and as a fraction of total exogenous income in many states, and that the multiplier values are often similarly large, then it seems almost paradoxical that the correlation between the measures of growth should be weak. The seeming paradox, however, may be more apparent than real.

Bolton's study considers defense income as an annual stock of income to a region and completely ignores the flow aspects. As a stock, this

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[1] Symbolically, this is:

$$\text{relative contribution} = \frac{\frac{D_o}{E_o} r_d}{r_e}$$

where D_o is defense income in the initial period, E_o exogenous income in base period, and r_d and r_e are growth rates in defense and exogenous incomes.

portion of exogenous income is sizable in many states and regions. But if this stock is accumulated on an annual basis as a sequence of large but infrequent and irregular spurts of spending, then it is possible that the contribution this makes to growth is incidental and largely insignificant. The irregularity of the flows does not apply to the whole of defense purchases but only to that part defined here as procurement. However, a comparison of Table 1 with Table 2 shows that procurement of goods represents the bulk of total expenditures, especially in the regions with a high level of established industrial capital.

Inferences about the income impact of defense spending within a region deduced from observations which consist of aggregated figures developed from flows where the period of aggregation is not less than one year may well be spurious. The accumulated quantities upon which these influences are based may be insensitive to the myriad of lesser forces acting positively and negatively on the economic environment in which they are embedded. The use of a Keynesian type macroeconomic model adapted to a subregion of a country may be subject to just such difficulties due to the gross nature of the observations employed. A well-known property of the multiplier principle is that, when viewed as a dynamic process, an increment in autonomous spending unless maintained in perpetuity will have diminishing impact on the level of income. If the increment in exogenous spending is viewed as a kind of "investment shock" which occurs during one period and ceases to exist thereafter, then the "multiplied" effect this has on income will diminish incrementally over subsequent periods. The intial increase in income will be the distributed fraction of the total shock, but in subsequent periods this will diminish as a convergent power series where the base of this series is the marginal propensity to consume.

Moreover, the theory of the multiplier principle is completely symmetrical in that increments and decrements function with the same magnitude. That is, negative shocks in exogenous spending have a deleterious impact on income in subsequent periods which is the image of the effect a positive shock produces. The result is that a sudden and temporary withdrawal of spending in one period will have the immediate effect of lowering income in the initial period by the amount of the withdrawal, and subsequently will take away small increments, diminishing as the number of periods after the initial shock increases.

The situation that emerges in regions where defense procurement is significant may be one where the annual net expenditure total is positive and large, but when disaggregated on the basis of the firms in the region receiving these expenditures, the situation is quite different. Consider that in any geographical region there is a set of firms that produces for defense demand. In an annual period, the defense procurement total for this region would be the sum of income to each of these firms that is retained in the region.[1] However, consider that this annual sum is arrived at by aggregating over the set of firms on, say, a monthly basis and then summed over months. Then for any one month, not all of these firms need reports a positive figure for defense income received. Some will have completed the output required under one contract and others may have experi-

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[1]Recall that the value of prime contract awards overstates income received in three ways: (1) the time lag between contract award and final production; (2) the spatial relocation due to subcontracting; and (3) payment which is not distributed as income.

enced a contract cancellation so that their contribution for that particular month is zero. Another possibility is that a subset of these firms may report a positive figure for any given month, but this quantity does not represent their full potential, since some of their capacity has remained idle during all or a portion of the month; or their total capacity may have been idle for part of the month.

In summary, defense spending may be sizable and growing in a particular region when viewed on an annual basis. But when annual totals are disaggregated on the basis of shorter time periods and on a firm-by-firm basis, a great deal of variability may be present. The origins of this variability are in the defense customer's fulfilling its requirements. These requirements are dynamic and not rigid in the sense that both the form of the bundle of goods is changing and the system of priorities is changing. At any given decision node, the hardware requirements of the Department of Defense are specified and arranged in order of importance. From this ordering and specification, contracts are let for work. At the next decision node, circumstances may be quite different so that now a judgment is made that certain contracts will be cancelled and others not extended. As is well known, many defense commodities have a short life span in that they are technically superseded by a model that will perform the same function more efficiently or a greater range of functions. An example of such and its effects on the producer is the Titan II rocket system that was replaced by the advance-design Titan III (see Chapter II, p. 29).

In spite of the fact that aggregate defense demand is roughly a constant proportion of GNP, many of the disaggregated demand schedules are highly variable. Thus, when broken into its lesser parts, defense spending may represent a highly irregular set of income flows for a region, and as a consequence, weaken the growth in a region's total and per capita income.

The above situation alone, however, is not sufficient to cause the relationship between defense spending and growth in personal income to be as weak as Bolton's correlation estimates show. If the firms involved in defense production are devoting only a portion of their productive capacity to this type of output and if they can readily convert their facilities to producing for civilian markets, then there need be no disturbing effect brought through changes in defense demand. There is reason to believe, however, that this is not the case. The true situation seems to be that defense firms are quite dependent on defense demand in the sense that this is their only outlet.

To appreciate this "locked-in" effect, we need to examine the characteristics of the market relationship that exists between the buyer and seller of defense goods. When this dependent relationship is brought into focus, we can better assess the added complication that is brought about by the geographic concentration of defense spending shown in Chapter II.

The resources devoted to modern defense production were attracted there through the economic incentive of a higher return. This allocation, or in some instances a reallocation, of resources is little different, in the behavioral sense, from a dynamic change in the civilian sector of the economy. The similarity between the two sectors does not, however, extend much further. The nature of the firms producing for defense demand and the consumer of this output are quite different from those in the civilian sector.

The unique features of defense firms follow largely from the unusual nature of the customer and his specialized requirements. The Department of Defense represents, for defense suppliers, essentially a monopsonistic market. As such, it is in a position to dictate organizational and structural terms as well as technical requirements to the defense firms it confronts. In terms of internal operations, the consumer is able to dictate such aspects as financial reporting systems, industrial engineering and planning, limitations on use of overtime, purchases from outside sources, foreign and domestic, patent control, and pay rates.

From the technical point of view, the government as the customer is able to establish its own list of specifications and then choose from the firms capable of producing these the ones it wishes. The choice need not be, and often is not, the firm from the set of alternative competitors that offers to perform the task at least cost. In spite of the fact that the specifications each competitor includes in his version of any piece of defense hardware are rigidly spelled out, the final product differs by supplier and the customer is able to choose, virtually without restraint, the one he prefers. Similarly, the Department of Defense can simply designate one firm to be the recipient of a contract for a certain item, without regard for competitive bidding. This is not unusual when one firm has amassed an expertise in, say, a certain type weapon system, and therefore is the logical recipient of a contract for a similar item.

An additional power possessed by the defense customer that overshadows all others is its ability to modify unilaterally any relationship with a supplier. Although all work is done under the aegis of a formal contract, the defense customer has the prerogative of outright cancellation, cutbacks in output called for, and stretching the work over a greater period of time than originally specified. The usual cancellation clause does provide that payment will be made for costs incurred and a profit on these. The problem is not, however, any direct financial loss, but the indirect losses caused by the discontinuity in output. For the large firm with sizable overhead expenses, such a disruption could be extremely costly. Moreover, unless a firm is willing to bear a financial loss from having an idle staff of workers, it must terminate their employment.[1] Consequently, for many firms producing solely for defense demand, and their employees, the continuity of their operation hangs in a precarious balance.

It is, of course, true that the defense customer is not the only outlet for the output of many firms. Multi-product firms often produce for both civilian and military markets. However, this division by product market is not alone a sufficient condition for shifting personnel and capital equipment from one type of production to the other. Quite on the contrary, firms that have a significant involvement in defense production and at the same time produce for civilian markets possess the characteristic of keeping the two operations completely separated. Furthermore, the two activities are structurally different in the sense that the defense activity involves a disproportionately large number of research and development personnel. A functional difference also exists, since the behavioral motivation underlying much of the research activity is different.

Studies have been conducted to examine both the efforts of firms

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[1]It is interesting to note that the financial standing of defense firms is the subject of some suspicion. This is reflected by their financial rating established by Moody's standard reporting service. Such firms' outstanding bonds are usually categorized Baa (lower medium grade) or Ba (speculative).

producing solely for a defense market to shift to or jointly adopt a civilian line, and the matter of completely separated facilities.[1] Some of the findings are summarized in the following paragraphs.

Many of the major defense contractors have successfully shifted from one technically-oriented product line to another (aircraft to missiles). However, their attempts to use military technology to penetrate commercial markets have been largely unsuccessful. Numerous, but relatively small, attempts at diversification have been made, many of which were abandoned. Those remaining are at the marginal level as an economic endeavor. Firms without a significant amount of commercial work reported that, were they to attempt penetrating these markets, they would establish physically separate facilities.

This separation of facilities is not restricted to the physical plant, but extends to a significant portion of the human resources. The research and development personnel are in general drawn from the professional designations of scientist or engineer. These are not, however, a homogeneous class of human inputs, but this set is split into two distinct subclasses by functional designation of "defense" or "nondefense". The peculiar nature of the subgroups is the correspondence between them; scientists and engineers move freely from the commercial subset into the defense subset, but the flow is irreversible, defense research people do not and cannot flow back. This one-way street phenomenon exists even in companies having both commercial and defense divisions. Several cases have been observed where a given firm's commercial division would be hiring research personnel while

[1]A comprehensive study of these problems is given in (24).

at the same time the defense division was laying them off. The reason often cited for the lack of a flow of talent and information from defense to civilian was the excessive sophistication of the former's technology. It was considered that a temporal lag of several years is attached to a transfer of information and its utilization. In addition, defense research people are often precluded from shifting into commercial work, because it is felt that they would be dissatisifed with the somewhat mundane nature of the work and soon leave their employment for other defense work. Consequently, idled defense research workers by choice or default are unemployed in the interim period between defense contracts. The tenure of unemployment may be long or short depending on defense activity and the mobility of this class of labor.

It is estimated that some 30,500 scientists and engineers were engaged in work on strategic weapon systems at the beginning of 1963.[1] This figure includes only those specialists working in private U.S. industries that are supported by defense funds. This estimated number of scientists and engineers directly supported by defense funds exceeds the total number employed in the following major industry groupings: petroleum; lumber and wood products; primary metals; fabricated metal products; food and kindred products; and stone, clay, and glass products (36, p. 9).

Another measure of the disproportionately heavy concentration of scientists and engineers in defense industries is given by the ratio of expenditures on research and development to total sales by industry. The

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[1]The employment estimates were derived from support percentages given in (35, p. 104).

Table 6. Importance of R&D in the sales dollar, 1960[a]

Industry	Amount (in cents)
Aircraft and missiles	22.5
Communication equipment and electrical	12.9
Scientific and mechanical measuring	11.8
Other electrical	9.4
Optical, surgical, photographic, and other instruments	6.5
Industrial chemicals	5.3
Drugs and medicines	4.4
Machinery	4.3
All manufacturing average	4.3
Motor vehicles and other transportation equipment	3.1
Nonindustrial chemicals	2.2
Rubber products	2.1
Fabricated metal products	1.5
Other manufacturing industries	1.4
Primary metals	.8
Paper and allied products	.7
Textiles and apparel	.6
Lumber, wood products, and furniture	.6
Food and kindred products	.3

[a]Source: (34, p. 82).

figures for 1960 are exhibited in Table 6. It is interesting to note that a one-to-one correspondence exists between the top three industries in Table 6 and the top defense producers.

The functional difference that separates and stands as a barrier between research and development activities in defense and commercial lines is of a subtle psychological nature. The scientist working on a defense task usually feels himself at the frontier of knowledge. He is engaged in pure research as opposed to applied research.

The pure-applied adjectives are rather vague, but the meaning implied can be easily translated into an elementary distinction. The scientist working on defense product is searching for a "better" system and need not be mindful of costs. A 10 percent increase in quality at a 20 percent increase in cost may be highly acceptable to his employer. The researcher in a commercial product line would be tightly constrained by cost. To his employer, a 10 percent reduction in quality to gain a 20 percent reduction in cost may be highly acceptable. The commercial researcher is looking for a "cheaper" system.

In summary then, defense producers are characterized as being dependent upon their single customer, the Department of Defense. A high percentage of their work force is devoted to research and development; and transfer of personnel and facilities to producing for commercial markets is not practiced. In other words, the resources devoted to defense production are almost completely "locked in".

Returning to the matter of unstable disaggregated defense demand, it can be seen that the dependent quality of the defense supplier makes him highly vulnerable to shifts in this demand. This seems to explain the somewhat popular reference to the "feast-or-famine" phenomenon which surrounds defense firms. A more important consequence of the relationship between defense suppliers and their customer, however, is that defense spending may have an undesirable effect on economic growth in a region. The variations in defense spending coupled with the "locked in" nature of defense suppliers, and both in turn connected to the concentration in defense expenditures may well imply that the economic growth impact is weak, much weaker than what would be expected from an expenditure the size that defense spending represents in many regions. The reason this type spending contributes insignificantly to the growth of a region is that it induces a work force in excess of what can be utilized at all times. This impedes economic growth, especially when measured by the growth in per capita personal income.

The pattern of events that develop in a region where defense spending is concentrated would be, in light of the unique characteristics of this market, as follows. The capital items devoted to current defense production are such that they are unable to produce for a civilian market; or, the managers of these resources are unwilling to convert their production facilities to civilian outputs. The latter hypothesis seems reasonable when we consider that the expiration or termination of one defense contract is not, in the view of the defense supplier, necessarily cause for alarm, since another is likely to follow shortly. Thus, it would be unwise to waste resources and effort in converting production to civilian uses when the need for this may be vitiated by another defense contract.

From the human resource side, the problem is more complex. The geographical concentration of modern defense industries coupled with the lucrative wage incentives have caused a good deal of worker migration into these areas. The problem, however, is not one of labor mobility which overreacts to these incentives such that a labor force is accumulated in excess of what can be employed, but rather, that inherent in the nature of defense procurement, a good deal of temporary or frictional unemployment is caused to exist when viewed on an annual basis. That is, at some peak period within a year, or for that matter, a somewhat longer period, the labor requirements may be such that a sufficient number of workers are attracted to fill all vacant positions. Around this peak, contracts may expire or be cancelled with the effect that a portion of one area's defense work force is unemployed. On the likelihood that another contract will be awarded their old employer or to another requiring similar skills in a short period of time, the workers do not emigrate from the region but remain in a temporarily unemployed situation.

In a limited view, such a set of circumstances would seem rather insignificant. However, as defense procurement becomes more concentrated the problem begins to sum quickly to significant proportions. The result of having a labor force which is not entirely employed over a prolonged period is that while a region's level of personal income may be raised as a total measure, when expressed on a per capita basis, the increase is considerably less impressive.

A further characteristic of the human resources engaged in work for defense-related firms is that a large proportion of this labor force consists of persons with highly specialized technical and scientific skills that have either a limited or no application elsewhere, at least within a reasonably long period of time. This unique feature introduces an additional difficulty in that highly talented individuals may be unemployed and perhaps temporarily unemployable even should there be an excess demand for labor services in the same geographic region. Again, the expected period of unemployment may be so short that there is no incentive to move from the area and seek employment elsewhere.

The hypothesis that emerges from the preceding arguments is that in fulfilling its procurement requirements the Department of Defense's spending flows are characterized by a high degree of variability when disaggregated to industries; this variability in conjunction with the dependent relationship of defense suppliers causes temporary or frictional unemployment to occur. In turn, the geographical concentration of defense spending and the frictional unemployment this spending creates causes the regional economic growth impact of defense spending to be weakened. The increase in income that defense spending represents to a region is largely offset by increases in population. Of this increment in population, the working or employable portion is not at all times employed so that the annual per capita income figure is not as large as it could have been were these workers engaged for the entire year.

It is important also to bear in mind that direct defense spending, as represented by prime contract awards, gives rise to two kinds of secondary or indirect effects. Most prime contracts are divided into portions that are let as subcontracts. The subcontractors, therefore, are likewise vulnerable to changes in defense demand, and possibly more vulnerable because they are usually smaller than prime recipients in the sense that they produce for only one contract at a time. The second indirect effect is the purely local firms that are induced by increased economic activity. In the language of regional economics, these are the nonbasic or residential industries that are brought into existence by a given level of basic or primary activity.

The hypothesis as expressed contends that defense spending's contribution to regional economic growth is weakened by offsetting increases in population, the working component of which is not continuously employed. If we accept the variations in the level of employment in industries not involved in defense production as a standard or norm, then we can compare the variation in defense industries to this. Such a comparison would allow a direct empirical test of the hypothesis that employment in defense industries is more variable than in nondefense industries. An affirmative conclusion to such a test would provide empirical support for the argument that the positive economic effect of defense spending is diminished due to a significant level of unemployment.

It is realized that only primary employment effects are being observed by avoiding reference to unemployment figures; however, the unreliability of the existing data leaves little hope for improving on this shortcoming. Ideally, of course, we should like to know the magnitude of variations in indirect employment induced by defense spending. This cannot be known, nor can it be approximated in any reasonable manner, and as a consequence any conclusions about the impact of defense spending on indirect employment must be obtained by implication. That is, if defense spending to a region is variable, then the consequences of this variation extend to the nonbasic or residential industries.

The major point of the above discussion is that defense spending contributes weakly to economic growth. The matter of contribution is a relative notion and is only meaningful when compared and contrasted to some standard or norm. The comparison suggested above was to examine variations in employment between defense-related and nondefense-related industries. Phrased in a broader context, erratic changes in the level of employment can be used as an index of macroeconomic activity in general. Using observations on employment figures as a kind of proxy for a set of macro variables, say, income or output, the connection between the hypothesis advanced here and the Keynesian type model referred to earlier is formed. While not perhaps a perfect relationship, changes in employment will be closely related to changes in output and income. Thus, to avoid the problems of measurement and identification that would be inherent in an attempt to use income or output data, the present study will focus on employment changes only.

The subsequent chapter will develop a functional criterion of dependency and a statistical technique suitable for testing the employment variability hypothesis. The nature of this test is to identify defense-dependent and nondefense-dependent industries and to examine differences between the two groups. The employment data to be used are sufficiently disaggregated temporally that employment cycles can be identified. Measurement will then be made on a set of variables that are characteristics of a cycle.

IV. METHOD OF ANALYSIS

The latter portion of Chapter III developed the hypothesis this study is designated to test. The proposition was established only as it emerged from the exposition and remains to be stated rigorously. The purpose of the first portion of this present chapter is to accomplish this. Before doing so, however, definitions of what, for the purpose of this study, are to be considered defense-related and nondefense-related industries will be given.

The second section of the present chapter identifies the data employed and the techniques used to reduce these data to a form suitable for analysis. Section three develops the statistical technique to be utilized. In addition, the set of variables upon which observations will be made and which, in turn, form the basis for testing will be specified in the last section.

A. Hypothesis

The latter pages of Chapter III (see pages 51 and 52) established as a foundation for this study the variability in employment in defense industries *vis-a-vis* nondefense industries. Previously, a distinction was made between these two classes of industries (see pages 32-42) but no criterion for determining class membership was provided.

The data to be utilized are the number of employees in manufacturing industries and are collected and classified by four-digit Standard Industrial Classification (SIC) codes. A selected number of these industries will be separated into two groups. Let the first group, designated Group I, be characterized by having a significant proportion of its output devoted to defense procurement. Group II, on the other hand, has the bulk of its output consumed in the nondefense or civilian section of the economy. Functionally, the presence of the criterion characteristic peculiar to Group I can be determined by examining the Census of Manufactures, Special Report: Shipments of Defense-Oriented Industries (27).

Table 4 of this publication records the value of shipments and receipts, by product class and agency. These data are reported for four-digit SIC industries, and correspond suitably with the employment data to be used in the analysis. Of the three major defense agencies covered in this table, Department of Defense, National Aeronautics and Space Administration, and Atomic Energy Commission, this study is concerned only with the Department of Defense. The simple ratio of receipts to this agency to the total value of shipments by an industry measures the proportion of output consumed by the Department of Defense.

Note, however, that this measure only informs us of the degree to which an industry is involved in producing for defense. The determination of what constitutes a "significant proportion" remains arbitrary. Initially, any industry having 50 percent or more of its output going to defense procurement will arbitrarily be considered a member of Group I. Rigid maintenance of this rule need not be adhered to, however, since information is available for industries less heavily involved and the threshold value can be lowered to include these. That is, the analysis can be repeated for different definitions of Group I.

In selecting the set of industries to comprise Group II, the information contained in the special census report cited above was used as a guide (27, Introduction). The four-digit SIC industries covered in that report, of which there are thirty, were chosen on the basis that the bulk of them ship finished goods or components produced to military specifications. This is true for all except the machinery industries. The output of any industry not on this list that might go to defense is simply a standard production item with no special defense-customer dictated features. Thus, an industry not on the list can be considered free from the "locked in" feature discussed in Chapter III.

Membership in Group II therefore requires that a manufacturing industry be free of defense procurement influences in this restricted sense. It is true that certain industries in Group II may ship to the defense purchaser, but only in terms of common, off-the-shelf items. In the actual analysis, not all industries qualifying for inclusion in Group II are considered. A subset of these will be chosen to reflect certain characteristics of the civilian economy.

Having avoided the inclusion in Group II of any industry contained in the 30 industries designated defense-oriented by the Census survey, we have ensured that the degree of economic independence between the two groups is maximized. The sense in which independence is used here means that the economic cause-effect interrelatedness is made as small as possible. It is true, of course, that independence is not perfect, but documentary evidence exists to support the contention that defense requirements are met without regard for economic stability.[1]

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[1]An example of such evidence is the following exerpt from a report (28, p. 5667) by a subcommittee of the House Armed Services Committee. "To extend the authorization ... requested by the Secretary of Defense, is putting too much power in the hands of one man whose area of responsibility is the running of the Military Establishment rather than controlling inflationary pressures in the United States."

Since it seems reasonable to consider that defense procurement policies are conducted without regard for economic stability, the variations in the level of economic activity in the defense-related industries are primarily a consequence of variations in implementing these policies. As mentioned previously, the set of commodities purchased by defense is not rigid over long periods of time but is characterized by a degree of volatility. The point to be made is that this volatilness is a consequence of meeting national-security requirements and is not related to or derived from changes in the level of aggregate demand in the economy. If we accept changes in the level of employment in an industry as being a reasonable measure of the capriciousness of defense demand, then observations on this variate will provide a representation of variations in this type of demand. Moreover, a finely spaced time series of these observations will allow us to construct a smooth curve that traces the oscillatory movements inherent in defense procurement activities.

Making similar observations for nondefense-related industries, a smooth curve representing the oscillations in the level of employment in these industries can be constructed. Variable movements in this latter series, however, would represent changes in the form and level of economic activity in general and would be almost completely free of the influence of changes in defense spending. The nondefense series would be sensitive to shifts in the level of demand, both aggregate and specific, autonomously following from taste changes, say, or induced by monetary and fiscal actions. In addition, such phenomena as strikes and material shortages may introduce irregularity in these loci.

The essence of the above arguments is that the level of employment in the industries contained in the two groups can be plotted over time to obtain a smooth curve for each industry. These curves will have irregular oscillatory properties that derive from the economic situation in which they are imbedded.[1] Industries in the defense-related group, however, are subjected to a different set of demand conditions than are the industries producing for the civilian sector of the economy. As was argued in Chapter III, the very special nature of the defense-related industries and the needs of the monopsonist they supply leaves them in a precarious position. The instability present in these industries is not an absolute condition in the sense of a difference in kind but rather a difference in degree, and consequently must be judged relative to the degree of oscillatory movement in the nondefense industries.

It is the interest of this study to contrast these two groups of industries on the basis of their employment behavior over time. In the preceding chapter, it was hypothesized that excessive variability exists in the level of employment in defense-related industries, and that consequently the positive economic benefits from defense procurement expenditures are diminished. The hypothesis can be restated in terms of the loci described above. Couched in these terms, the oscillatory movements of the industries comprising Group I are more pronounced and severe than are the movements of Group II. That is, the fluctuations in the level of employment of the

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[1]In reference to the rising and falling properties of these loci, use of the term "cycle" has been avoided. We have chosen to call these irregular components oscillations for two reasons: a cycle is a special case of an oscillation and is appropriate only when the peaks and troughs occur at equal intervals; and use of the term cycle in an economic treatise admits connotations of business or trade cycles that are not relevant to this discussion.

industries in Group I are more severe in magnitude and occur more frequently than are those in Group II.

This is, of course, a hypothesis and may well not stand in the face of empirical evidence. The possibility must be recognized that the fluctuations in Group I may be indistinguishable from Group II's; or that Group II's oscillatory movement may be greater than I's.

B. Data Utilized

The data to be utilized in testing the proposed hypothesis are the monthly series of employment for a selected array of manufacturing industries. National totals of employment by industry, by month, are reported by the Bureau of Labor Statistics in the series <u>Employment and Earnings in the United States</u> (33). These figures are collected and recorded, at least for the cases that are of interest here, at the 4-digit SIC level of disaggregation. A further distinction is possible, since these data permit production employment to be separated from total employment. This refinement allows us to ignore the somewhat invariant nature of non-production employee totals under conditions of change that are not extreme in magnitude.

The time period for which continuous information on the industries of interest exists is the one hundred eight consecutive months beginning in January 1958 and concluding with December 1966. This series is sufficiently long to cover the period during which the very specialized properties of defense industries have become widespread. While a longer series may be desirable from a statistical viewpoint, the applicability of such a series is doubtful, since the special purpose nature of defense industries did not evolve until after the Korean Conflict.

As a series of observations on a phenomenon that is moving through time, the employment figures used in this analysis can be considered to reflect certain consequences that exist in the time-span examined. Quite clearly the time-points at which observations are made are fixed and beyond control so that we cannot correctly represent this employment series as being continuous even though the variable (employment) is continuous. However, we can to a degree of accuracy consider that each observation was created from a stochastic process which is dependent on time. Temporal dependence here means that as the phenomenon in question moves through time an ordered set of observations is generated.

This ordered set of observations, or more commonly, a time-series, typically can be considered as being composed of four parts:

(1) a trend, or long-term movement;

(2) a seasonal effect;

(3) oscillations about the trend;

(4) a random component.

As a mathematical description, we can always represent a series as a subset of these terms. Not all elements need be present in every series, and caution must be taken that no presumption of independence necessarily follows from such a separation.

Having broken the series up into the four components above, we can see that not all of these are applicable to this study. The formulation of the hypothesis specified that attention was to be focused on irregular changes in employment levels which may be quite short-lived in a temporal sense. Moreover, our interest is in the economically disturbing aspects of these changes such that regular or recurring changes are not really applicable to the analysis. A seasonal variation that recurs with predictable regularity will not cause any unexpected effect, since such a swing will have been anticipated well in advance. For industries such as construction and automobile, where seasonal changes are pronounced, it is reasonable to consider that the hourly wage rate reflects this regular variation. The workers in an industry with pronounced seasonal variation are well able to realize that their earning period is some fraction of a year and adjust their consumption pattern accordingly.

The trend or long term movement in an economic series reflects the growth or decline, absolute or relative, in that series caused by economic consequences other than those which are seasonal or irregular. In the present analysis, the existence of a trend, like the seasonal component, confounds the particular properties of oscillations in employment that are of interest. One commonly used measure applied to a locus characterized by an oscillatory pattern is to examine the amplitude at the peaks. If this measure is made from a base line that is invariant with respect to time, then the amplitudes of subsequent oscillations may appear to increase or decrease when in fact they may not be changing at all. The measure would be measuring more than was intended. Consequently, the trend component, like the seasonal, should be removed before an attempt is made to measure the properties of the irregular variations in the employment series. Unfortunately, there is no unequivocally preferred technique for removing the undesired components from a time-series of observations.

The complications encountered in arriving at a straightforward smoothing technique are many faceted, and an initial difficulty stems from an inability to specify the structural form of any series. As was stated previously, a time-series can be considered as a sequence of observations over time, where each item is made up of four constituents. However, no specification was made as to the form of relationship between these elements. Consequently, before we are in a position to suggest a technique suitable for removing the trend component and then for the seasonal component, we must arbitrarily specify the form of relationship. As always, arbitariness must be tempered by the properties peculiar to a particular application. For this study then, since there appears to be no strong evidence against it, we shall specify an additive relationship.[1] That is, each observation is the sum of four constituents.

In view of the method we shall propose for smoothing the seasonal variations, it is important that correction for the trend component be made first. The reason for this will be elaborated when discussing the mechanism for seasonal adjustment.

An essential part of the concept of trend is that the movement over fairly long periods of time is smooth. What exactly constitutes a period of reasonable length depends, of course, on the subject under discussion, and even with specific knowledge, it is doubtful that an accurate determination can be made. The problem is that what may appear, from the plot of the data observed, to be a smooth drift in the series is in fact a portion of a much longer oscillation that has not been considered.[2]

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[1]This procedure has a precedence in economic studies. Such a relationship was assumed to exist for time-series of prices by Tintner (25, p. 24) in a rather comprehensive study of trade cycles.

[2]This is especially relevant to economic series, and some of the common pitfalls have been uncovered through (footnote continued on next page)

In spite of having recognized that such a complication may exist, there is little that can be done about it here. The series available for observation is simply too short in its entirety to search for long term oscillations; and gaining insight into the existence of any long term movement from a related economic series would not tell us how to account for this in the employment series being used. Thus realizing we may be building on a somewhat unstable foundation, the trend component will be removed from the employment series by fitting a polynomial dependent on time to the original series by the least squares technique.[1] The degree of this function will depend on the particular case being considered. In all instances the polynomial will be constructed iteratively by adding successively higher order terms and testing each for significance of contribution.[2]

Having fit a polynomial of suitable degree to the employment series for each industry, we can determine deviations from this trend line by subtraction. Depending on the accurateness of our assumption of an additive connection between the constituents of the series and the quality of fit of each polynomial, the resulting differences will yield a series free of trend. Next we want to remove the seasonal influence.

(footnote continued from previous page) studies of business cycles. See, for example, Davis (6).

[1]Given the series U_t, where t is an index of time in months, we want to fit by least squares $U_t = \alpha_0 + \alpha_1 t + \alpha_2 t^2 + \ldots + \alpha_r t^r$.

[2]Ideally, the use of orthogonal polynomials would simplify this procedure. Unfortunately, computer routines with the necessary values are not available. See Anderson and Bancroft (1, pp. 207-216). For the appropriate statistical test, see Johnston (14, pp. 123-127).

In adjusting for seasonal fluctuations, we have the advantage of knowing that the period of seasonal recurrence is one year. This does simplify the matter of removing seasonal movements, but appreciable difficulty yet remains. Seasonal movements are often sufficiently marked in an unadjusted series to require no demonstration. In some instances, however, we are not certain whether the movements are seasonal or if they are irregular fluctuations imposed on a secular trend. What is more likely is that each observation contains a mixture of seasonal and secular variation. In this circumstance, we must be careful that the method employed for seasonal smoothing is not adversely affected by trend. In consequence, it seems advisable to separate secular movement as a first step.

In eliminating the seasonal movement we start by assuming that the seasonal component is a cyclical variation, always covering a period of one year. We are, of course, continuing the assumption of additivity between components.

Allowing these two suppositions to hold, we shall remove seasonal variation with the method of a centered moving average. Thirteen monthly values will be used instead of twelve so that the calculated mean falls exactly on the seventh month. To completely center this estimate on an annual basis, we shall weight the first and thirteenth month by one-half.[1]

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[1]The exact formula used is

$$U^*_{i,j} = \frac{U_{i,j-6} + 2 \sum_{n=5}^{5} U_{i,j+k} + U_{i,j+6}}{24}$$

Where i refers to the year, j refers to month (j = 1, ..., 12); $U_{i,j}$ are the observations, adjusted for trend; and $U_{i,j}*$, are the seasonally adjusted numbers.

The mean values obtained from this mechanical smoothing will be free of both seasonal and secular influence, since the trend was already removed, and will contain only the irregular and random elements. Unfortunately, use of this smoothing technique destroys twelve monthly observations, six at the beginning and six at the end of the series. Since our series was not long to begin with, this loss is somewhat deplorable.

With the secular component removed by subtraction and the seasonal movement smoothed by averaging, all that remains of the original observations is the random and oscillatory components. While little can be done to separate these, a careful distinction must be made between them. The oscillatory component of a series may be highly irregular in its behavior between several adjacent time points so that it has the appearance of a random or stochastic shock. In spite of how they may appear, oscillations must be distinguished from haphazard, random movement arising purely by chance in sampling from a homogeneous population of unknown characteristics.

Several methods exist for testing the turning points of a series for randomness. One of these, namely the turning points test, is interesting since it is computationally facile and is distribution free.[1] The mechanics of this test procedure are to compare the expected number of peaks with the observed number. If a statistically significant difference exists, the conclusion that the observed oscillations occurred by chance alone is unwarranted.

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[1]For a description of this test, see Kendall and Stuart (15, pp. 351-355). The non-parametric character of this test is additionally important in view of the distorted errors introduced by the moving average.

Having reduced the original employment series for several industries of interest down to a series containing only oscillatory and random movements, we need an analytical device that will allow attention to be focused on the hypothesis established in Section A of this chapter. The following section develops such a method.

C. Statistical Technique

With respect to the formulation of a technique suitable for testing the hypothesis posed in Section A of this chapter, consider the following question: can we develop a criterion or function that will distinguish statistically significant differences in the employment magnitudes of the two industry groups cited above, under oscillatorily fluctuating conditions? In other words, having separated the industries into defense and nondefense categories on *a priori* grounds, is there then some kind of statistical device that will indicate the appropriateness of our prior categorization by discriminating between the groups? And having such a device, will it lend itself to statistical testing for significant differences?

What is required then is some relationship that will discriminate differences in the sample of industries, and for which a tabulated distribution exists that depends only on the sample statistics. This type problem was originally considered by Fisher (7, 8) and the statistical analysis that was developed from the solution of the problem is called a *discriminant analysis*.

The nature of this problem can be explained in the following manner. Suppose we have two samples from multivariate distributions of dimension k. Geometrically, these can be represented as two sample clusters in Euclidean k-space. We want to project these two sample clusters onto a line so that the variation between the two projected samples is as large as possible, relative to the variation within the two projected samples. The problem now reduces to that of finding the direction of projection that will accomplish this objective. Stated in other words, we want to project the two observed sample clusters of k-dimension back into one dimension so that the two sample clusters after projection are as far apart as possible relative to the within-sample variability.

To derive the set of directional weights that will satisfy the requirements established above, consider the following elements:[1] suppose $(x^{\gamma}_{1\lambda_{\gamma}}, \ldots, x^{\gamma}_{k\lambda_{\gamma}})$, λ_{γ} - 1,2,...,N_{γ}, γ = 1,2 where $N_1 > k$, $N_2 > k$ are samples from two populations, each characterized by k variates; where λ_{γ} refers to observations on the k variates and γ refers to the group from which the observation was taken. The size of the sample from group 1 is N_1 and from group 2 N_2. Observe that in both groups the sample size must exceed the number of variates. Let $(\bar{x}^{\gamma}_1, \ldots, \bar{x}^{\gamma}_k)$, $\gamma = 1,2$ be the vector of means in the two samples and $(\bar{x}_1, \ldots, \bar{x}_k)$ the vector of sample means in the grand sample. Let U be the (k x k) dispersion matrix of the grand sample composed of the two group samples pooled together, and let U^W be the (k x k) within sample dispersion matrix. In order for the analysis to proceed, we must stipulate that U^W is positive definite. The matrix $U^B = U - U^W$ is the between-sample dispersion matrix, also of order (k x k).

[1]The earlier portions of this derivation are similar to one given by Wilks (38, pp. 573-576).

For an arbitrary vector $(c_1, c_2, \ldots, c_k)$, define

$$z^{\gamma}_{\lambda\gamma} = \sum_{i=1}^{k} c_i x^{\gamma}_{\lambda\gamma i}, \lambda_{\gamma} = 1, \ldots, N_{\gamma}, \gamma = 1,2 \tag{4-1}$$

The $(z^1_1, \ldots, z^1_{N_1})$ and $(z^2_1, \ldots, z^2_{N_2})$, except for scaling, are one-dimensional samples obtained by projecting the original k-dimensional samples respectively onto a line.

Let $\bar{z}^1$ and $\bar{z}^2$ be the means of the two samples of z's and $\bar{z}$ the means of the pooled samples. Let

$$S_W = \sum_{\gamma=1}^{2} \sum_{\lambda_{\gamma}=1}^{N_{\gamma}} (z^{\gamma}_{\lambda_{\gamma}} - \bar{z}^{\gamma})^2 \qquad \text{and} \tag{4-2}$$

$$S_B = \sum_{\gamma=1}^{2} N_{\gamma} (\bar{z}^{\gamma} - \bar{z})^2 \tag{4-3}$$

The quantities S_W and S_B are, respectively, the within-sample and between-sample dispersion matrices of the linear function of the original k variates. Similar to the condition in the k-dimensional samples, we have $S = S_W + S_B$, the dispersion of the pooled sample of z values.

In terms of the notation established, the basic problem is to determine a vector of constants, $(c_1, c_2, \ldots, c_k)$, so as to maximize S_B subject to a fixed value of S_W.

Before performing this maximization, observe that

$$S_B = \sum_{\gamma=1}^{2} N_{\gamma} \left[\sum_{i=1}^{k} c_i (\bar{x}^{\gamma}_i - \bar{x}_i)\right]^2 \tag{4-4}$$

$$= \sum_{i=1}^{k} \sum_{j=1}^{k} U^B_{ij} c_i c_j \tag{4-5}$$

But since $\bar{x}_i = \frac{1}{N} \sum_{\gamma=1}^{2} N_\gamma \bar{x}_i^\gamma$, where $N = N_1 + N_2$, Equation 4-4 can be written as

$$S_B = \sum_{\gamma=1}^{2} N_\gamma \left[\sum_{i=1}^{k} c_i (\bar{x}_i^\gamma - \frac{1}{N} \sum_{\gamma=1}^{2} N_\gamma \bar{x}_i^\gamma) \right]^2 \tag{4-4a}$$

$$= \sum_{i=1}^{k} c_i^2 \sum_{\gamma=1}^{2} N_\gamma (\bar{x}_i^\gamma - \frac{1}{N} \sum_{\gamma=1}^{2} N_\gamma \bar{x}_i^\gamma)^2 +$$

$$\sum_i \sum_j c_i c_j \sum_{\gamma=1}^{2} N_\gamma (\bar{x}_i^\gamma - \frac{1}{N} \sum_{\gamma=1}^{2} N_\gamma \bar{x}_i^\gamma) \ (\bar{x}_j^\gamma - \frac{1}{N} \sum_{\gamma=1}^{2} \bar{x}_j^\gamma)$$

Expanding and collecting terms, this becomes

$$= \sum_{i=1}^{k} c_i^2 \left[\frac{N_1 N_2}{N} \left\{ \sum_\gamma (\bar{x}_i)^2 - \sum_{\gamma \neq \theta} \sum (\bar{x}_i^\gamma)(\bar{x}_i^\theta) \right\} \right] + \tag{4-4b}$$

$$\sum_{i \neq j} \sum c_i c_j \left[\sum_\gamma N_\gamma \bar{x}_i^\gamma \bar{x}_j^\gamma - \frac{1}{N} \sum_\gamma N_\gamma \bar{x}_i^\gamma \sum_\gamma N_\gamma \bar{x}_j^\gamma \right]$$

$$= \frac{N_1 N_2}{N} \left[\sum_i c_i^2 (\bar{x}_i^1 - \bar{x}_i^2)^2 + \sum_{i \neq j} \sum c_i c_j (\bar{x}_i^1 - \bar{x}_i^2)(\bar{x}_j^1 - \bar{x}_j^2) \right]$$

$$= \frac{N_1 N_2}{N} \left[\sum_i c_i (\bar{x}_i^1 - \bar{x}_i^2) \right]^2 \tag{4-4c}$$

That is, the between-sample dispersion of the z's can be expressed as a weighted mean difference squared, where the means are those of the original variates and the difference measured is that between groups. As will be seen shortly, expressing the between-sample dispersion as in Equation 4-4c facilitates computation of the weights ($c_1, \ldots, c_k$), in an application of this technique. However, for the immediate purpose we shall use the less cumbersome notation of Equation 4-5.

In a manner similar to Equation 4-4, S_W can be expressed as

$$S_W = \sum_{\gamma=1}^{2} \sum_{\lambda_\gamma=1}^{N_\gamma} \left[\sum_{i=1}^{k} c_i (x_{i\lambda_\gamma}^{\gamma} - \bar{x}_i^{\gamma}) \right]^2 \quad (4\text{-}6)$$

$$= \sum_{i=1}^{k} \sum_{j=1}^{k} U_{ij}^{W} c_i c_j \quad (4\text{-}7)$$

To facilitate the maximization, we can write Equations 4-5 and 4-7 in matrix notation as

$$S_B = c^T U^B c \quad \text{and} \quad (4\text{-}8)$$

$$S_W = c^T U^W c , \quad (4\text{-}9)$$

where c^T is a (1 x k) vector, U^B and U^W are (k x k) matrices, and the symbol T designates the transpose.

Returning to the stated problem, we want to maximize with respect to c the expression

$$L = c^T U^B c + \phi(K - c^T U^W c) , \quad (4\text{-}10)$$

where ϕ is the Lagrangian multiplier and K is a constant scaler.

Differentiating Equation 4-10 with respect to c, we get

$$\left[U^B - \phi U^W \right] c = 0 \quad (4\text{-}11)$$

To have a non-trivial solution, say c' , for Equation 4-11 it is necessary that

$$\left| U^B - \phi U^W \right| = 0 \quad (4\text{-}12)$$ [1]

From the above relationship we see that the Lagrangian multiplier, ϕ, must take the value of the nonzero root of this characteristic equation.[2] It may be observed that, as written, Equation 4-12 is not of the usual form

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[1]The symbol | | refers to the determinant of this matrix.

[2]Since U^W is positive-definite, the characteristic roots of this matrix will be positive.

for the characteristic value problem. But since, U^B is symmetric and U^W is positive-definite and symmetric, there exists a suitable transformation that will reduce Equation 4-12 to the basic type characteristic value problem, $|A - \lambda I| = 0$.[1]

In seeking a solution for Equation 4-12 note that

$$\left|U^B - \phi U^W\right| = \phi^k \left|U^W - \frac{U^B}{\phi}\right| = 0 \qquad (4\text{-}13)$$

which is equivalent to

$$\phi^k \left| U^W \left(I - \frac{U_W U^B}{\phi}\right) \right| = 0 \qquad (4\text{-}14)$$

where $U_W = (U^W)^{-1}$, which is known to exist since U^W is positive-definite.

Moreover, recognizing that the determinant of a product of two matrices can be written as the product of the respective determinants, Equation 4-14 can be written as

$$\phi^k \left| U^W \right| \left| I - \frac{U_W U^B}{\phi} \right| = 0 \qquad (4\text{-}15)$$

$$\phi^k \left| U^W \right| \left| \frac{1}{\phi} \left(\phi - \sum_{ij}^{kk}\sum U_W^{ij}\, U_{ij}^B\right. + \phi^{k-2} \left| U^B U_W \right| \right| = 0$$

But $\left| U^B \right| = 0$, and consequently, Equation 4-15 becomes

$$\phi^{k-1} \left| U^W \right| \left(\phi - \sum_{ij}^{kk}\sum U_W^{ij}\, U_{ij}^B\right) = 0 \qquad \text{or} \qquad (4\text{-}16)$$

$$\phi = \sum_{ij}^{kk}\sum U_W^{ij}\, U_{ij}^B \qquad (4\text{-}16a)$$

Computationally, we can simplify the determination of ϕ by recognizing

[1] A proof of this statement is in Hohn (12, pp. 347-348).

from Equation 4-4c that

$$U^B_{ij} = \frac{N_1 N_2}{N} (\bar{x}^1_i - \bar{x}^2_i)\ (\bar{x}^1_j - \bar{x}^2_j)$$

Thus, in a practical exercise the value of ϕ would be derived as follows

$$\phi = \frac{N_1 N_2}{N} \sum_i^k \sum_j^k U^{ij}_W\ (\bar{x}^1_i - \bar{x}^2_i)\ (\bar{x}^1_j - \bar{x}^2_j) \qquad (4\text{-}17)$$

Having established a value for ϕ, say $\hat{\phi}$, from Equation 4-17, we can insert this in Equation 4-11 and solve this set of homogeneous equations for the vector c. The solution to this system of equations will provide a set of weights, say c', that is optimum in the sense that the linear combination of the k variates will best discriminate between the two groups that were established _a priori_.

The idea of discriminating in a preferred manner refers to the requirement originally imposed on the technique when introduced. That is, we initially sought a method by which samples from two multivariate populations could be collapsed into univariate samples with the additional feature that after being transformed, the resulting samples would be as far apart as possible. This matter of distance requires the limited interpretation that the variation between samples be as great as possible; or what has been shown to be equivalent, that the original sample mean difference squared be a maximum. Following this notion of discriminating best in the sense that the weighted sample mean difference squared is a constrained maximum, the relationship

$$Z = c'_1 d_1 + c'_2 d_2 + \ldots + c'_k d_k\ , \qquad (4\text{-}18)$$

where $d_i = (\bar{x}^1_i - \bar{x}^2_i)$, can be considered the best discriminant function attainable. That this is so follows from the equivalence shown to exist between $\sum_{i=1}^{k} \sum_{j=1}^{k} U_{ij}^{B} c_i c_j$ and $\frac{N_1 N_2}{N} \left[\sum_{i=1}^{k} c_i (\bar{x}_i^1 - \bar{x}_i^2) \right]^2$, recalling that the former of these quantities was the one maximized.

The introduction of this discriminant function affords a technique for deriving a test criterion suitable for multiple variates. The problem, however, has been reduced to the case of a single variate by using a linear compound of the several variables, where the compounding coefficients were chosen to maximize the value of a statistic suitable for a single variate. The matter of testing refers to an inquiry into the possibility that a derived discriminant function, such as shown in Equation 4-18, arose by chance. Such a test, however, requires some clarification.

A test of significance applied to a discriminant function is not so much a test of the ability of the function to discriminate but a test of homogeneity in the parent populations by use of the function. If heterogeneity exists, the function, for that reason, is significant in the sense that it discriminates between real differences. Thus, the discriminant function provides a simple and straightforward method of testing for differences between the populations from which the two group samples were drawn. In addition, it offers some specific information about the individual variates and their relative importance that other techniques do not. This aspect will be elaborated later.

Before examining the sampling properties of the Z statistic displayed in Equation 4-18, let us look at the eigenvalue[1], ϕ, and the maximization performed in Equation 4-10. The constrained expression established there

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[1]Eigenvalue is synonomous with characteristic root.

required a maximization of S_B while holding S_W at a fixed level, K. This is equivalent to minimizing the following ratio with respect to the same variate, again holding S_W at a fixed level:

$$\underset{c}{\text{minimize}}\ R = \frac{S_W}{S_W+S_B} \tag{4-19}$$

Thus, the same solution, c', that maximizes Equation 4-10 will minimize Equation 4-19. But it can be shown that the minimum value of R for $S_W = K$ is $\frac{1}{1+\hat{\phi}}$, where $\hat{\phi}$ is given as a solution to Equation 4-17.

Rewriting R as

$$R = \frac{c^T U^W c}{c^T U^W c + c^T U^B c} \tag{4-20}$$

and observing from Equation 4-11 that for the solution vector, c',

$$c'^T U^B c' = \hat{\phi}\ c'^T U^W c', \quad \text{then } R_{min} \text{ (minimum)} \tag{4-21}$$

is given by

$$R_{min} = \frac{1}{1+\hat{\phi}} \tag{4-22}$$

Clearly, R takes on its lowest value for the largest ϕ. In the case of two groups, as is true here, there is only one nonzero root for the characteristic equation. The value of $\hat{\phi}$, however, is based on sample values and as such may have arisen purely from chance alone. Moreover, as follows from the relationship between the maximum value for L and the minimum value for R, the extent to which two k-dimensional sample clusters are separated in k-space depends on the magnitude of the eigenvalue. In this sense a large eigenvalue corresponds to a sizable separation. Thus a test of statistical significance performed on the eigenvalue is the same as testing for differences in the parent populations, and as a consequence of the earlier remarks, performs the same service as testing the discriminant function.

The performance of such a test requires that we know the distribution of the eigenvalue and that tabulated values of this distribution exist. To fulfill both of these requirements we shall assume that the two samples observed were drawn from identical k-variate normal populations. This is only slightly different than assuming two k-variate normal populations that have a common dispersion matrix and differ only in the means, and then setting up the test under the null hypothesis that the means are identical. The assumption of a common dispersion matrix is unavoidable as long as a linear compound is desired. A nonlinear relationship is manageable, but only with great difficulty, both in computation and interpretation.

To determine the distribution of the eigenvalue, $\hat{\phi}$, observe that

$$Q = \frac{|U^W|}{|U^W + U^B|} = \frac{|U^W|}{|U^W|\,|I + U_W U^B|}$$

$$= \frac{1}{|I + U_W U^B|} \qquad \text{where } (U^W)^{-1} = U_W \tag{4-23}$$

But from Equation 4-15 the quantity in the denominator can be written as

$$(1+\sum_i^k\sum_j^k(U_W^{ij}U_{ij}^B)) = (1 + \frac{N_1+N_2}{N}\sum_i\sum_j U_W^{ij}(\bar{x}_i^1-\bar{x}_i^2)(\bar{x}_j^1-\bar{x}_j^2)) \tag{4-24}$$

and consequently, Q is equivalent to

$$Q = \frac{1}{1+\hat{\phi}} \tag{4-25}$$

and therefore,

$$\hat{\phi} = \frac{1-Q}{Q} \tag{4-26}$$

The ratio for Q given in Equation 4-23 has been shown by Wilks (38, pp. 556-558) to have the Beta distribution with parameters $\frac{1}{2}(N_1+N_2-k-1)$ and $\frac{1}{2}(k)$, respectively. For simplicity, let the quantity $(N_1+N_2-k-1) = m$. Then Q is distributed as a Beta with m/2 and k/2 degrees of freedom.

The relationship between $\hat{\phi}$ and Q suggests that we apply the following transformation to the random variable Q and seek the resulting distribution:

$$\frac{m}{k}\hat{\phi} = \frac{1 - Q}{k/m\ Q} \tag{4-27}$$

If we designate q and θ to represent observations on the random variables Q and $\frac{m}{k}\hat{\phi}$, respectively, then we can write the probability density function of Q as

$$f_Q(q) = \frac{\Gamma\left(\frac{m+k}{2}\right)}{\Gamma\left(\frac{m}{2}\right)\Gamma\left(\frac{k}{2}\right)} q^{\frac{m}{2}-1} (1-q)^{\frac{k}{2}-1} dq \tag{4-28}$$

from Equation 4-27 we have

$$\theta = \frac{1 - q}{k/m\ q} \Rightarrow q = \frac{1}{1 + k/m\ \theta} \text{ and } dq = \frac{-k/m}{(1 + k/m\ \theta)^2} d\theta \tag{4-29}$$

and the absolute value of the Jacobian, $|J|$, equals $-dq$. Thus

$$f_\Theta(\theta) = \frac{\Gamma\left(\frac{m+k}{2}\right)}{\Gamma\left(\frac{m}{2}\right)\Gamma\left(\frac{k}{2}\right)} \left(1 - \frac{1}{\left(1+\frac{k}{m}\theta\right)}\right)^{\frac{k}{2}-1} \frac{1}{\left(1+\frac{k}{m}\theta\right)^{\frac{m}{2}-1}} \frac{k/m}{\left(1+\frac{k}{m}\theta\right)^2} d\theta \tag{4-30}$$

$$= \frac{\Gamma\left(\frac{m+k}{2}\right)}{\Gamma\left(\frac{m}{2}\right)\Gamma\left(\frac{k}{2}\right)} \left(\frac{k}{m}\right)^{\frac{k}{2}} \theta^{\frac{k}{2}-1} \frac{1}{\left(1+\frac{k}{m}\theta\right)^{\frac{m+k}{2}}} d\theta \tag{4-31}$$

Equation 4-31, however, is the probability density function of the Snedecor F with parameters m and k, respectively. Therefore, $\Theta = \frac{m}{k}\hat{\phi}$ is distributed as an F with k and m degrees of freedom. Consequently, a means for testing the significance of the only eigenvalue involved in the two-sample case is readily available, and recall, this is equivalent to testing for homogeneity in the parent populations.

Assuming that we have obtained a significant discriminant function from a practical application of the described technique, several pieces of information are provided from this regarding the a priori classification and the variates observed. Recall that group membership was determined prior to statistical analysis and by a criterion related to the original hypothesis. If we utilize the solution vector, c', in Equation 4-1 to compute the set of z-values, and subsequently $\bar{z}$, then we can compare each z-value with $\bar{z}$ to determine the appropriateness of our forced classification. If the two groups as arranged are perfectly heterogeneous, then all the z-values corresponding to one group should lie above the mean value $\bar{z}$ and those values for the other group should lie below it. There is, however, neither need nor reason to presume that perfect heterogenity exists. It is quite conceivable that the two k-dimensional clusters may overlap in a certain area. In this case we would have individual items which were misclassified in the sense that their behavior is that of Group I when our a priori criterion indicated they belonged to Group II, and vice versa. We should prefer, though, that the number of classification errors be small and that an equal number of errors be made against each group. If this is not so, it is doubtful that we can take our discriminant function seriously.[1]

Another interesting parcel of information is the algebraic sign of the $d_i = (\bar{x}_i^1 - \bar{x}_i^2)$. If the k values of d all agree in sign then one group is

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[1]In an a fortiori manner, the circumstance of many errors or errors biased in one direction would preclude a significant function. This cannot, however, be generalized since extremely distant values in each group could cause a significant result.

consistently larger or smaller than another. In this instance, conclusions are rather straightforward. If, on the contrary, a mixed set of signs occur, then an unqualified conclusion that one set of observations on k-characteristics are of a magnitude different than another set is not permissible. The resolution of this difficulty will require a careful consideration of the specific problem at hand.

One possibility that is suggested, and which is important for reasons other than this, is to inquire if the variable possessing a questionable sign is really important. The possibility exists that not all variables contribute to a discriminant function's ability to detect differences. Thus, for this specific reason, and for a more general analysis, we should like to have a method of testing each term in any derived function with respect to its value in discriminating between two populations. Expressed in terms of the distance concept introduced earlier, we wish to develop a test to judge the significance of the additional distance contributed by the inclusion of some extra characters. It is clear that the addition of characters that do not increase the distance between groups in the population will weaken the test.

As a first approximation to such a test, the absolute magnitude of the respective coefficients in the derived discriminant function would be indicative. These would only suggest the direction of refinement, and such a crude observance is not rigorous enough to determine the significance of each variable's contribution.

To derive a more powerful test technique, let us consider the set of k characteristics as being split into k_1 and k_2 subsets, where $k_1 + k_2 = k$. If we continue the notation established earlier and let R denote the minimum ratio obtained when using observations on all k variates, and R_1 then to denote this minimum when only observations on k_1 of the variates are used, then we want to examine the ratio

$$G = \frac{R_1}{R} = \frac{1 + \hat{\phi}}{1 + \hat{\phi}_1} \tag{4-32}$$

The values $\hat{\phi}$ and $\hat{\phi}_1$ would be determined from Equation 4-17 for the respective cases.

If the value of G is at or near unity, the k_2 variates excluded contribute little or nothing to the distance between the two populations. In fact, since they do not add to the ability to discriminate, they weaken the original test of significance. This is especially so if the sample size is small. The question being put to a test then is: does G differ significantly from unity? A simplification is possible if we define $G^* = G-1$. Then

$$G^* = \frac{\hat{\phi} - \hat{\phi}_1}{1 + \hat{\phi}_1}, \tag{4-33}$$

and the question now is whether G^* is, statistically speaking, significantly different from zero. As usual, such a test requires knowledge of the distribution of G^*.

To learn the form of this distribution, observe that under the present conditions the statistic

$$H = \frac{\left|U^W + U^B\right|k_1}{\left|U^W\right|k_1} \cdot \frac{\left|U^W\right|k_1 + k_2}{\left|U^W + U^B\right|k_1 + k_2} \tag{4-34}$$

has the Beta distribution with parameters $\frac{1}{2}(N_1+N_2-k_1-k_2-1)$ and $\frac{1}{2}(k_2)$.[1]

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[1]For a proof of this result, see Rao (23, p. 73).

The quantities U^W and U^B have the same meaning as previously, and k_1 and k_2 are defined above. The first member of the right-hand side of Equation 4-34 is the ratio of total to within dispersion when k_1 characters are observed, and the second is the inverse of these quantities when all k characters are observed.

Using the results of Equations 4-23 and 4-24, we can observe that $1/H = G$, where G is defined in Equation 4-32. Moreover, we have that

$$G^* = G - 1 = \frac{1}{H} - 1 = \frac{1 - H}{H} , \tag{4-35}$$

and using the same technique as that employed in deriving the distribution of Θ, it is seen that

$$\frac{(N_1+N_2-k_1-k_2-1)}{k_2} \quad G^* = V \tag{4-36}$$

follows the F distribution with k_2 and $(N_1+N_2-k_1-k_2-1)$ degrees of freedom.

Thus, we can apply this test in an iterative fashion to determine the relative contribution of a single character or a set of characters chosen from the original set. As will be seen shortly, the above test will be of considerable value in this study, since certain of the characters under observation appear to be closely related. This seemingly close relationship may be apparent from the nature of the characters observed, but an a priori judgment is not sufficient to rule out their importance as an item of discrimination.

This section has developed a statistical technique that allows us to examine certain characteristics of employment in the two groups established, and to test for differences between them. This device has the desirable feature that several characters can be observed but then collapsed into a single measure. In addition, the technique is flexible enough to allow an inquiry into the relative contribution made by each character. In other words, we can investigate whether a reduced set of the original characters is sufficient to discern differences. It remains only to specify the set of variables that will be used in this study.

D. Variables

The nature of the specific exercise developed in this study is to test whether or not a difference exists between defense and nondefense firms' employment levels. Moreover, the differences that are of interest here are limited to those of economic significance in the sense described in Chapter III. To this end, the present section will establish the set of characters upon which observations are to be made and then subjected to the statistical analysis developed in the previous section. The set of characters to be used are selected on the basis that they relate, as closely as is practicable, to the aspects of employment variation that would be of economic importance.

For the purpose of this study the employment series referred to earlier will be reduced in such a manner as to yield observations on the following oscillatory properties:

X_1 = average length of the oscillation in months, measured from minimum to minimum;

X_2 = average of the ratios of rising months to total months in an oscillation;

X_3 = average amplitude of oscillations, measured as a percentage of the trend;

X_4 = average monthly rate of change in oscillations as a percentage of the trend;

X_5 = sample-standard error of X_4.

Clearly, observations on the above set of characters measure quite different characteristics. The economic implications are likewise greatly varied. Recall that the behavior of the industries comprising the nondefense groups are to be taken as a standard for comparison. Based on this premise, the set of variables presented are designed to examine how the defense industries deviate from this standard.

The first variable, X_1, concentrates on the duration in the irregular movement of the corrected series. In this respect, X_1 is motivated by the consideration given to the purchaser of defense goods. Following the argument of Chapter III, the vulnerableness of defense industries coupled with the variable demand conditions alleged to exist, should cause the length of the oscillatory period for these industries to deviate from the norm.

For similar reasons, the variable X_2 is included to reflect the nonsymmetric properties that may be characteristic of defense industries. Contract cancellations and nonrenewals could conceivably cause the defense industries' curves to drop off sharply, as opposed to a gentle decline. Likewise, unless an anticipatory action has been taken, a contract award might lead to sharp rises in employment for these industries. The nondefense producers' not being confronted by a monopsonist would lead to the expectation of a smoother and more regular change. This measure, unlike the first measure which was sensitive to durational differences, is sensitive to the shape of the curve between extreme points.

The variable X_3 utilizes the same notion of deviations from a normal level of employment. In this case, however, the character we are concentrating on is the severity of an oscillatory movement. Whereas X_1 measures the duration of a swing in the employment series, this variable measures the height or depth of the irregularity and allows a contrast of the two groups based on the magnitude of movements away from the trend.

The variable X_4 is quite similar to X_2 but differs in that it particularly emphasizes rates of change. Where X_2 is concerned with the form or shape of the curve during an oscillation, the present measure concentrates on the rate at which this form is changing. Interest in this measure follows from largely the same reasons as X_2.

The reason for measuring these finite changes as a percentage of the trend is to take account of changes in the base conditions. Clearly, a certain finite change in the level of employment would have a different degree of significance than would the same magnitude of change at a later date, if in the interim the total level of employment had grown. Hence, we want this measure to take account of deviations from a normal level of employment. For lack of a better representation, the trend line will be regarded as the normal level.

The sample-standard error of X_4, namely variable X_5, is included as a safeguard against obscuring large deviations through averaging. Variable X_4 is an arithmetic average of 95 first differences. Within this set could be a number of changes of an outstanding magnitude that could be lost due to averaging. Thus, the standard error of this average is included to measure such occurrences within each industry group and to see if these are different between groups.

The economic importance of the five measures proposed here has been fairly well established by the discussion leading up to the hypothesis. The following chapter, which reports the findings of the statistical analysis proposed, will discuss each of these measures in detail in light of the evidence generated. Consequently, further consideration of these is deferred until then.

V. RESULTS OF THE DISCRIMINANT ANALYSIS APPLIED TO NATIONAL DATA

A. Measurement of the Oscillatory Characters

In the preceding chapter the hypothesis to be tested and the statistical technique to be utilized were specified. In addition, the procedures to be employed in reducing the data to an appropriate form were discussed. The present chapter reports the findings of the analysis. Before discussing these results, however, it is important that a few comments be made regarding the reduction of the data.

The 108 monthly observations on total and production employment for selected 4-digit SIC industries were corrected for both trend and seasonal fluctuations. The trend correction was accomplished by fitting a polynomial to the original observations by the method of least squares. The order of polynomial suitable for this adjustment was, in all cases except one, of first degree. The only exception was SIC 2819, Industrial Inorganic Chemical, wherein the existence of a nonzero slope could not be supported statistically. The fact that linear trends were found sufficient is quite reasonable considering the short period of time under consideration.

After removing the contribution due to trend from the original series by subtraction of the predicted from the actual value, the residuals were input to a centered moving average to correct for seasonal fluctuations. The output of this adjustment was 96 observations that can be considered reasonably free of both seasonal and secular influences. The industry series, so corrected, allow observation of their oscillatory movements that are unaffected by the former influences. It is possible, however, that an extreme or turning point observed in a particular series arose by chance.

It was not possible to test each turning point for random origin, but only the entire series. This test was performed by comparing the observed number of extreme points with the number expected to occur at random in a series of this length.

The expected number of points for a series of 96 observations is 62.6.[1] For all industries under consideration the observed number of points was safely beneath this expected value such that no further test seemed necessary.

After being satisfied that the oscillatory pattern present in the employment series of each industry did not occur by chance, observations were made on the five variables of interest established in Section D of Chapter IV. An index and description of these variables are reproduced in Table 8 for the reader's convenience.

One of the Group I industries, SIC 3731, Shipbuilding and Repairing, did not permit observation on all the variables, since the series did not possess a sufficient number of minima. The configuration of this industry's series, for both total and production employment, showed a gentle decline from the outset of the time period examined until January of 1964, then a gentle rise over the remainder of the period. The reasons explaining this employment pattern seem to be the collective effect of a net stability in defense purchases and competition to this industry from foreign shipbuilders in the nondefense area. The loss of this observation from the defense group is unfortunate, inasmuch as the sample size for Group I is not

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[1]For a series of length N, the expected number of turning points is 2/3 (N-2).

comfortably large.

Similar circumstances prevailed in a limited number of the cases surveyed for the nondefense group. For Group II, however, these are not particularly damaging, since a latitude of choice is possible that allows certain industries to be substituted for others without injuring the representative qualities of the group. In one case, SIC 2911, Petroleum Refining, observation was possible only for production employment. The industry was included in the analysis in this limited sense.

The course of the oscillation, in spite of the previous smoothings, was not always so regular and smooth that it would allow an accurate and unequivocal determination of the first three measures, variables X_1, X_2 and X_3. The difficulty encountered was that in certain cases a maximum or minimum was reached, and then after a short fall or rise, employment moved to a new extreme point. To resolve this dilemma and establish a unique month for each turning point, we chose the month halfway between any two extreme points, and ascribed to this the value of the greater extreme point. This value would be the higher maximum or lower minimum, depending upon the portion of the oscillation in question.

Except for the difficulty just mentioned, no other problems were encountered in making observations on the five characters under consideration. Since we are dealing with a multivariate distribution, an observation on the five individual characters for each industry considered represents a sample of measurements. There are, of course, two sets of data: one applicable to the total employment series, and the other to the production employment only series. These sets of measurements are presented in Table 9 and 10, respectively. To simplify presentation and identification, each

Table 7. Manufacturing industries utilized in the discriminant analysis, and percent of output consumed by the Department of Defense

Index	Number		% to DoD[a]
Group I (Defense-oriented)			
1	1925	Guided Missiles	69.7
2	191,3,5,6,9	Ordnance & Ammunition (n.e.c.)	90.0
3	3722	Aircraft Engines & Parts	71.4
4	1929	Ammunition (exc. small-arms)	97.6
5	3673	Transmitting, Industrial & Special Purpose Tubes	50.0
6	3662	Radio & Television Transmitting and Signalling Devices	80.1
7	3811	Scientific & Research Equip.	67.9
8	1941	Sighting and Fire Control	97.4
9	3721	Aircraft	80.4
10	3541	Machine Tools	5.6
11	3674,9	Elect. Components & Access.	20.7
12	3511	Steam Engines	16.1
Group II (Nondefense-oriented)			
13	3312	Blast Furnaces & Steel Mills	
14	3321	Gray Iron Foundries	
15	3621	Motors & Generators	
16	2821	Plastic Materials	
17	2834	Pharmaceutical Preparations	
18	2819	Industrial Inorganic Chemicals	
19	3441	Fabricated Steel Structures	
20	3613	Switchgear & Switchboards	
21	2818	Industrial Organic Chemicals	
22	3562	Ball and Roller Bearings	
23	3711	Motor Vehicles	
24	2011	Meat Packing	
25	3632	Household Refrigerators	
26	2421	Sawmills and Planing Mills	
27	3352	Aluminum Rolling & Drawing	
28	2653	Corrugated Shipping Containers	
29	2911	Petroleum Refining	

[a]Applicable to Group I only. The determination of these figures is described in Chapter IV, p. 54.

Table 8. Set of variables observed in discriminant analysis

Index	Description
X_1	average length of the oscillation in months, measured from minimum to minimum;
X_2	average of the ratios of rising months to total months in an oscillation;
X_3	average amplitude of oscillations, measured as a percentage of the trend;
X_4	average monthly rate of change in oscillations as a percentage of the trend;
X_5	sample - standard error of X_4.

industry has been assigned a numerical index. This is solely for notational purposes. Table 7 identifies each industry by SIC code number and title, and associates each with its respective index number. In addition, Table 7 distinguishes between the defense and nondefense groups that were established _a priori_, and designates the proportion of shipments, measured in dollar value, going to the Department of Defense.

An examination of Column 4 of Table 7 discloses that three industries with a percentage of output to the Department of Defense below 50% are included in Group I. This is seemingly in violation of our previous definition of Group I membership. This breach was committed merely to allow a more compact identification scheme, and a careful adherence to the original definition of Group I was exercised. The reader may recall that the criterion for membership in this group was arbitrarily set, and we suggested that the analysis may be extended by relaxing this arbitrary threshold. The analysis has been conducted in this manner, and the results

Table 9. Observations on oscillatory characteristics: total employment series

Variable Industry Index	X_1	X_2	X_3	X_4	X_5 [a]
1	93.0	45.1	17.2	.84	88
2	83.0	57.8	9.1	.74	64
3	55.0	52.7	5.9	.44	28
4	50.0	52.0	24.4	2.03	107
5	38.5	41.0	5.3	.63	50
6	83.0	58.3	12.6	.62	34
7	77.0	26.9	6.7	.35	33
8	71.0	43.7	13.4	1.23	136
9	43.0	51.2	9.5	.75	70
10	54.0	25.9	6.7	.54	46
11	69.0	26.1	7.3	.59	41
12	47.0	68.1	4.0	.43	38
13	27.3	56.7	5.6	.97	107
14	34.0	35.2	5.0	.39	35
15	69.0	21.7	5.8	.45	34
16	38.0	55.3	1.9	.21	15
17	63.0	28.6	2.1	.20	17
18	45.0	51.8	1.6	.13	9
19	34.0	17.6	4.5	.40	42
20	65.0	38.5	4.1	.35	25
21	58.0	39.7	1.7	.17	17
22	33.0	45.6	5.4	.54	58
23	51.0	35.3	7.1	.65	65
24	47.0	27.7	1.4	.14	14
25	41.5	26.0	3.8	.54	48
26	36.0	36.1	4.6	.32	32
27	32.0	40.6	2.8	.33	29
28	37.0	40.5	1.6	.14	12

[a] All items in column five have been coded. The actual observations ($X_5 \times 10^{-6}$).

Table 10. Observations on oscillatory characteristics: production employment only series

Variable Industry Index	X_1	X_2	X_3	X_4	X_5[a]
1	83.0	53.6	18.4	.83	83
2	80.0	58.7	13.3	.82	75
3	51.0	52.9	6.2	.55	43
4	50.0	52.0	26.9	2.37	132
5	37.0	39.8	5.8	.77	65
6	81.0	62.2	13.2	.71	44
7	77.0	25.6	7.9	.49	41
8	32.5	38.6	9.3	1.43	202
9	40.0	84.6	11.9	.96	94
10	54.0	25.9	7.5	.63	58
11	37.0	32.4	6.8	.71	46
12	56.0	73.2	5.3	.56	60
13	27.3	57.6	6.6	1.16	128
14	35.0	34.3	5.4	.42	41
15	69.0	21.7	7.4	.59	46
16	34.0	50.3	1.8	.22	14
17	27.0	36.1	1.3	.23	25
18	45.0	46.2	1.3	.12	9
19	34.0	17.6	5.2	.47	56
20	60.0	23.3	5.1	.42	28
21	31.5	44.0	1.4	.17	12
22	47.0	31.9	9.6	.63	69
23	50.0	36.0	9.6	.81	87
24	38.0	26.4	.9	.14	16
25	43.0	39.5	7.8	.66	56
26	35.0	34.3	4.9	.35	33
27	32.0	37.4	3.4	.41	36
28	37.0	37.8	1.8	.16	15
29	43.0	25.6	1.8	.15	10

[a]All items in column five have been coded. The actual observations ($X_5 \times 10^{-6}$).

are presented with a clear distinction made between the differently constructed defense groups.

Another anomoly appears in this table in that industry number 2, Ordnance and Ammunition, n.e.c., is recorded with only a 3-digit SIC specification. This is of no practical consequence, however, since no distinction exists between the 3-digit and 4-digit breakdown for these industries. In effect, SIC 191 and SIC 1911 identify exactly the same set of producers. The fact that they are recorded under their 3-digit designation is simply to maintain conformity with the reporting of these data by the Bureau of Labor Statistics.

The fact that five industries are aggregated into one for purposes of observation is somewhat disappointing, both from the point of view of sample size and the degree of refinement desired in the analysis. No alternative exists, however, since the data are reported only under the composite classification and these industries are too important to the defense group to be ignored. Industry number 11, Electronic Components and Accessories, is a similar composite of two 4-digit industries.

B. Results of the Analysis

The discriminant analysis described in Section III of Chapter 4 was performed on the measurements derived from the two adjusted employment series, total employment and production employment only. The computations were carried out on a Control Data Corporation 3600 series computer.

1. Total employment series

Table 11 presents the results for the total employment series and Table 12 for the production employment only series. The two tables are rather lengthy; however, the information presented is essential to the interpretation of the outcome and the tables have been separated into sections to provide some clarity and ease in comprehsion.

Section A of Table 11 shows the general results for the total employment series. The first column indicates the industries omitted from the analysis. Cross reference with Table 7 will show that the omission of industries 10, 11, and 12 is in keeping with the original definition of Group I, defense-oriented industries. Industry number 29 is omitted here since no observation for this series was possible.

The variable means are identified for each group and the mean difference is given. The algebraic sign of these differences shows that the means of the measurements for Group I are in all cases larger than Group II's. Broken down by characters measured, this indicates that the period required to complete a full oscillation is, on the average, longer for Group I; the proportion of rising months to total months in an oscillation is greater; the average amplitude is of a greater magnitude; and the average monthly rate of change and its standard error are larger for the first group. We shall delay a further consideration of these mean differences until the remaining portions of the table have been considered.

The first portion of Section B of this table presents the derived discriminant function for six different combinations of the variables. The six variants do not, of course, represent all possible combinations that could have been formed. These presented were chosen for the special purpose of allowing us to isolate the contribution made by each variable.

Column 4 and 5 of this section present the eigenvalue for each variant and the associated F-statistic, respectively. The computed F-values for

Table 11. Results of discriminant analysis applied to total employment series using different combinations of variables

A. Industries omitted, variable means by group, and difference in means

Index of industries omitted from full set	Variables	Mean G_I	Mean G_{II}	Difference (d)[a]
10,11,12,29	X_1	65.94444	44.42500	21.51944
	X_2	47.63333	37.30625	10.32708
	X_3	11.56667	3.68750	7.87917
	X_4	0.84778	0.37062	0.47715
	X_5	0.00007	0.00003	0.00003
	Sample size	9	16	

[a]The difference posted may not agree with the difference of the two reported columns due to rounding.

Table 11 (Continued)

B. Variants

1. Discriminant functions and tests of significance

Variant No.	Variables included	Discriminant functions (Z)	Eigenvalue	F-statistic[b]
1	X_1, X_2, X_3, X_4, X_5	$Z_1 = .00375d_1 + .00453d_2 + .02228d_3 - .06409d_4 + 470.32233d_5$	$\phi_1 = 1.6572$	6.2974** (5,19)
2	X_1, X_2, X_3, X_4	$Z_2 = .00387d_1 + .00450d_2 + .02081d_3 - .01518d_4$	$\phi_2 = 1.6502$	8.2510** (4,20)
3	X_1, X_2, X_3	$Z_3 = .00398d_1 + .00448d_2 + .01962d_3$	$\phi_3 = 1.6495$	11.5465** (3,21)
4	X_1, X_3, X_4	$Z_4 = .00333d_1 + .02036d_2 + .00615d_4$	$\phi_4 = 1.3530$	9.4710** (3,21)
5	X_1, X_2	$Z_5 = .00455d_1 + .00521d_2$	$\phi_5 = .8740$	9.6140** (2,22)
6	X_3, X_4	$Z_6 = .03448d_3 - .16233d_4$	$\phi_6 = 1.1183$	12.3013** (2,22)

[b]A double asterisk (**) denotes statistical significance at the .01 level. The numbers in parentheses denote the degrees of freedom of the respective F-test.

Table 11 (Continued)

2. Rank of z-values

Variant and Group Rank	z-value[c] 1 G_I[d]	1 G_{II}[d]	2 G_I[d]	2 G_{II}[d]	3 G_I[d]	3 G_{II}[d]
1	.92326(1)		.90828(1)		.91050(4)	
2	.88644(4)		.90445(4)		.90935(1)	
3	.83177(6)		.83649(6)		.83851(6)	
4	.75796(2)		.75959(2)		.76762(2)	
5	.74743(8)		.73174(8)		.74105(8)	
6	.58932(9)		.58310(9)		.58681(9)	
7	.56099(3)		.56613(3)		.57064(3)	
8	.55257(7)		.55340(7)		.55819(7)	
9		.49844(20)		.50495(20)		.51146(20)
10		.49792(23)		.49419(23)		.50029(23)
11		.47308(15)		.47878(15)		.48542(15)
12		.47182(13)		.46250(13)		.47253(13)
13		.44299(22)		.43356(18)		.44250(18)
14		.43459(18)		.43705(22)		.44193(21)
15		.43196(21)		.43601(21)		.44152(22)
16	.43102(5)		.43423(5)		.44082(5)	
17		.42859(16)		.43220(16)		.43623(16)
18		.40744(17)		.41335(17)		.41991(17)
19		.39528(26)		.39265(26)		.39519(26)
20		.38955(14)		.38812(14)		.39104(14)
21		.35851(27)		.35978(27)		.36414(27)
22		.35425(28)		.35661(28)		.36004(28)
23		.34578(25)		.34857(25)		.35610(25)

[c]The reported z-values are computed from Equation 4-1, Chapter IV.

[d]The number in parentheses is the industry index.

Table 11 (Continued)

2. Rank of z-values

Variant and Group Rank	z-value[c] 1 G_{I}[d]	G_{II}[d]	2 G_{I}[d]	G_{II}[d]	3 G_{I}[d]	G_{II}[d]
24		.33026(24)		.33365(24)		.33852(24)
25		.30140(19)		.29844(19)		.30236(19)
Mean z						
G_{I}	.69786		.69749		.70261	
G_{II}		.41012		.41096		.41620
Overall	.51412		.51411		.51931	

Variant and Group Rank	4 G_{I}[d]	G_{II}[d]	5 G_{I}[d]	G_{II}[d]	6 G_{I}[d]	G_{II}[d]
1	.67553(4)		.68164(6)		.51168(4)	
2	.66475(1)		.67903(2)		.45662(1)	
3	.53648(6)		.65832(1)		.33375(6)	
4	.51658(8)		.55092(8)		.26231(8)	
5	.46597(2)		.52504(3)		.20577(9)	
6	.39476(7)		.49864(4)		.19360(2)	
7		.35043(15)		.49650(20)	.17417(7)	
8	.34107(9)		.49062(7)			.13926(23)
9		.31823(23)		.47484(18)	.13198(3)	
10	.30582(3)			.47091(21)		.12961(15)
11		.30190(20)	.46261(9)			.10907(14)
12		.25361(17)		.46124(16)		.10664(26)

Table 11 (Continued)

2. Rank of z-values

Variant and Group Rank	z-value[c] 4 G_I[d]		5 G_I[d]		6 G_I[d]	
	G_I[d]	G_{II}[d]	G_I[d]	G_{II}[d]	G_I[d]	G_{II}[d]
13	.23987(5)			.43578(17)		.09851(22)
14		.22865(21)		.42711(15)		.09021(19)
15		.22305(22)		.41985(13)		.08453(20)
16		.21876(25)		.41611(23)	.08045(5)	
17		.21731(14)	.38895(5)			.04335(25)
18		.21540(26)		.38791(22)		.04296(27)
19		.21080(13)		.37952(28)		.03993(17)
20		.20720(19)		.35829(24)		.03560(13)
21		.18575(24)		.35729(27)		.03406(18)
22		.18311(18)		.35203(26)		.03243(28)
23		.16641(16)		.33824(14)		.03141(16)
24		.16551(27)		.32440(25)		.03101(21)
25		.15655(28)		.24647(19)		.02554(24)
Mean z						
G_I	.46009		.54842		.26115	
G_{II}		.22517		.39666		.06697
Overall	.30974		.45129		.13687	

Table 11 (Continued)

C. Relative contribution of each variable

Comparison[e]	Variable excluded	G^{*f}	F-statistic
1 vs. 2	X_5	.0026	.0494
2 vs. 3	X_4	.0003	.0060
3 vs. 5	X_3	.4138	8.6898**
2 vs. 4	X_2	.1263	2.5260[g]
4 vs. 6	X_1	.1108	2.3266[g]

[e]A comparison between paired variants from Section B of this table.

[f]The value of G^* is given by the relationship $G^* = \frac{\phi_i - \phi_j}{1 + \phi_j}$ where i and j refer to the different variants being compared and are the corresponding eigenvalues presented in Section B.

[g]This value is just below the tabular value for statistical significance at the .10 level.

all the derived discriminant functions given are highly significant at the 1% level. In fact, variants 2, 3, 4, and 6 remain statistically significant at the .05% level; and the remaining variants retain significance at the .5% level. Thus, using any one of the combinations of variables shown, we can discern a statistically significant difference between the two groups of industries. Recalling the interpretation given a significant discriminant function in Chapter 4, the analysis provides substantial empirical evidence that heterogeneity exists between the parent populations of the two groups.

The form in which the discriminant function is presented in part 1 of Section B is, in its entirety, of little interest. What is valuable, however, is the set of derived coefficients. Equation 4-1 was introduced and described as a means of collapsing an observation in k-dimensions into a point on a line. The form of this mapping was $z^{\gamma}_{\lambda_\gamma} = \sum_{i=1}^{k} c_i x^{\gamma}_{\lambda_\gamma i}$ and the desired vector of constants, $(c_1, \ldots\ldots, c_k)$, developed to be the coefficients of a discriminant function. Therefore, if the variables in each observation in the present sample, which concentrates on multiple characters, is weighted by the appropriate coefficients and summed, then the original sample in multiple-dimensions is reduced to a scatter of points all lying on a line.[1] By the test of significance on the discriminant function, the arrangement of the mapped points on the line has been shown to form two distinct groups, at least with respect to their means. By examining a ranking of the mapped values (z-values) derived from Equation

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[1]The number of original dimensions depends on the variant under consideration.

4-1 in contrast to the general mean of these values, we can examine the appropriateness of the a priori groupings. The criterion for judgment is as follows: if a computed value is larger than the general mean, it should be classified in Group I; if smaller, then Group II.

Part 2 of Section B, Table 11 presents the ranked z-values and the mean z for the six variants examined. For the first three variants, a clean separation exists between the two groups, with only one industry being misclassified. For the last three variants the distinction is still apparent, but the separation is not as nicely formed and more mistakes were made. It is interesting to note that industry number 5, Transmitting, Industrial and Special Purpose Tubes, remains misclassified in all cases. In spite of its involvement in defense production, the oscillatory behavior of this industry's employment is like that of a nondefense industry.

Of the latter three, variant 4 has two industries misclassified in each direction. The misplaced items from the defense group are SIC 3722, Aircraft Engines and Parts, and SIC 3673, Transmitting Industrial and Special Purpose Tubes; and from the nondefense group, SIC 3621, Motors and Generators, and SIC 3711, Motor Vehicles. Variant 5 shows the largest number of misclassifications with four nondefense industries being misplaced and one defense industry. Again the defense industry that is out of its group is SIC 3673. For the nondefense firms, we have a set entirely different from those out of order in variant 4. For this case, industries SIC 2821, Plastic Materials, SIC 2819, Inorganic Chemicals, SIC 3613, Switchgear and Switchboards, and SIC 2818, Organic Chemicals, are out of order. Variant 6 exhibits the same set of misclassifications as variant 4, except SIC 3621 is not out of place.

The reason for the misclassification in these three variants is that in each instance either variable X_1, X_2, or X_3 is missing from the discriminator. These, of course, are not the only ones excluded, but as we shall show in the following paragraphs, these three have the most discriminating power. Moreover, from this subset of the five original variables, it will soon be shown that X_3 is the most important. The omission of this character from variant 5, therefore, explains the large number of mistakes for this case. By taking away the measure that has the best discriminating power, we have seriously weakened the significance of the discriminator and its ability to decipher differences between the groups. Thus, when using this inferior discriminator as a classificatory device, the mapped clusters of points overlap. When the three important variables cited are included, the mapped clusters are distinct, with one exception, as the break between the ranked z-values shows.

The findings reported in Section C of Table 11 make use of the results derived from considering different combinations of the variables in Section B, part 1. An eclectic pairing of the variants of Section B allows us to isolate for consideration the contribution made by each variable to our ability to discriminate between the two groups. Moreover, as shown in Section III, Chapter 4, we can utilize the concept of distance between the transformed sample clusters and test whether the omission of any one character reduces this distance. A measure of the distance associated with each discriminator is given by the respective eigenvalue, although this measure does not have a unit concept associated with it. We can, however, relate the eigenvalues of any pair of variants and test whether a significant difference exists. Equation 4-33 is the computational relationship for this measure, and Equation 4-36 is the associated test statistic.

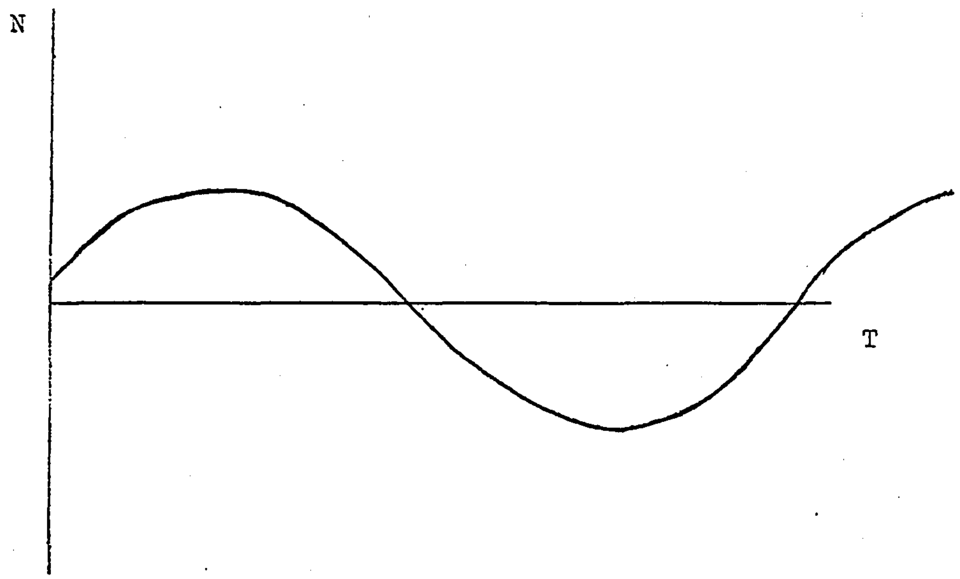
Column 1 of Section C designates the variants being paired, and column 3 contains a measurement of the relative contribution made by the excluded variable, computed from Equation 4-33, while column 4 gives the computed value of the F. Comparison of the computed F-value with the tabular value tests for a contribution significantly different from zero.

The first thing to notice in this section of the table is that variables X_4 and X_5 contribute virtually nothing and could just as well have been left out. Our ability to distinguish heterogeneity between the two parent populations is not enhanced by including these characters, and their inclusion only weakens the significance test applied to the discriminators that included them. The test result for these two characters only confirms what already could have been suspected from an examination of the eigenvalues given in an earlier portion of the table. As the analysis proceeded from variant 1, using all characters, to variant 3, the magnitude of the eigenvalue diminished only slightly. This miniscule diminution indicates that the loss in distance, or the ability to discern differences, may be trivial, and therefore, the variables omitted were superfluous. Such an observation on the behavior of the eigenvalues can be considered only indicative, and the associated F-test is necessary before any conclusion is justified.

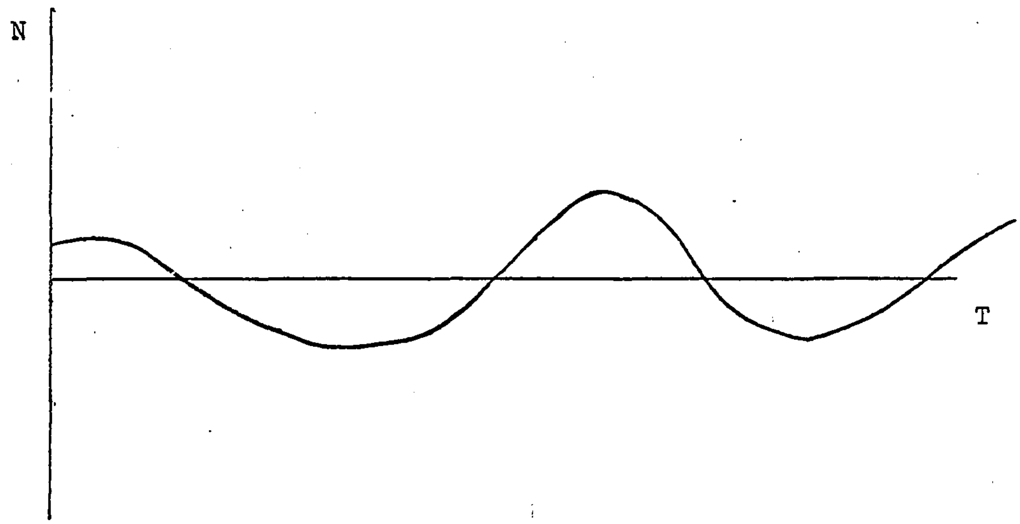
The comparison that examines the contribution made by variable X_3 produces a rather striking result. This is especially true in light of the subsequent comparisons that examine X_1 and X_2's contribution. While X_4 and X_5 contribute almost nothing and X_1 and X_2 contribute a questionable amount, X_3 tests to be highly significant. So much so, in fact, that we can conclude that this character alone is extremely significant in determining heterogeneity. To say that this variable alone is the only significant element allowing discrimination does not seem justified, since X_1 and X_2 do test to be significant at just below the 10% level. Moreover, the best separation between the two groups in the ranked z-values was obtained when variables X_1, X_2, and X_3 were included. The omission of either X_1 or X_2, or both, made the division between the groups less pronounced and admitted several misclassifications not otherwise present. Consequently, the set of variables most important for discriminating between the oscillatory behavior associated with the total employment series appear to be X_1, X_2, and X_3. We recognize, of course, that of these three, X_3 provides the bulk of discriminating power.

Recalling the description of the three variables that best discriminate and the algebraic sign of their mean values, we can draw certain conclusions about the oscillatory behavior of defense industries in contrast to nondefense industries. The former of these are characterized by a temporally longer oscillation, and the increasing portion of this oscillatory movement is more pronounced for these industries. The average amplitude, X_3, and again the most significant character, shows that the magnitude of employment shifts are more severe for the defense groups. Figure 1 shows a stylized representation of a usual curve for each of the two groups. In both instances the configuration exhibits deviations in employment about the trend over time. In summary then, the defense industries take longer to complete an oscillation, the curve is more symmetrical in form, and the average amplitude is considerably greater.

Implicit in the discussion presented in Chapter III was the belief that the on-again, off-again nature of defense procurement might cause one to expect the period of oscillation to be shorter for defense industries.



A. Group I



B. Group II

Figure 1. Illustration of Group I and II oscillations

That this did not come to pass is clearly evident in the present sample. This result, however, does not permit the judgment that defense industries are more stable in an economic sense than nondefense industries. Such a conclusion ignores the outcome for variables X_2 and X_3. For the first of these measures, the defense sector requires a longer period to reach the top of its swing or peak level of employment. For the second, the peak, and similarly the trough, is on the average a far greater deviation from the normal or trend level that characterizes these industrys' movement over time.

If we consider, for example, the average defense industry starting at the minimum point of an oscillation, then it is initially in a worse position of unemployment, vis-a-vis the average nondefense industry, and it takes longer to rise to its best position. A nondefense industry, on the other hand, does not fall to the severe depth of unemployment and when it ascends it does so rapidly, and then not to a point at a great distance above its normal pattern. Over a long period where several such swings occur, the economic consequences may be quite unstable in the sense that national and regional economic growth may be impaired. Moreover, the regional consequences could be expected to be more severe, since defense procurement expenditures have undergone a geographical shift leading to a more local concentration.

A further undesirable consequence follows from the locked-in property of resources devoted to defense production. Earlier it was argued that the resources attracted into defense employment could not or would not move out of this use when not utilized. Consequently, the upper limit of resource requirements is met at a level considerably above normal, and these resources remain idle through deep swings below normal. In addition, the findings show that the period of time required to re-employ these resources is significantly longer relative to the nondefense group.

The variable X_4 and its standard error, X_5, do not come into play in discriminating between the two groups for the total employment series. This indicates that rapid changes in employment are not more prevalent in the defense group than in the nondefense group. The explanation of why this is so seems to follow from the high proportion of research and development personnel found in defense industries. This type of worker tends to act as a buffer against sharp changes, since such a staff is not easily assembled and would be retained for as long as possible before being unemployed. We shall see that a very different outcome for this measure is observed for the production employment series, and the underlying reasons are examined in more detail there.

In summary then, the results of the discriminant analysis applied to the total employment series support the hypothesis established previously. Of the five characters chosen for examination, only three were of value in discriminating heterogeneity in the parent populations of the two groups established *a priori*. Of the three useful measures, moreover, the one concentrating on average amplitude was significantly more important in terms of discriminating power. Using the discriminator as a classificatory instrument, we found that for the preferred case our *a priori* categorization was appropriate with only one exception. By this criterion, the defense group was readily distinguishable from the nondefense group with a sizable gap between the two sets of z-values.

2. Production employment only series

The results of the analysis applied to the adjusted series for production workers only did not produce results markedly different from those presented above. The differences that did occur will be pointed out as the various features of the analysis are presented.

Following the previous format, Table 12 presents the results of this application of the analysis. Section B gives the various discriminant functions and their associated eigenvalues and F-statistics. As before, all the F-values are significant at the 1% level, with several of them remaining significant at higher levels of error probability.

The behavior of the eigenvalues for this series shows a fall in magnitude when moving from variant 2 to variant 3. From such a change we may suspect that, unlike the previous series, the variable X_4 is now important to our discriminating ability. An examination of the relative contribution made by each variable does show this measure to be important. In addition, we see that three variables, X_1, X_3, and X_4, contribute significantly at the 10% level, and variable X_2 is significant at the 5% level. These results depart somewhat from the earlier set in that here we have no one measure with extreme power, but several of almost equal value in discriminating. The one variable that does rise somewhat above the others in discriminating power is X_2. The measure X_3 does not here have the high level of importance it possessed previously, where it alone was sufficient for discrimination.

The measure X_5, as before, is worthless in terms of contribution to discrimination. This is not a surprising result, however, since the numerical values this measure assumes are extremely small _vis-a-vis_ the rest of

Table 12. Results of discriminant analysis applied to production employment only series using different combinations of variables

A. Industries omitted, variable means by group, and difference in means

Index of industries omitted from full set	Variable	Mean G_I	Mean G_{II}	Difference (d)[a]
10,11,12	X_1	59.05556	40.45882	18.59673
	X_2	52.0000	35.29412	16.70588
	X_3	12.54444	4.42941	8.11503
	X_4	0.99222	0.41824	0.57399
	X_5	0.00009	0.00004	0.00005
	Sample size	9	17	

[a]The differences posted may not agree with the difference of the two reported columns due to rounding.

Table 12 (Continued)

B. Variants

1. Discriminant functions and tests of significance

Variant No.	Variables included	Discriminant functions (Z)	Eigenvalue	F-statistic[b]
1	X_1, X_2, X_3, X_4, X_5	$Z = .00727d_1 + .00561d_2 - .01020d_3 + .18883d_4 + 1016.22656d_5$	$\phi_1 = 1.7750$	7.1000^{**} (5,20)
2	X_1, X_2, X_3, X_4	$Z = .00742d_1 + .00562d_2 - .01449d_3 + .30745d_4$	$\phi_2 = 1.7106$	8.9807^{**} (4,21)
3	X_1, X_2, X_3	$Z = .00316d_1 + .00448d_2 + .01146d_3$	$\phi_3 = 1.3343$	9.7848^{**} (3,22)
4	X_1, X_3, X_4	$Z = .00472d_1 - .00261d_2 + .20262d_4$	$\phi_4 = 1.0765$	7.8943^{**} (3,22)
5	X_1, X_2	$Z = .00434d_1 + .00528d_2$	$\phi_5 = .9936$	11.4264^{**} (2,23)
6	X_3, X_4	$Z = .01570d_3 + .00619d_4$	$\phi_6 = .7705$	8.8608^{**} (2,23)

[b]A double asterisk (**) denotes statistical significance at the .01 level. The numbers in parentheses denote the degrees of freedom of the respective F-test.

Table 12 (Continued)

2. Rank of z-values

Variant and Group Rank	z-values[c] 1 G_I[d]	G_{II}[d]	2 G_I[d]	G_{II}[d]	3 G_I[d]	G_{II}[d]
1	1.00582(2)		1.00189(4)		.71379(1)	
2	.98146(6)		.98268(2)		.69964(4)	
3	.96206(4)		.97739(6)		.68637(6)	
4	.95700(1)		.90545(1)		.66867(2)	
5	.92039(9)		.89471(9)		.64209(9)	
6	.83300(8)			.78711(13)	.46951(3)	
7		.80312(13)	.76285(8)		.44896(7)	
8	.75668(7)		.75481(3)			.42960(23)
9	.75151(3)		.75129(7)			.42015(13)
10		.70860(23)		.70801(15)		.40249(25)
11		.70574(15)		.68312(23)		.40174(22)
12	.64430(5)		.65078(5)			.40043(15)
13		.63590(25)		.63129(20)	.38243(8)	
14		.62239(20)		.63081(25)		.36432(18)
15		.61153(22)		.61147(18)	.36192(5)	
16		.60460(18)		.58249(22)		.35362(16)
17		.56651(16)		.57638(16)		.35275(20)
18		.52155(27)		.52430(27)		.32636(14)
19		.51253(14)		.51286(21)		.32063(26)
20		.50791(28)		.50997(28)		.31289(21)
21		.50563(21)		.50324(14)		.30783(27)
22		.49629(26)		.48896(26)		.30710(28)
23		.47614(29)		.48289(29)		.27142(29)

[c]The reported z-values are computed from Equation 4-1, Chapter IV.

[d]The number in parentheses is the industry index.

Table 12 (Continued)

2. Rank of z-values

Variant and Group Rank	z-values[c] 1 G_I[d]	G_{II}[d]	2 G_I[d]	G_{II}[d]	3 G_I[d]	G_{II}[d]
24		.45769(24)		.46025(24)		.26210(17)
25		.43835(19)		.42028(19)		.24608(19)
Mean z						
G_I	.86803		.85354		.56371	
G_{II}		.56639		.56285		.33696
Overall	.67080		.68347		.41545	

	4 G_I[d]	G_{II}[d]	5 G_I[d]	G_{II}[d]	6 G_I[d]	G_{II}[d]
1	.64608(4)		.67967(6)		.43589(4)	
2	.51206(1)		.65686(2)		.29394(1)	
3	.50917(2)		.64295(1)		.21383(2)	
4	.49187(6)		.62009(9)		.21158(6)	
5	.44224(7)		.50046(3)		.19272(9)	
6		.42603(15)	.49137(4)			.15569(23)
7	.41893(8)		.46912(7)		.15483(8)	
8		.37515(23)		.43907(18)		.15458(22)
9		.35509(20)		.42247(13)	.12703(7)	
10	.35232(9)			.41383(15)		.12651(25)
11		.34671(13)		.41300(16)		.11980(15)
12	.33607(3)			.40691(23)		.11070(13)

Table 12 (Continued)

2. Rank of z-values

Variant and Group Rank	z-values[c] 4 G_I[d]	G_{II}[d]	5 G_I[d]	G_{II}[d]	6 G_I[d]	G_{II}[d]
13		.32452(22)		.39502(25)	.10072(3)	
14		.31641(25)		.38324(20)	.09580(5)	
15	.31558(5)			.37225(22)		.08736(14)
16		.24220(19)	.37058(5)			.08453(19)
17		.23627(14)		.36890(21)		.08265(20)
18		.23340(18)		.36002(28)		.07908(26)
19		.22873(29)	.34473(8)			.05590(27)
20		.22530(27)		.33623(27)		.02961(16)
21		.22339(26)		.33287(14)		.02924(28)
22		.20544(24)		.33287(26)		.02918(29)
23		.20243(28)		.32165(29)		.02303(21)
24		.20042(16)		.30768(17)		.02183(17)
25		.17953(21)		.30418(24)		.02115(18)
26		.17070(17)		.24038(19)		.01499(24)
Mean z						
G_I	.44715		.53065		.20304	
G_{II}		.26422		.36180		.07211
Overall	.32754		.42025		.11743	

Table 12 (Continued)

C. Relative contribution of each variable

Comparison[e]	Variable excluded	G^{*f}	F-statistic
1 vs. 2	X_5	.0238	.4760
2 vs. 3	X_4	.1612	3.3852[g]
3 vs. 5	X_3	.1709	3.7598[g]
2 vs. 4	X_2	.3054	6.4134[h]
4 vs. 6	X_1	.1728	3.8016[g]

[e]A comparison between paired variants from Section B of this table.

[f]The value of G^* is given by the relationship $G^* = \frac{\phi_i - \phi_j}{1 + \phi_j}$ where i and j refer to the different variants being compared and are the corresponding eigenvalues presented in Section B.

[g]Statistically significant at the .10 level.

[h]Statistically significant at the .05 level.

the set. A related result is the high magnitude of the coefficient attached to this variable. This is true for both employment series and follows from the formation and inverse of the product matrix used in determining a solution for the vector of coefficients.

The ranked z-values for the present series are presented in part 2 of Section B. The sharp dichotomy between the two groups of industries is not as well formed here as it was for the total employment series. As would be expected, the best result is obtained for variant 2. The number of misclassified industries is three; two nondefense industries are in the defense group and one error in the other direction. As before, the misclassified defense industry is number 5. Since few industries are bunched closely around the general mean z, we can conclude that the prior classification into groups is valid for production employment as well as for total employment.

The interpretation of the general results presented in Section A of Table 12 is largely similar to that of Table 11 except that an additional character was found important in the present case. In terms of oscillatory behavior, the production employment series for the average element in Group I takes longer to complete an oscillation, the form of the movement is more symmetrical, and the amplitude is greater, all in average terms, than for Group II. In addition, and peculiar to the production employment series, the average monthly rate of change is greater for the defense group.

The importance of the first three measures to the hypothesis are the same as before, although the symmetricity aspect is more pronounced. The significance of the fourth character signifies that the defense industries suffer from a more pronounced volatility in terms of employment changes on a month-to-month basis. Since the sign of the difference in means between Group I and Group II is shown to be positive, the evidence supports a belief that a perceptibly more unstable behavior is associated with the monthly changes in the level of production employment in the defense industries. From the viewpoint of the hypothesis, the observed result for this variable associates with the contention that the erratic behavior of the monopsonist is reflected in sudden changes in the level of employment.

The fact that the measure of monthly rate of change is significant for the production employment series and not for total employment does not appear to be inconsistent with actual conditions. It was shown in Chapter III that defense industries have a high proportion of their work force invested in research and development activities. These staffs are difficult to develop and once assembled would be maintained for a limited period even if they present a financial liability. As a result, the entire work force for these industries would not be so susceptible to small changes in demand, and consequently, this measure would be damped or offset somewhat. The result then is that on this point alone, the two groups do not look different when examining total employment. The production workers, on the other hand, do not have the protection afforded the research personnel to the effect that they are susceptible to changes in the level of defense demand.

The very special and in many instances highly complex and hitherto undeveloped form of defense hardware items presents an additional reason why this variable should show significance only in the one case. In this respect a distinction may be drawn between defense and nondefense production. To the nondefense firm, production of a certain class of items continues without serious modification to the items for very long periods of time.

Innovation and drastic revisions are not commonplace. Under these conditions, inventory buildups that signal a slowing down or stopping of the production process can be imposed and then relaxed without great complications *vis-a-vis* the production staff.

The member firms comprising a defense industry do not enjoy the favorable situation of common and continuous production with an inventory to absorb small irregularities. These firms often concentrate on one item or type of output until requirements are fulfilled and then switch to another that is quite different. Preparing for production of a new item requires a great deal of preparation and testing before repetitive production occurs. Such activity does not involve the production staff, and thus, the period of re-employment takes substantially longer.

The same set of consequences could obtain for an industry following from a shift of emphasis in defense expenditures. The effect on an industry of such a decision would be to create unemployment. This may not occur, however, until contracts have reached maturity and all work has been completed. The re-establishment of contracts or obligations for work in this industry would set in motion a great deal of developmental activity, antedating, however, any resumption of a prototypical production scheme.

The essence of this argument is that once pushed to an extreme point of unemployment, the production workers for the defense group experience a much slower recovery process. In contrast to the production employment in nondefense work, the peak attained by these is slightly higher. In the sense that we have attempted to form measures, these circumstances lead to a significant difference in the average monthly rate of change.

A further point to be made from the heavy proportion of research and development personnel in defense industries is the fact that variable X_3 is so powerful in distinguishing between groups in the total employment series, but not in the production series. What appears to be happening with respect to this measure is that the research staff is not immediately affected by changes in the workload, as shown by the insignificance of X_4. When conditions become severe enough, however, this segment of the defense staff is unemployed, and the extreme point is forced to a greater magnitude of deviation than in a nondefense industry.

The total employment in a typical nondefense industry would be made up of production workers, supervisors, and a rather small number of research personnel. The typical defense industry would have the same breakdown, except the research group would be much larger. In the face of small changes, the research personnel in the defense firm, like the supervisory personnel in the nondefense firm, would not be adversely affected. When conditions grew bad enough, however, the defense research staff would not have the protection of the nondefense supervisory staff and the deviation from normal would be more pronounced. Thus, the measure, X_3, shows to be very significant for the total employment series even though X_4 does not.

This same set of consequences is embodied in the typical curves of the two groups for the employment series. If we utilize the mean values presented in Part A of Table 12 as elements of geometric configurations, then we can construct a pair of typical curves for the two groups. Doing so, we observe that the rising portion of the expected curve for the defense group is less accentuated than its counterpart, but that the extreme point is attained at a higher level. The significance of the difference in mean levels for variable X_4 seems to indicate that the curve for the defense group rises gently at first, then climbs quite rapidly. The falling portion of the curve could likewise be rapid. Sufficient information does not exist, however, to uniquely determine the shape of the respective curves.

It is interesting to note that with respect to the total employment series the defense group curve does not have the same degree of symmetry displayed by its counterpart in the smaller series. And at the same time, variable X_4 is of insignificant discriminatory value in the total employment series.

Contrasting the two employment series investigated in this analysis, we see that an ability to distinguish group differences exists in both cases. With respect to adverse economic consequences in the short run, the production employment series appears to be worse than the more inclusive series. This is supported by the significance of variable X_4 in the former but not the latter case. In addition, the consequences surrounding the production employment series seem to be more consonant with the arguments presented in developing the hypothesis.

Before concluding this section one additional point needs to be exposed. Although not examined in detail, there does not appear to be a close correspondence between the time of occurence of the extreme points for the two groups. Even though the nondefense group as chosen is not homogeneous with respect to its business cycle behavior, it did show more uniformity than the defense group in the years investigated. Crude as it is, this observation is in keeping with the independence argument given in Section I of Chapter IV.

3. Some extensions of the analysis

It was suggested earlier that an interesting extension of the analysis would be to augment Group I with industries less involved in defense production. The purpose of doing so would be to inquire if we can still effectively discriminate between the two groups after weakening the distinction between them. Of further interest, of course, is to see where the supplemental industries lie in the ranking of z-values.

Should we still be able to discern a difference between the two groups after introducing the less involved industries, then we will have generated evidence that our previous results were not precariously balanced on the sample used. The existence of a significant discriminator even after weakening the defense set could still be a consequence of the preponderantly powerful influence of heavily defense-oriented industries. These could be so strong an influence that the addition of a few more industries, even though less involved in defense production and presumably less like the other defense industries, does not vitiate the previous discriminating power.

An examination of the relative position of the newly introduced industires will afford insight into the nature of their contribution to discrimination. If these industries lie near or below the general mean z, then we have reason to believe that they are either on the borderline and hardly distinguishable by group behavior or that they behave as nondefense industries. Such a position would, however, support the condition that the main strength of a significant discriminator flows from the more involved industries.

The above line of argument suggests an additional direction for the analysis: namely, if the discriminating ability is not upset by introducing less involved industries, what damage is done by omitting the more heavily involved industries. Severity in this case is not to be construed as the most involved in defense production, but the industries most removed from the nondefense set in terms of mapped sample values. Since the mapping function is an after the fact kind of thing, what we are seeking in terms of the results presented is the industries with the uppermost z-values in the ranking. How many we are able to throw out will be restricted by the size of the sample. In the present case it does not seem practical to omit more than two.

Using Tables 11 and 12 as a guide, and the cases applicable to the best discriminators developed there, the two candidates for exclusion are industries 1 and 4. In both instances these stand a fair bit above the rest, especially for the total employment series.

One further variation of the original analysis may yield additional insight into the nature of the defense group's behavior. The set of industries chosen for the nondefense group were all drawn from manufacturing. However, some of these produce more closely for final demand than others. Recalling that one of the distinguishing features of the defense market was the existence of a monopsonist, it seems reasonable to contrast the defense industries with intermediate nondefense manufacturing. The common element such an alignment would hinge on is the fact that the intermediate producers are confronted by fewer buyers. While clearly not the same situation as the monopsonistic defense customer, these producers in many instances face an oligopsonistic structure. The point of interest, of course, is to see if the defense industries behave differently than do nondefense industries facing a similar demand structure.

Following the suggested extensions outlined above, the appropriate industries were omitted and the analysis conducted without them. In this application only the subset of variables demonstrated to be significant in each case was utilized. For the total employment series this subset consists of variables X_1, X_2 and X_3, and for the production only series, X_1, X_2, X_3, and X_4. Tables 13 and 14 present the main results and Tables A-2 and A-3 in the appendix the ranked z-values.

The outcome designated case 1 in Table 13 represents the extension associated with relaxing the cut off level for inclusion in Group I. As shown in the table heading, Table 13 pertains to the total employment series. It is clear from the highly significant F value that weakening the defense set in no way diminishes the ability to discriminate. Turning to the employment only series in Table 14, the same result holds here as well. The F-value reported is significantly above the tabular F for the 1% level. In fact the computed F in both cases remains significant at much more restrictive error probabilities.

The z-values for this case for the total employment series does not have the sharp break between groups that was observed in the more restricted analysis. The supplemental industries remain bunched closely around the general mean, such that they can't be safely identified with either group.

The situation for the production employment series is that the ranked z-values indicate several misclassifications. Two of the improperly classified defense industries are from the supplemental set, but the remaining element of this set, industry number 12, Steam Engines, ranks well within the defense group. Quite possibly due to its involvement in ship construction, this industry possesses many of the defense group characteristics, at least with respect to production employment behavior.

Table 13. Extensions of the analysis to include different compositions of the industry-groups: total employment series

Case No.	Index of industries excluded	Discriminant function (Z)[a]	F-statistic[b]
1	29	$Z_1 = .00302d_1 + .00264d_2 + .01247d_3$	8.8344**
2	1,4,10-12,29	$Z_2 = .00351d_1 + .00421d_2 + .04085d_3$	10.0652**
3	10-12,17,23-26,29	$Z_3 = .00428d_1 + .00388d_2 + .02100d_3$	7.7450**
4	17,23-26,29	$Z_4 = .00328d_1 + .00207d_2 + .01311d_3$	5.9951**

[a]Only the variant using variables X_1, X_2, and X_3 is given here.

[b]A double asterisk (**) denotes statistical significance at the .01 level.

Table 14. Extensions of the analysis to include different composition of the industry-groups: production employment only series

Case No.	Index of industries excluded	Discriminant function (Z)[a]	F-statistic[b]
1		$Z_1 = .00504d_1 + .00293d_2 - .01085d_3 + .22949d_4$	6.8996^{**}
2	1,4,10-12	$Z_2 = .00732d_1 + .00548d_2 - .01613d_3 + .34904d_4$	6.2713^{**}
3	10-12,17,23-26,29	$Z_3 = .00841d_1 + .00607d_2 - .01484d_3 + .35488d_4$	5.9981^{**}
4	17,23-26,29	$Z_4 = .00534d_1 + .00294d_2 - .00997d_3 + .24410d_4$	4.4105^{*}

[a]Only the variant using variables X_1, X_2, X_3, and X_4 is given here.

[b]A double asterisk (**) designates statistical significance at the .01 level and a single asterisk (*) denotes significance at the .05 level.

As the findings have shown, the discriminators remain highly significant while the added industries are either misclassified or in a difficult to classify region. This indicates that the discriminating power may well follow from the more defense-dependent industries. Case 2 in Tables 13 and 14 is designed to examine this in a crude sense. For this extension we choose industries 1 and 4 as the candidates for removal, since these are at the top of the ranking for both employment series for the variant having the best discriminator.

The outcome in both employment situations is obvious from a glance at the tables. The discriminators are still significant at a high level of confidence. The ranked z-values, however, no longer possess the clean break between the two groups. This suggests that the results must be interpreted cautiously, especially when speaking of the defense group in general.

The last extension introduced deals with contrasting the defense group, for both employment series, to the sampled manufacturing industries excluding those producing for final demand. This extension takes two forms that are designated as cases 3 and 4 in the tables. Case 3 forms the contrast using the first or more restrictive definition of Group I; case 4 uses the larger set of defense industries.

The outcome of the various contasts formed is again obvious from the information reported. The computed F-values all indicate significance, although one, case 4 for the production employment series, does not remain significant beyond the 5% level. It is interesting to note that the computed F's are of a smaller magnitude in all cases considered under this contrast.

In general, we can conclude that the defense industries surveyed behave differently than do the manufacturing industries producing for intermediate demand. The adverse economic consequences implied by the more inclusive analysis are still supported for these subcases. The ranked z-values, at least for case 3, show a reasonably well formed division between the two groups. Consequently, we can be confident that the heterogeneity found to exist by the discriminant function is well delimited.

C. Conclusion

This chapter formed several contrasts between defense-oriented and nondefense-oriented industries. The analysis performed examined certain oscillatory properties of corrected employment series for the two groups of industries, concentrating on total employment and production employment separately. The purpose of the inquiry was to test for heterogeneity between the parent populations of the two industry groups. In general, the analysis supported the contention of heterogeneity. In almost all instances, the test result permitted a high level of confidence to be placed in the outcome. In light of the hypothesis formed earlier, and the economic consequences of finding this empirically valid, we are able to conclude that defense industries assert an undesirable influence on the economy.

The findings of this analysis and the conslusions derived from these are necessarily limited by the shortness of the time-series with which we had to work. Because of the current nature of the defense-oriented industry, a longer series of data would not serve our purpose even if it existed. As conducted and reported, the analysis can be considered as an attempt to offer some information on a hitherto untested situation. Quite clearly, a number of important questions have been left unanswered.

One such question is the relationship between the oscillatory behavior of the defense industry and the Department of Defense's purchasing policies. What is required in this regard is an identification of the relationships between internal decisions and the effect these have on the industries involved. In addition, the time period between such a decision and the effect of this on an industry must be isolated before policy implications can be examined.

VI. REGIONAL INFLUENCES OF DEFENSE SPENDING

A. Preliminary Remarks

At the outset of this study it was hoped that the influences of defense procurement could be studied from both a national and regional dimension. The national data were available, of course, and the results of the analysis at this level of aggregation were shown in Chapter V. Comparable series of data with the extended feature of being disaggregated to the state level are not published and could not be made available.

The desire for data disaggregated to the state level was to examine more deeply the currently developing geographical concentration of defense spending for goods. With state data, regions could have been constructed by the criterion of proportion of total defense outlay made to each state. In other words, the proportion of the national total of defense procurement going to each state could have been computed and then these ranked by order of magnitude into regions.

This is, of course, not the only way geographical regions may be formed. For example, an alternative arrangement that would be interesting in light of the geographical shifting in defense spending would be to contrast the states of Illinois, Indiana, Michigan, and Ohio with California, Oregon, and Washington. Such an arrangement would allow a contrast of the historically industrialized states, where defense production formerly took place through conversion, with the states containing the modern defense producers.

The statistical technique discussed in Chapter IV is amenable, with minor modification, to handling more than two groups. Consequently, an analysis similar to that applied to the national data could have been performed. That this was not possible reduces the breadth of the study considerably. To compensate for this loss, an incomplete set of data was introduced and analyzed. Due to the incompleteness of these, however, the technique utilized does not afford the detail of the earlier method. In addition, the limitation imposed by the brevity of the data requires the results of this analysis be interpreted with caution. At best, the results should be considered indicative rather than conclusive.

B. Analytical Technique

In this section the limited data that are available and the statistical technique used to reduce these will be discussed. The following section will report the findings.

Whereas the national data used earlier is a series of monthly observations on employment by industry published by the Bureau of Labor Statistics, the series to be used here are unpublished figures collected by the Bureau of Employment Security. These cover total employment only and are collected only for the first three months of each year. The disaggregation to industries does conform with the BLS series, with the additional feature of being recorded by state.

The fact that the series are discontinuous in that observations are made only for the first quarter of each year causes numerous difficulties. Principal among these is the amount of information that is unavailable; but further is the matter of secular and seasonal adjustment. With the national data, we were able to fit an appropriate polynomial to the reported observations to correct for changes over time. Also, seasonal variations were removed by the method of moving averages. After correcting for these two influences, measurements were made on five oscillatory characters. The discontinuity in the present series precludes these adjustments and consequently prevents measuring the deviations from the trend or normal level of employment for each industry in each state.

In the earlier form of the analysis, the point of interest was to form two groups of industries, one defense-oriented and the other nondefense-oriented, and contrast the oscillatory behavior of the two groups' employment series. In the present analysis, we want to retain the group structure and supplement this with a regional dimension.[1] The purpose of this added feature is to see if the group distinction is more pronounced in some geographical areas than in others. A hypothesis to the effect that the regional influence should accentuate group differences seems reasonable in light of the concentration in defense spending shown in Chapter III. This contention is supported further by the results from the analysis of the national data. These showed that considerable difference exists between the defense and nondefense groups on the national level.

Two of the measures used on the national data were average amplitude and average monthly rate of change in the oscillations. Both of these were relative measures in the sense that they were corrected for size of industry. This correction was accomplished by expressing each deviation measured as a percentage of the appropriate trend value. For the present series, such relative measures are not possible because of discontinuities. To approximate a measure as similar as possible in relativity, in spite of the

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[1]The several states have been accumulated into specific regions. These will be identified shortly.

incompleteness in the series, we have chosen to concentrate on monthly rates of change. The exact form of the measure is to express the difference in the level of employment between two months as a proportion of the earlier month. This was done for each industry and region examined with a set of 12 observations beginning with January 1961 and ending March 1964. The observations applicable to each year were treated separately with no attempt to connect the different years. This was done to avoid an undue influence from any trend that might be present.

The 48 contiguous states (Alaska and Hawaii were excluded) were not examined separately but were accumulated into 9 regions. These regions are different from those utilized in the tables in Chapter III. The accumulation of states exhibited in the earlier tables follows the nine census regions. For the present purpose, it seemed preferable to deviate from these and construct a set of regions by a different criterion, although the number of regions utilized remains at nine. Table 15 shows the regional construction of the 48 states examined. The criterion employed was that of associating states with similar manufacturing characteristics. This was done through a rather crude assessment of the more significant industries in each state and did not involve a rigorous and thorough analysis in each candidate case. The common property of similar manufacturing characteristics is somewhat of an elastic criterion in the sense that it considers both long-established types of manufacturing as well as more recent trends. For example, region 5, which contains such states as California, Colorado, Utah, and New Mexico, was constructed to capture the modern trend in manufacturing for defense purposes.

As mentioned previously, the group distinction between the several

Table 15. Regional association of the 48 contiguous states and the District of Columbia

Region Number	State
1	Maine New Hampshire Vermont Massachusetts Connecticut Rhode Island
2	New York New Jersey Pennsylvania District of Columbia Delaware Maryland Virginia West Virginia
3	Tennessee Alabama Mississippi North Carolina South Carolina Georgia Florida
4	Montana Idaho Oregon Washington
5	Colorado Utah Nevada Arizona New Mexico California
6	Arkansas Texas Oklahoma Louisiana

Table 15 (Continued)

Region Number	State
7	Missouri Kansas
8	Ohio Indiana Illinois Michigan Wisconsin Minnesota Kentucky
9	Iowa Wyoming North Dakota South Dakota Nebraska

industries examined that was established in Chapter V is maintained here. A slight difference exists between the industries included here and those considered previously. The shipbuilding industry, SIC 3731, which was omitted from the earlier set, is now included in the defense group, and the nondefense group has been reduced in number of elements to 11. Table 16 presents these industries, again distinguishing between the defense and nondefense groups.

Following the above breakdown, each observation on the measure of monthly percentage change in total employment can be identified with an industry, region, and group. In formulating a statistical model for a typical set of observations, we can consider that each percentage change is a consequence of a regional, group, industry, and random influence, plus an influence contributed by the interaction of these elements. Such a con-

Table 16. Industries considered in the regional analysis

Industry index	SIC	Name
Group I (Defense-oriented)		
1	3662	Radio and Television Transmission
2	3673	Transmitting, Industrial and Special Purpose Tubes
3	3721	Aircraft
4	3722	Aircraft Engines and Parts
5	1925	Guided Missiles
6	3731	Shipbuilding and Repairing
7	1929	Ammunition (exc. small-arms)
8	191,3,5,6,9	Ordnance and Ammunition (n.e.c.)
9	1941	Sighting and Fire Control
10	3811	Scientific and Research Equipment
11	3674,9	Electrical Components and Accessories
Group II (Nondefense-oriented)		
12	2653	Corrugated Shipping Containers
13	3312	Blast Furnaces and Steel Mills
14	3711	Motor Vehicles
15	3651	Radio and Television Receiving Sets
16	2421	Sawmills and Planing Mills
17	3531	Construction Machinery
18	2011	Meat Packing
19	2211	Broad Woven Fabrics (Cotton)
20	2818	Industrial Organic Chemicals
21	2821	Plastic Materials
22	3621	Motors and Generators

struction has the appearance of an analysis of variance model of the factorial design type.

This is not quite true. Since the industries in the two groups are not identical, and consequently not all levels of each factor combine with all levels of every other factor, the arrangement at hand does not fulfill all the requirements of a factorial design. What we do have, however, is a "nested" design (10, p. 13). In this scheme, several levels of one factor are nested within one level of another factor and are quite different for other levels of the same primary effect.

The nested factor in the present situation is the set of industries. The member industries of Group I, the defense group, are distinctly different from the Group II set. Thus, the two levels of the group factor do not pair with each level of the industry factor, but the two sets of industries are peculiar to one or the other group, and therefore, are nested within their respective group. The nested property precludes any interaction between groups and industries, since the industries are considered unique to the group. Similarly, the principal effect or influence of each industry must be taken within the context of the group it is imbedded in. This means that the deviation caused by industries must be adjusted around its own group mean and not the mean of the combined influences.

The two other factors, regions and groups, do pair at all levels such that they fulfill the requirements of an ANOV factorial design. Hence, these will introduce main influences and an interaction influence. In addition, the pairing of regions with industries is done at each level of the two factors so that an interaction influence between these is possible.

The above remarks can be summarized into the following type ANOV statistical model. We have a 2 x 9 factorial type design in the region and group influences with 11 industries nested within each group and eight replications in each region-group-industry cell. The eight replicates follow from the two first differences observable in each of the four years considered. The format of the model for this problem is presented in Part A of Table 17. As in Table 16, the industries are numbered 1 through 22 to show that they are distinct between groups.

Table 17. ANOV format for regional analysis

A. Data format

	Group	
	I	II
	Industry	Industry
	1 2 3 11	1 2 3 11
Region 1		
2		
. . . . .		
9		

B. ANOV format

Source of variation	d.f.	EMS
Regions	8	$\sigma_e^2 + 176\ K_R^2$
Groups	1	$\sigma_e^2 + 792\ K_G^2$
Region-Group interaction	8	$\sigma_e^2 + 88\ K_{(RG)}^2$
Among Industries within Groups	20	$\sigma_e^2 + 72\ K_{I(G)}^2$
Region-Industry interaction	160	$\sigma_e^2 + 8\ K_{(RI)}^2$
Error	1386	σ_e^2
Total		

The statistical model associated with this format is as follows:

$$X_{ijkr} = u + R_i + G_j + (RG)_{ij} + I_{k(j)} + (RI)_{ik(j)} + e_{r(ijk)} \qquad (7\text{-}1)$$

Where

R_i is the region effect, $i = 1,2,\ldots,9$;

G_j is the group effect, $j = 1,2$;

$(RG)_{ij}$ is the region-group interaction effect;

$I_{k(j)}$ is the industries-within-group effect, $k = 1,2,\ldots,11$ for all j;

$(RI)_{ik(j)}$ is the region-industry interaction effect; and,

$e_{r(ijk)}$ is the error component.

Since regions, groups, and interactions were not chosen or assigned at random, all effects in this problem, except error, are fixed. Consequently, the significance of each influence and interaction can be tested against the estimated mean square for error as an F-ratio. Part B of Table 17 presents the ANOV format, including the Expected Mean Square (EMS). The EMS values were derived by the technique given in Bennett and Franklin (3, pp. 413-415).

This completes the discussion of the data examined and the model used to reduce these. The following section presents the results obtained.

C. Results of the Regional Analysis

The statistical model described above was applied to the set of measurements on the partial series of regionally disaggregated total employment data. The outcome of this application is summarized in Tables 18 and 19.

As shown in the EMS column of Table 17, the appropriate F-value for each influence is found by forming the ratio of the computed mean square for each influence to the error mean square. Following this procedure for

Table 18. ANOV for regional analysis

Source of deviation	d.f.	S.S.	M.S.
Regions	8	150.11	18.76[a]
Groups	1	2.09	2.09
Region-Group interaction	8	74.56	9.32
Among Industries within Groups	20	917.87	45.89[a]
Region-Industry interaction	160	2253.01	14.08[a]
Error	1386	15230.04	10.98
Total		18627.68	

[a]Significant at the 5% level.

the entries in the M.S. column of Table 18, we see that the hypothesis of a difference between regions may be accepted at the 5% level of error probability. The hypothesis of a difference between groups, however, must be rejected. The F-value for this test is less than one and hense not significant. The same situation prevails for the region-group interaction.

The fact that the F-value for the group effect is considerably less than one may be, at first glance, taken as an indication that this main influence has little or no significance in determining the value of a typical observation. To dismiss the matter this simply, however, may be unwise. The reciprocal of this calculated F-value is seen to be highly significant. Such an outcome raises considerable doubt about the postulated statistical model and its applicability to the data.[1]

[1]The implication of F-ratios that are less than unity are discussed in Ostle (20, pp. 301-302).

Table 19. Mean values of main influences

Source	Mean (%)	Source	Mean (%)
Group I	.19	Industry 1	.08
Group II	.12	2	-.70
		3	.71
Region 1	-.44	4	.14
2	-.16	5	.37
3	.46	6	.36
4	.52	7	-.23
5	.05	8	1.47
6	.46	9	-.70
7	.36	10	-.03
8	.16	11	-.76
9	-.01	12	.06
		13	1.14
		14	-.80
		15	-1.34
		16	.80
		17	1.36
		18	-.69
		19	-.35
		20	.10
		21	.64
		22	.37

In the present problem, it seems appropriate to question the data. The fact that observations only for the first three calendar months of each year were available may introduce a distortion of considerable magnitude. Since the partial nature of each series does not permit a correction for seasonal variations, the changes observed may be heavily influenced by a regular seasonal movement. This could not be expected to be the same for all industries. For some the usual pattern of events would be a decline and for others a rise. The direction of movement would depend strongly on the type of industry. For some the first quarter period would be one of high activity in preparation for the months of warm weather; for others this period follows a peak load preceding the late-year holiday period. The mean values shown in Table 19 point this out. Industry 15, Radio and Television Receiving Sets, shows a strong average decline during the first quarter, while Industries 16 and 17, Sawmills and Planing Mills and Construction Machinery, experienced a sharp increase.

With respect to the defense group, it does not seem that this series should be heavily influenced by seasonal changes. A very different set of conditions may be working, however, that would have the same appearance. The defense producers are closely tied to the requirements of the Department of Defense, with the consequence that production of some items is phasing out while that of others is just approaching full force. The sample of three consecutive monthly observations on such a process would have the same appearance of a seasonal movement. Thus, what may be very real differences between the two groups of industries could be obscured by the presence of ephemeral seasonal influences. In other words, the defense industries may be undergoing a change in employment levels that will not be almost automatically corrected by a short passage of time, while the non-defense firm is experiencing such a change.

In contrasting these two groups then, what appear as homogeneous behavior may in fact be the manifestation of very different influences. A comparison of the mean values for the various main influences shown in Table 19 provides some evidence of this type behavior. The mean values for each industry show that both groups contain cases that are moving strongly in both directions. The mean value for each group, however, reveals that they are quite similar in terms of a combined industry effect.

Further evidence that a good deal of variation exists among industries is apparent from the ANOV. The F-value associated with the among industries within groups influence is seen to be highly significant. Considering the fact that the general conditions of the economy were quite healthy during the period covered, the high magnitude of variation among industries appears to be a bit of a paradox unless what is being observed is a very pronounced seasonal influence. Similarly, the region-industry interaction is significant, although the F-value is not so large as for the main effect. Again, this could be a consequence of seasonal movement, since different industries predominate in different regions, and the strength of industry variations could extend to or coincide with the regional breakdown. Some support for this exists in the mean values for regions. Region 4 shows the largest average increase and Region 1 the largest decline. The former of these is heavily involved in the production of lumber and building materials, while the latter is strong in electrical machinery and equipment.

D. Conclusion

The regional analysis of differences between the two groups of industries leads to distinguishable differences between regions but not between groups. The inability to decipher differences between the groups appears surprising in light of the sharp differences observed at the national level. The validity of this result, however, is questionable when contrasted with the variation found among industries.

The general findings of the ANOV place considerable doubt on the data employed. The peculiar circumstances observed in the data and their association with certain industries raises the suspicion that strong seasonal influences may be in operation. The net effect of these is to obscure the difference between the established groups.

At the outset of this chapter we stated that any result obtained could be taken only as an indication and not conclusive evidence. In light of what has been unearthed, however, it seems warranted to say that a suitably rigorous examination of the regional economic impact of defense procurement has not been accomplished.

VII. SUMMARY

This general summary gives some of the major results of the test of the hypothesis initially introduced in Chapter I and elaborated in Chapter III. Because the bulk of the findings are numerical in nature and voluminous in quantity, no attempt will be made at reiterating them here.

The contention being tested is that a difference exists between the oscillatory behavior of the employment series applicable to two groups of industries, defense and nondefense. The statistical technique used to test this hypothesis at the national level of aggregation is that known as a discriminant analysis. The principal feature of this method is that it allows an examination of several characters common to the two groups, but collapses these multiple characters into one for purposes of testing. In other words, a sample from a multivariate population is separated, on *a priori* grounds, into two groups. The multivariate sample then is collapsed into a univariate sample by means of the coefficients of the discriminant function. The univariate sample then can be subjected to a test for differences between the established groups.

The coefficients of the discriminant function are chosen so that the difference between the sample variance for the two groups is maximized. In terms of the univariate sample, these coefficients maximize the distance between the two clusters of points, one for each group. The test statistic appropriate for assessing significance in this distance is the F-ratio.

The application of this technique to the total and production employment series for selected manufacturing industries yielded significant results for both cases. The level of error probability was safely below the

1% level, often appreciably lower. The stability of these results was examined by various modifications to the structure of the two groups. In the first instance, the degree of involvement in defense production required for inclusion was reduced substantially below the initial threshold level of 50%. The second variant tried was to exclude from the defense group the two industries exhibiting the most severe magnitude of deviation. In neither case was the significance of the discriminant function disturbed.

The outcome of the tests for significance and stability applied to the discriminant functions empirically demonstrates that a difference exists between the two groups. The specific form of this is somewhat different between the total and production employment series. For total employment, the period of oscillation is longer, the proportion of the period in which employment is rising is greater, and the amplitude is of a greater magnitude for the defense group. Of these, the measure of amplitude is by far the most important in deciphering a difference between the groups.

With respect to production employment in the defense group, the three measures cited above were important and a fourth, average monthly rate of change, was found to contribute significantly. In this latter series, the measure of amplitude did not have as great a discriminating power as in the former case. The measure of symmetry, however, was found to be more important here.

The conclusion that may be drawn from this empirical analysis is that industries involved heavily in producing for the Department of Defense experience a variability in employment that is in excess of that experienced by civilian oriented industries. The cause of this unusual and more extreme behavior follows from the monopsonistic role played by the Department of

Defense and its varying set of requirements. This impact is accentuated by the peculiar, locked-in property of the resources devoted to defense production.

An attempt was made at examining the hypothesis from a regionally disaggregated dimension. Due to strong seasonal influences in the data that could not be removed, the results of this effort were inconclusive.

VIII. APPENDIX

Table A-1. Defense and defense-related purchases of goods and services of the Federal Government and relation to GNP, 1945-64[a]

Calendar Year	National defense purchases of goods and services: Amount (bill. of dollars)	Percent of GNP
1945	75.9	35.5
1946	18.8	8.9
1947	11.4	4.9
1948	11.6	4.5
1949	13.6	5.3
1950	14.3	5.0
1951	33.9	10.3
1952	46.4	13.4
1953	49.3	13.5
1954	41.2	11.3
1955	39.1	9.8
1956	40.4	9.6
1957	44.4	10.0
1958	44.8	10.1
1959	46.2	9.6
1960	45.7	9.1
1961	49.0	9.4
1962	53.6	9.6
1963	55.2	9.5
1964	55.4	8.9

[a]Source: Report of the Committee on Economic Impact of Defense and Disarmament.

Table A-2. Rank of z-values for extensions of discriminant analysis: total employment series

Case and Group Rank	z-value[a] 1 G_I[b]	G_{II}[b]	2 G_I[b]	G_{II}[b]	3 G_I[b]	G_{II}[b]
1	.61391(1)		1.05112(6)		.93367(1)	
2	.59223(4)		.98029(8)		.92770(4)	
3	.56117(6)		.90604(2)		.84548(6)	
4	.51619(2)		.75430(9)		.77005(2)	
5	.49647(8)		.65697(7)		.75437(8)	
6	.38670(7)		.65564(3)		.58180(9)	
7	.38315(9)			.61744(23)	.57424(7)	
8	.37838(3)			.57027(15)	.56334(3)	
9	.37115(12)			.56304(13)		.51328(20)
10	.36795(11)			.55745(20)		.50097(15)
11		.34866(20)		.52817(22)		.45408(13)
12		.33764(15)	.52403(5)			.43760(21)
13		.33542(23)		.47159(14)	.43484(5)	
14	.31470(10)			.46605(26)		.43124(22)
15		.30165(13)		.44354(16)		.42680(18)
16		.30077(21)		.44111(18)		.41673(16)
17		.29221(18)		.43990(21)		.38681(14)
18		.29158(17)		.42709(17)		.35299(27)
19	.29030(5)			.41018(25)		.34879(28)
20		.28708(22)		.39742(27)		.30810(19)
21		.28407(16)		.37712(19)		
22		.26111(26)		.36552(28)		
23		.25770(14)		.33858(24)		
24		.24109(25)				
25		.23845(27)				
26		.23830(28)				
27		.23222(24)				
28		.20507(19)				
Mean z						
G_I	.43936		.78977		.70950	
G_{II}		.27832		.46341		.41613
Overall	.34734		.56273		.54815	

[a]The reported z-values are computed from Equation 4-1, Chapter IV.

[b]The number in parentheses is the industry index.

Table A-2 (Continued)

Case and Group Rank	z-value[a] 4 G_I[b]		G_{II}[b]
1	.62433(1)		
2	.59185(4)		
3	.55854(6)		
4	.51161(2)		
5	.49937(8)		
6	.39641(7)		
7	.37635(11)		
8	.37185(9)		
9	.36715(3)		
10	.34789(12)		
11			.34757(15)
12			.34696(20)
13	.31882(10)		
14			.29499(21)
15	.28087(5)		
16			.28056(13)
17			.27608(18)
18			.27365(22)
19			.26428(16)
20			.25014(14)
21			.22639(28)
22			.22592(27)
23			.20711(19)
24			
25			
26			
27			
28			
Mean z			
G_I	.43709		
G_{II}			.27215
Overall		.35821	

Table A-3. Rank of z-values for extensions of discriminant analysis: production employment only series

Case and Group Rank	z-value[a] 1 G_I[b]	G_{II}[b]	2 G_I[b]	G_{II}[b]	3 G_I[b]	G_{II}[b]
1	.65655(4)		.97892(2)		1.17792(4)	
2	.61940(2)		.96865(6)		1.12248(2)	
3	.61054(6)		.89971(9)		1.11458(6)	
4	.56804(12)			.81403(13)	1.04464(1)	
5	.56651(1)		.79858(8)		1.01384(9)	
6	.54094(9)		.75520(3)			.89282(13)
7	.50432(8)		.74738(7)		.87699(8)	
8		.50115(13)		.71043(15)	.85938(7)	
9	.49009(7)			.69113(23)	.85300(3)	
10	.47124(3)		.66417(5)			.81136(15)
11		.46669(15)		.63578(25)	.73981(5)	
12		.43941(23)		.63111(20)		.71921(20)
13	.41705(5)			.60351(18)		.68199(18)
14		.41194(20)		.58387(22)		.66987(22)
15	.41145(10)			.57235(16)		.64247(16)
16		.39948(25)		.52749(27)		.59106(27)
17		.37584(18)		.50851(21)		.57141(21)
18		.37095(22)		.50481(28)		.57134(14)
19	.37073(11)			.50367(14)		.57053(28)
20		.34991(16)		.48730(26)		.48229(19)
21		.32823(27)		.47832(29)		
22		.31486(14)		.45713(24)		
23		.31462(28)		.45482(17)		
24		.31169(21)		.42546(19)		
25		.30681(29)				
26		.30422(26)				
27		.29141(24)				
28		.28069(17)				
29		.27449(19)				
Mean z						
G_I	.51891		.83037		.97807	
G_{II}		.35543		.56410		.65494
Overall	.42308		.64176		.80035	

[a]The reported z-values are computed from Equation 4-1, Chapter IV.

[b]The number in parentheses is the industry index.

Table A-3 (Continued)

Case and Group Rank	z-value[a] G_I[b]	4	G_{II}[b]
1	.73014(4)		
2	.66740(2)		
3	.65718(6)		
4	.62000(1)		
5	.59814(12)		
6	.57799(9)		
7	.54337(8)		
8			.53247(13)
9	.52739(7)		
10			.50259(15)
11	.50035(3)		
12	.44474(5)		
13	.44357(10)		
14			.44066(20)
15			.40286(22)
16			.39837(11)
17			.39252(18)
18			.36523(16)
19			.34704(27)
20			.33645(14)
21			.32986(28)
22			.32514(21)
23			.29622(19)
24			
25			
26			
27			
28			
29			
Mean z			
G_I	.55905		
G_{II}			.38828
Overall		.47738	

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