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ALASKAN ECONOMIC GROWTH: A REGIONAL MODEL WITH INDUCED MIGRATION

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The modeling of Alaska's future economic growth is a difficult yet critical task. The forces of change set in motion by the construction of the trans-Alaska oil pipeline are dimly perceived by state planners and policymakers, yet their decisions will have a large impact on the state's future economic growth and population growth. Exploration and development of Alaska's Outer Continental Shelf (OCS) resources, a pre-requisite of Project Independence, will also induce substantial growth and change in Alaska's economy.

These pressing demands for knowledge of Alaska's possible economic futures, the impacts of alternative state and federal policies toward further oil development, and the alternative uses of state oil revenue have led us to develop a simple model of the Alaskan economy which can be used by policymakers in their decisionmaking process. This paper is a preliminary report on the construction and operation of the model. The econometric model is discussed below, followed by a presentation of the demographic model and the economic-demographic links. Subsequent sections discuss results and suggestions for further research.

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Two models of Alaska's economy have been constructed: a statewide model, and a regional model in which the state is subdivided into seven regions (see map on page 24). The regional model retains some elements of the statewide model, partly for theoretical reasons, mostly as a result of data constraints. The discussion below will refer to both models with the emphasis on the regional model. Most of the results presented are from the regional model.

Real disposable personal income is the driving force in the statewide econometric model which has been constructed. Outputs in the endogenous sectors of the economy are functions of personal income. Export sector outputs are specified exogenously, without recourse to specific national economic projections.

The statewide output relationships are derived from OLS regressions using historical data for the 1961-1973 period, and 1965-1973 data for the regional relationships.[1] The outputs induced by the spending of personal income[2] create employment in the various sectors with the statistical relationships again based on historical data. These employment levels generate incomes through wage payments, with the wage in each sector a function of U. S. weekly earnings. Aggregation of the sector wage bills,

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[1]Norman Glickman [3] provides some evidence that TSLS or LISE estimates, for example, do not improve the accuracy of regional econometric models.

[2]Real disposable personal income is not available on a regional basis and, thus, real wages and salaries are used as proxies in the regional model.

plus nonwage income (a function of wage income) equals personal income and the circle is complete.[3] Oil production revenues influence the economy through the state government sector, where state expenditures (a policy variable) generate employment and wages which add to income.[4] Each region's state and local government (SLG) output is determined by the historical relationship between regional SLG wages and salaries and total SLG wages and salaries. In the projection period, statewide SLG wages and salaries are a function of state and local expenditures.[5]

In general, endogenous regional sector outputs are functions of regional economic activity. In the Anchorage and Fairbanks regions, however, some regional sector outputs are functions of statewide economic activity. (All regions are affected by statewide developments such as growth in state petroleum revenues.) A schematic outline of the econometric model and its linkage to the demographic model are depicted in Figure 1(a) on page 17.[6]

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[3]The Gauss-Seidel iterative algorithm is used to solve the simultaneous relationship between income and output.

[4]Other revenues accrue to the state principally through taxes (functions of personal income) and federal transfers. Local government revenue is a function of personal income and state transfers. Detailed fiscal data is contained in Beharie [2].

[5]Thus, state and local government expenditures do not directly lead to any outputs in other sectors of the model. The expenditures themselves are upwardly bounded by revenues. The percentage of oil revenue "saved" by the state is another policy variable.

[6]All other model equations and inputs are available from the author.

The linkage between economic activity and population growth operates through an equation determining net civilian migration to Alaska. Most of the variation in reported net civilian migration for the historical period 1960-1973 is explained by two economic variables: the annual growth of civilian employment and the lagged change in relative per capita income. The OLS regression[7] of net migration on these variables and a dummy variable is reported below:

$$(1)\quad NETMIG = \underset{}{-52.557} + \underset{(.114)}{1.236\ (\Delta E)} + \underset{(18.234)}{57.557\ (RPI)} \underset{(1.128)}{-3.541\ (D)}$$

$$R^2 = .948$$

Standard errors of the coefficients are in parentheses.

where NETMIG = Net civilian migration in thousands

ΔE = Annual growth in civilian employment in thousands

RPI = Alaska real disposable per capita income/U.S. real disposable per capita income (lagged one year)

D = Dummy variable (=1 in 1964) for 1964 earthquake

These parameter estimates are used to project net migration in the years 1974-1990. The econometric model generates total civilian employment and real per capita disposable personal income in each year. The model user must assume the rate of change of U. S. real per capita disposable income, although sensitivity tests show that the results are insensitive to reasonable rates of growth.

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[7] Net civilian migration is, of course, calculated as a residual. To reduce the amount of error in the dependent variable, consecutive observations of the dependent and independent variables are averaged. This procedure uses up an extra degree of freedom but provides more precise estimates. Data used for constructing RPI and ΔE is contained in Kresge [4]. Net civilian migration is derived from Alaska Department of Labor [1].

At the heart of the relatively simple population model is the age-sex structure of the civilian non-Native, non-military dependent population (CNNP). The growth rate of the Native population is assumed to be independent of economic conditions in Alaska and is fixed at 2 percent per year, the recent growth rate.[8] The military population is assumed constant at its recent level of 27,400 in the absence of any clues to its future level. The military dependent population is also assumed to remain constant at its recent level.

Each year, the population groups in the age-sex structure of the CNNP age and die and give birth in accordance with fertility and survival schedules based on recent historical data. The fertility schedule employed is the 1970 age-specific fertility rates for the non-Native population, estimated by combining age-specific births for 1970[9] with the 1970 Census age distribution. The survival schedule is created by adjusting the 1969 U. S. white life table entries for males and females by the ratios of Alaska age-specific death rates to U. S. rates.[10] The survival schedule and the number of deaths generated in the model is insensitive to the assumptions made about mortality.[11] This is not true

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[8]More details on the Native population are provided in Daniel A. Seiver and Susan Fison [8].

[9]These are unpublished data made available to the author by Michael Zugzda, National Vital Statistics Division.

[10]The ratios are reported in Seiver and Fison [8].

[11]The survival schedule smoothes the single-year age distribution by surviving a fixed fraction of each 5-year group to the next group.

with respect to fertility, however. Two important questions must be answered here: (1) should fertility be exogenous? and (2) if so, what rates should be projected into the future? An easy answer to the first question is that the historical data needed to determine the relation between economic activity and fertility in Alaska are not available. But it is unclear if there is a definitive relationship between fertility and economic activity that could be projected into the future.[12] If, instead, fertility is specified exogenously, what set of rates should be used for the projection period? While it is true that fertility in Alaska declined between 1970 and 1973 (although it rose in 1974), it is not unreasonable to assume that 1970 fertility will prevail in 1974-1990. American fertility is at the moment unusually depressed, and Alaskan fertility has consistently remained substantially above the U. S. average. In addition, boom conditions will persist in a sparsely inhabited state.[13]

The population model has been constructed on a statewide basis. The following equation was estimated for the 1961-1973 period for each region:

(1) $P_{it} = f_i(E_{it})$

where P_{it} = total population of region i in year t (in logarithms)

E_{it} = total employment in region i in year t (in logarithms)

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[12] Sweezy [9].

[13] A number of runs were made with fertility at 90 percent of the 1970 levels. None of the discussion in this paper is materially altered by the results.

For the projection period, state population is allocated to the regions using this formula:

$$(2) \qquad P^*_{it} = P_{st} \cdot \frac{f_i(E_{it})}{\sum_i f_i(E_{it})}$$

where P^*_{it} = projected population of region i in year t

P_{st} = projected state population in year t

Thus, internal redistribution of population is based solely on relative employment growth in the seven regions.[14]

Before discussing the mechanics of the population model, the migration equation and the allocation of migration should be examined in more detail. The estimated net civilian migration equation is highly plausible theoretically. A low rate of job creation combined with constant relative income would result in net out-migration from the state, a reasonable result. A coefficient of slightly greater than unity on the employment variable suggests one or both of the following conditions: (1) substantial migration to the state of individuals with few dependents, and (2) some tapping of a resident labor supply. The allocation of net civilian migration to age-sex categories requires more data and more assumptions. A special Census report[15] provides Alaskan 5-year migration data by age and sex, but these data are severely distorted by military migration in the

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[14]One output of research in progress will be a set of regional population models.

[15]U. S. Bureau of the Census [11].

key 20-29 age groups. The Alaskan data for the 40 and over age groups show net out-migration for all age and sex categories, and the migration rates derived are annualized and applied directly in the projections to the appropriate populations, giving annual estimates of net out-migration for the 40+ population. Each annual estimate is added to the computed value of total net migration derived from the net migration equation, determining net in-migration of the 0-39 population. This quantity is allocated to age and sex groups using data from the same Census report[16] on migration between California and non-contiguous states, thus assuming that the age-sex composition of the California 0-39 migration stream will be similar to the migration streams for Alaska 1974-1990. The migration percentages for the 0-39 groups and the migration rates for the 40 and over groups are listed on page 16. Almost 26 percent of the net migration of the 0-39 group is allocated to the 20-24 year old males with another 19 percent allocated to 20-24 year old females. This distribution matches fairly closely the data on probabilities of interstate moves by age for the U.S.[17] A schematic outline of the population model appears on page 18 (Figure 1(b)). All population parameters are listed in Table 1 on page 16.

A first attempt has been made to measure the effects of economic growth on equilibrium in the state's labor market. Labor force participation rates for each age-sex group of the civilian non-Native population

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[16] _Ibid_.

[17] See for example Long [6].

were estimated based on 1970 Census data.[18] This set of rates is applied to the age-sex structure to generate an estimate of labor supply of this group in each year of the projection period. An overall participation rate is applied to the Native population and this total is added to the non-Native total as a measure of civilian labor supply. This projected civilian labor supply can be compared with civilian employment demand projected by the model[19] although the current formulation of the model does not include any adjustment mechanisms.

The mechanics of the overall model can be sketched simply: starting from the base year, 1973, the economic model calculates iteratively 1974 output, employment, and income; the population model applies survival and fertility schedules to the age-sex distribution, and then the migration equation determines net migration which is allocated in the manner noted above. At each stage, labor supply is estimated as noted above. The process continues until the model converges and then it begins again for the next year. I now turn to the interpretation of the results.

The model is primarily designed to enable state policymakers to gauge the effects of various alternative "petroleum scenarios" on the state's future population and economic growth.[20] The state has acquired this

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[18] U.S. Bureau of the Census [10], Table 164.

[19] 1970 participation rates are also applied to the military dependent population, and the aggregate Native participation rate is assumed to rise one percentage point per year, from 21.2% in 1970 to 41.2% in 1990, as Natives are further assimilated into the cash economy.

[20] Under contract to the Bureau of Land Management, ISEGR is employing the regional model to analyze alternative natural gas pipelines for Alaska's North Slope gas.

leverage by means of the substantial state revenues that will be generated by oil production on Alaska's North Slope and other areas under state control and the effects of leasing and development of federal lands. The current formulation of the model provides three alternative "petroleum scenarios" for the period 1970-1990:[21] (1) a "limited development" case, in which present developments are carried forward (essentially Prudhoe Bay), a few additional fields are opened near existing areas and the federal OCS leasing program is limited to the Gulf of Alaska. Total oil production reaches 2 million barrels a day by 1980 and 4 million barrels a day by 1990.[22] (2) An "accelerated development" case in which, in addition to case (1), new petroleum areas are opened up in the northwest, both onshore and offshore, and a second North Slope Oil pipeline is constructed, mainly as a result of leasing in Naval Petroleum Reserve No. 4. In this case, oil production reaches 7.7 million barrels a day in 1990. (3) A "maximum development" scenario which approximates the maximum rate of petroleum development that could occur in Alaska.[23] The rate of development is comparable to that envisioned in the plan in "Project Independence." It is assumed in this scenario that in addition to case (2), the Federal government leases heavily in the Bering and Chukchi Seas. This, in turn, necessitates construction of oil and gas pipelines running from north to south in western Alaska. Availability of the pipelines and processing facilities

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[21] These scenarios are based on Kresge [5], pp. 9-10.

[22] Projections of oil production and employment are based on Morehouse [7].

[23] This scenario is dependent upon optimistic assumptions about economically recoverable reserves, and the availability of the capital and technology necessary to develop these reserves.

would then make additional leasing feasible in the new western areas for Native corporations and the state. Alaska's oil production reaches 5.2 million barrels a day in 1985 and nearly 10 million barrels in 1990.

The other key variable determining the size of the state's oil revenues will be the price of oil. The model has been run for three cases: wellhead prices of $7, $5, and $3 per barrel in 1975 prices (equal to $11, $9, and $7 per barrel market prices). These nine (3 policies x 3 prices) cases could be multiplied indefinitely to suit a policymaker's or researcher's preferences. The model is designed to permit almost any assumptions about state revenues and expenditures, fertility, oil prices, etc. What is of particular interest here are the implications of various policy alternatives for the growth of population, both statewide and regional, the response of net migration to economic growth, per capita income, and labor market effects.

Figure 2 shows the effect on population of the three development scenarios at $5 oil. It shows that the state has little "downside" leverage: an austere set of growth policies reduces 1990 population by less than 100,000 below the accelerated case, and 1990 population is still nearly twice the 1974 level. Maximum development could increase 1990 population to 894,000, almost triple the 1974 level, and 165,000 above the accelerated scenario.[24] Absolute populations are a little lower for

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[24]Restrictive state policies "fail" partly because there is no way to prevent revenue from accruing from North Slope production, partly because the interest earned on money "saved" by the state builds up rapidly and is assumed to be spent, and partly because the Federal government leases land in all the scenarios.

lower oil prices, but limited development and $3 oil still result in a 1990 population of 584,000. For comparison purposes, a recent projection of Alaska's population by the Bureau of Economic Analysis of the Commerce Department is included. This projection does not benefit from any economic-demographic interactions, nor do its economic projections benefit from the modeling of the oil development process.

Figure 3 displays the projected levels of population in the state's seven regions with $5 oil and accelerated development. Regional demarcations are shown on the map in Figure 7. The Anchorage region, already the largest in population by far, grows very rapidly during the projection period. This is mainly a result of rapid growth in support sector employment. The state's other urbanized area, Fairbanks, also grows fairly rapidly so that by 1990, Anchorage and Fairbanks comprise about two-thirds of the state's total population. The Southeast and Southcentral regions grow fairly rapidly, and will no doubt become more urbanized; the other regions of the state grow very slowly, in response to slow employment growth and a low population-employment elasticity.

The performance of the net migration equation is crucial to the projection of population; Figure 4 graphs projected net civilian migration 1974-1990. Natural increase of the civilian non-Native population is also graphed for the same period. The sharp peak and decline of 1975-1977 reflect accurately the inevitable boom-bust cycle of pipeline construction. The increase after 1977 reflects the effects of rising state revenues and expenditures as oil flows from the North Slope and elsewhere in the state. Natural increase is given a strong upward push by the age composition of the migration flow. The pattern for the other projections is quite similar.

The patterns of per capita income growth are graphed in Figure 5. Rapid growth in per capita income occurs in all projections to 1990. The range of per capita incomes in 1990 under different policy alternatives is much less than the variation in total income, as induced population growth offsets some of the income growth. It appears that policymakers can have more influence on the absolute size of the state's economy and population than on per capita income.

Figure 6 shows the statewide civilian unemployment rate for the years 1974-1990, calculated by subtracting estimated employment from labor force, which in turn is calculated from the age-sex structure and 1970 participation rates. Alaska has historically had a high unemployment rate relative to the U. S.; in addition, Alaska's unemployment rate normally peaks in booms, reflecting "overmigration" to the state. The 1990 unemployment rate in the accelerated - $5 case is a reasonable 6.0 percent, lower than historical rates but reflecting Alaska's new, relatively stable economic structure. In the limited - $5 scenario, the rate is only slightly higher at 6.6 percent but in the maximum case, the 1990 rate of 3.9 percent is probably lower than can be achieved. Either participation rates will rise somewhat or more interstate migration will be forthcoming.[25]

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[25] The 1990 unemployment rate is even lower in the maximum - $7 case, which suggests the same adjustments. The maximum case itself is not highly likely.

The results presented, selected from the infinite number that can be generated by this economic-demographic model, are sufficient to show the usefulness of this formulation for policymakers and researchers. Linking economic activity and net migration at the subnational level is clearly a step beyond independent projections of economic growth and population growth.

There are, of course, many limitations to model-building in general and many improvements that could be made to this model in particular. Some of these difficulties and possible remedies are discussed below.

The model relies almost totally on historical relationships which are assumed to persist in the future. I doubt there are reliable methods to remedy this common problem; users of the model should be made aware of these crucial assumptions. It is of particular importance in the state of Alaska where substantial structural change is bound to occur in response to oil development.[26]

The population model has not been truly regionalized. Natural increase clearly varies by region, as does military population and dependents. The current regional model in effect allocates population growth solely by relative employment growth. The major obstacle to complete regionalization of the population model is lack of data.

Explicit modeling of regional labor markets is in progress. The aggregate state model assumes equilibria will be achieved in all the state's labor markets without regard to skill levels and requirements and internal

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[26]An excellent validation test and measure of structural change will be possible when 1974 data becomes available. This data will enable us to evaluate every stochastic equation in the model.

migration. These phenomena will be taken into account in the refined regional models, and interstate migration will be disaggregated by location and occupation.

Demographers will also note that the marriage market is overlooked in the model. The number of males in the population is assumed to have no influence on the aggregate fertility of the women. Data on marital fertility and assumptions about nuptiality could remedy this shortcoming.

The models also oversimplify the growth of the Native population. The refined regional models will partly remedy this weakness as Natives are unevenly spread over the state. Patterns of Native mobility must also be analyzed for projection purposes, and Native labor force participation needs to be modeled in more detail.

An ambitious project is now underway to transform the current regional model into a quarterly forecasting model, to be utilized directly by the State of Alaska. Data constraints are even more severe, and projections of exogenous variables are much more difficult. Benefits to policymakers could be substantial, however.

All of the above refinements of the aggregate state economic-demographic model have important benefits to planners and policymakers and also represent improvements in modeling technique. This step is taken at high cost, however, as the data requirements and the weight of required assumptions expand exponentially. The results obtained from the aggregate state model and regional model are sufficiently encouraging to merit taking this next step.

Table I. PARAMETERS OF POPULATION MODEL

Age Group	Survival Rates Male	Survival Rates Female	Fertility Rate Per 1000	Migration Rates (40+) or Percents (0-39) Male	Migration Rates (40+) or Percents (0-39) Female
0-1	.98778	.99086	-----	----	----
1-4	.99915	.99929	-----	2.4	2.8
5-9	.99945	.99954	-----	1.7	2.0
10-14	.99943	.99959	-----	2.4	2.8
15-19	.99783	.99917	94.5	10.4	4.9
20-24	.99703	.99903	203.4	25.9	19.0
25-29	.99750	.99912	159.7	8.2	10.0
30-34	.99720	.99874	71.6	2.5	1.8
35-39	.99697	.99824	26.6	1.1	2.0
40-44	.99540	.99734	8.7	-0.16	-0.22
45-49	.99321	.99608	0.7	-0.16	-0.18
50-54	.98934	.99424	-----	-0.28	-0.18
55-59	.98353	.99295	-----	-0.26	-0.26
60-64	.97492	.98953	-----	-0.68	-0.84
65+	.92818	.96100	-----	-0.82	-0.78

Male Percentage at Birth = .5105

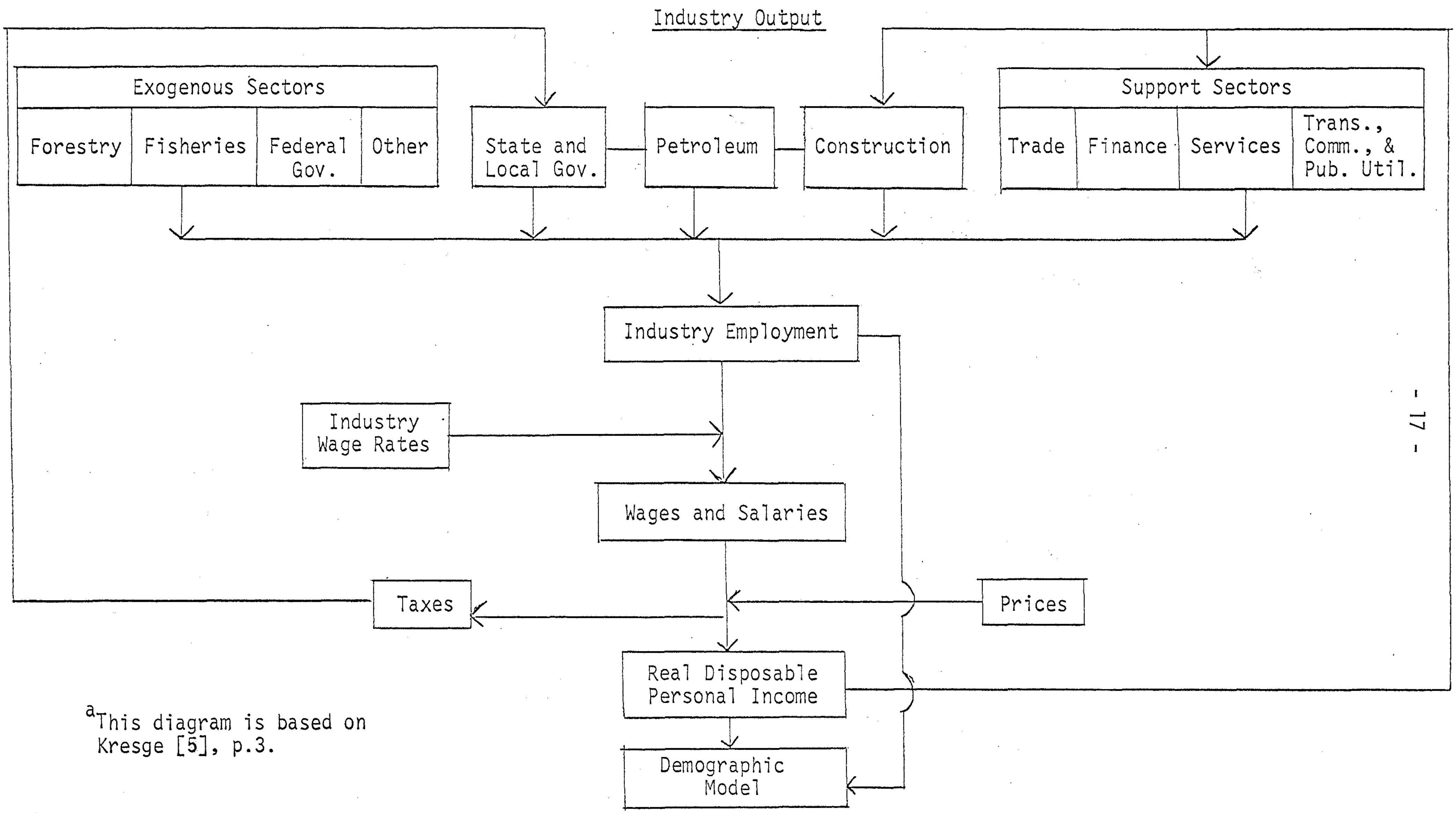
Infant mortality = .02310 (Male), .01716 (Female)

NETMIG = -52.557 + 1.236(ΔE) + 57.557(RPI)

Sources: See Text.

Figure 1a

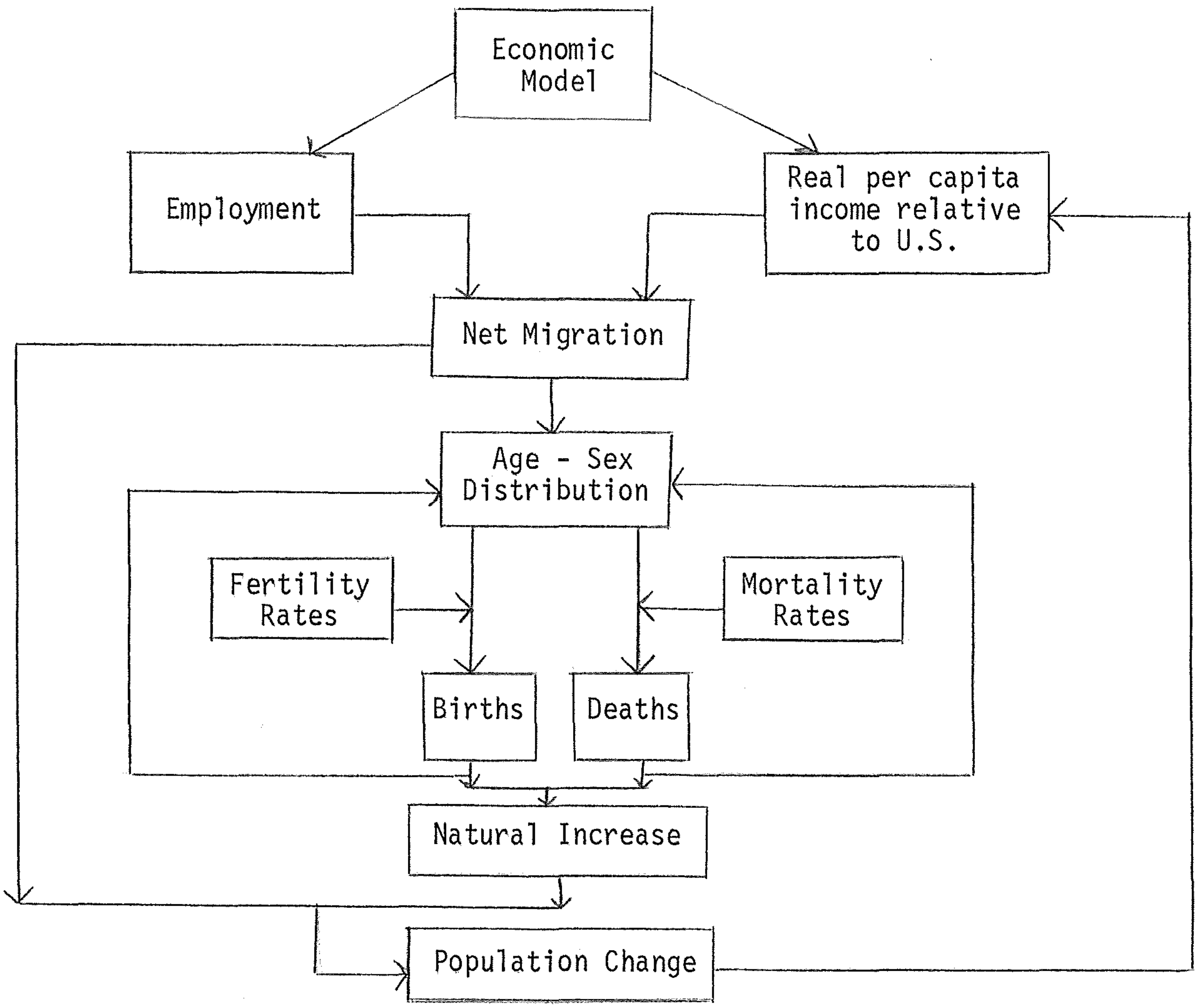
STRUCTURE OF THE MAP ECONOMIC MODEL[a]



[a]This diagram is based on Kresge [5], p.3.

Figure 1b

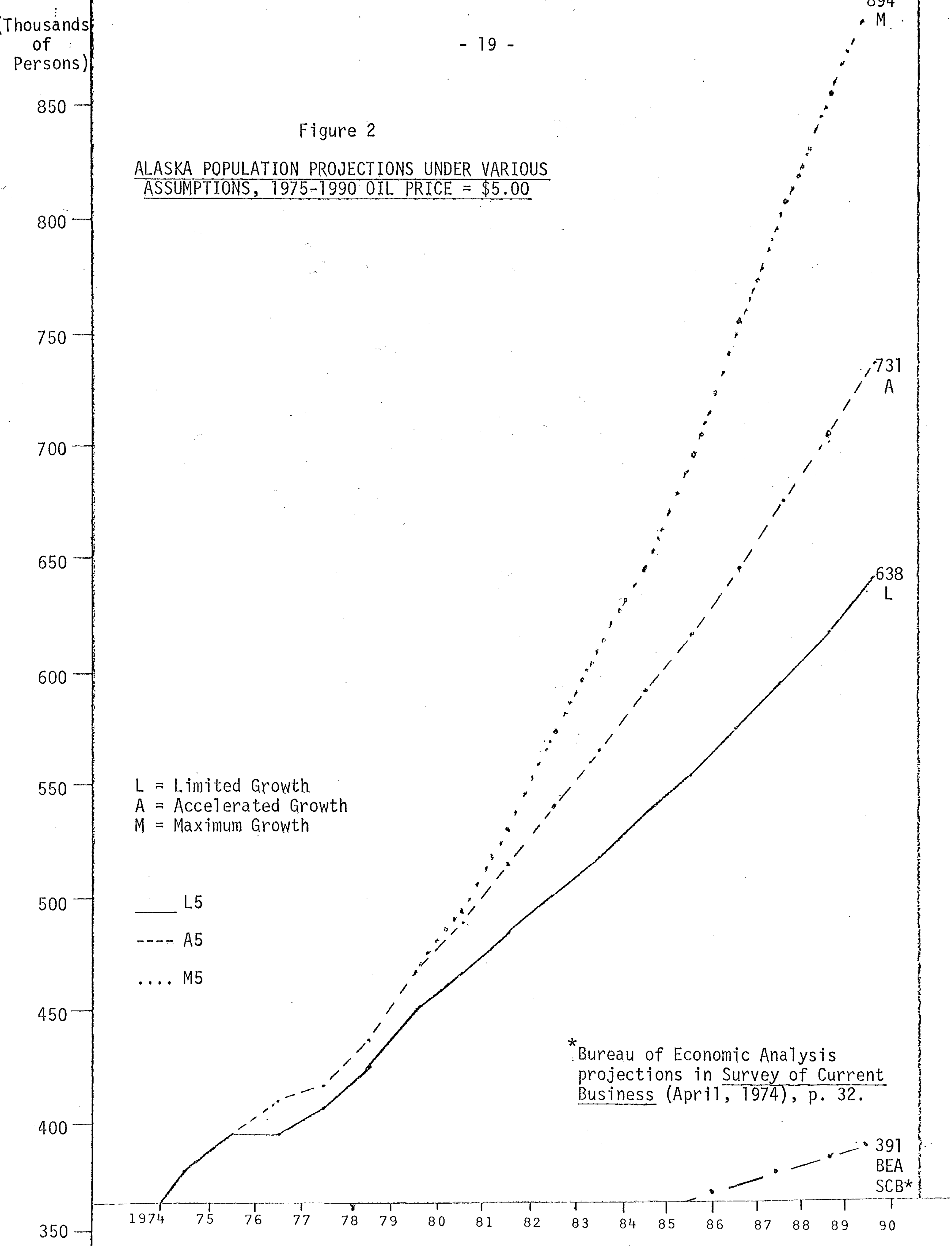
STRUCTURE OF THE MAP POPULATION MODEL[a]



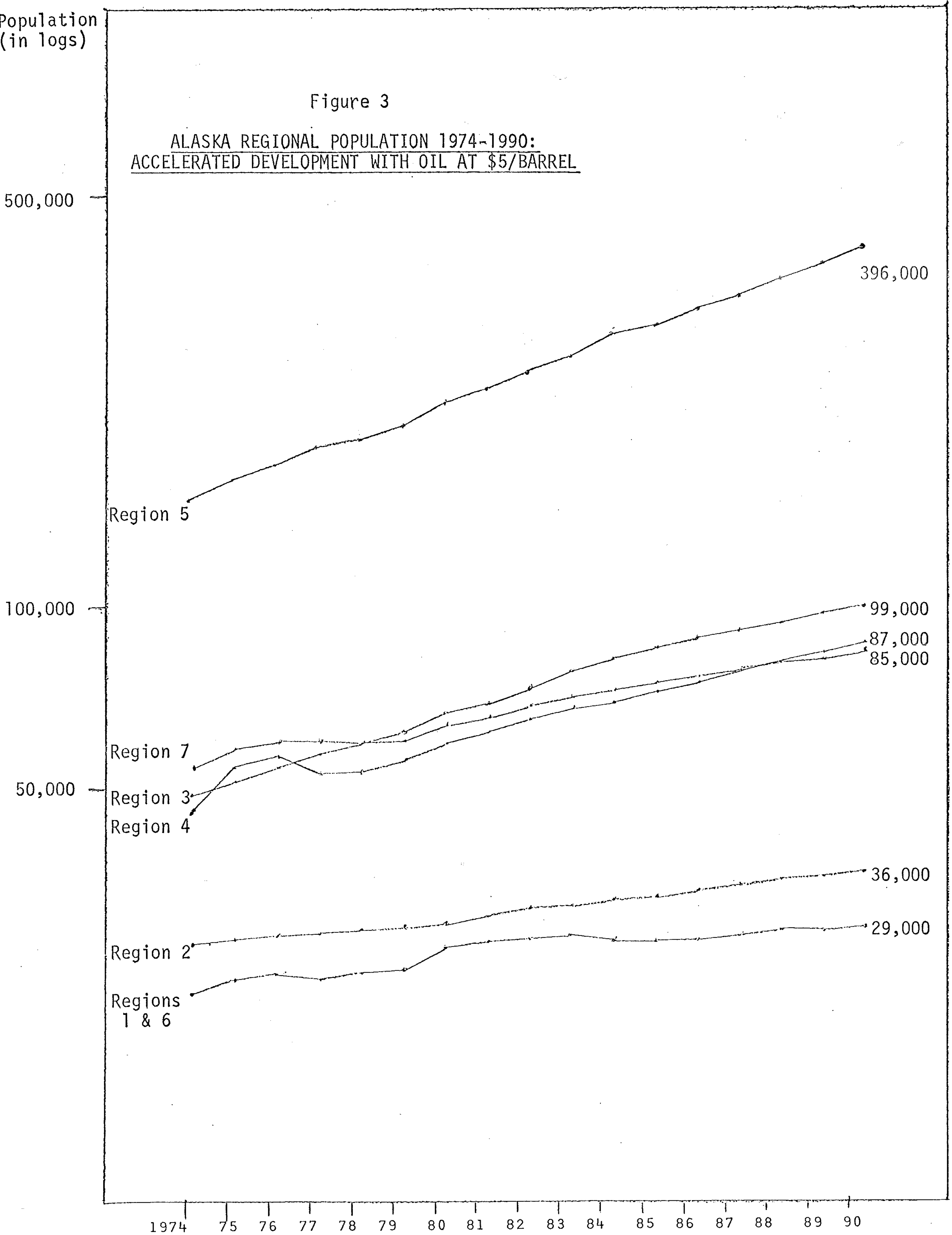
[a]This diagram is based on Kresge [5], p.7.

Figure 2

ALASKA POPULATION PROJECTIONS UNDER VARIOUS ASSUMPTIONS, 1975-1990 OIL PRICE = $5.00



*Bureau of Economic Analysis projections in Survey of Current Business (April, 1974), p. 32.


Population
(in logs)
Figure 3
ALASKA REGIONAL POPULATION 1974-1990:
ACCELERATED DEVELOPMENT WITH OIL AT $5/BARREL
500,000
396,000
Region 5
100,000
99,000
87,000
85,000
Region 7
50,000
Region 3
Region 4
36,000
29,000
Region 2
Regions
1 & 6
1974
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90

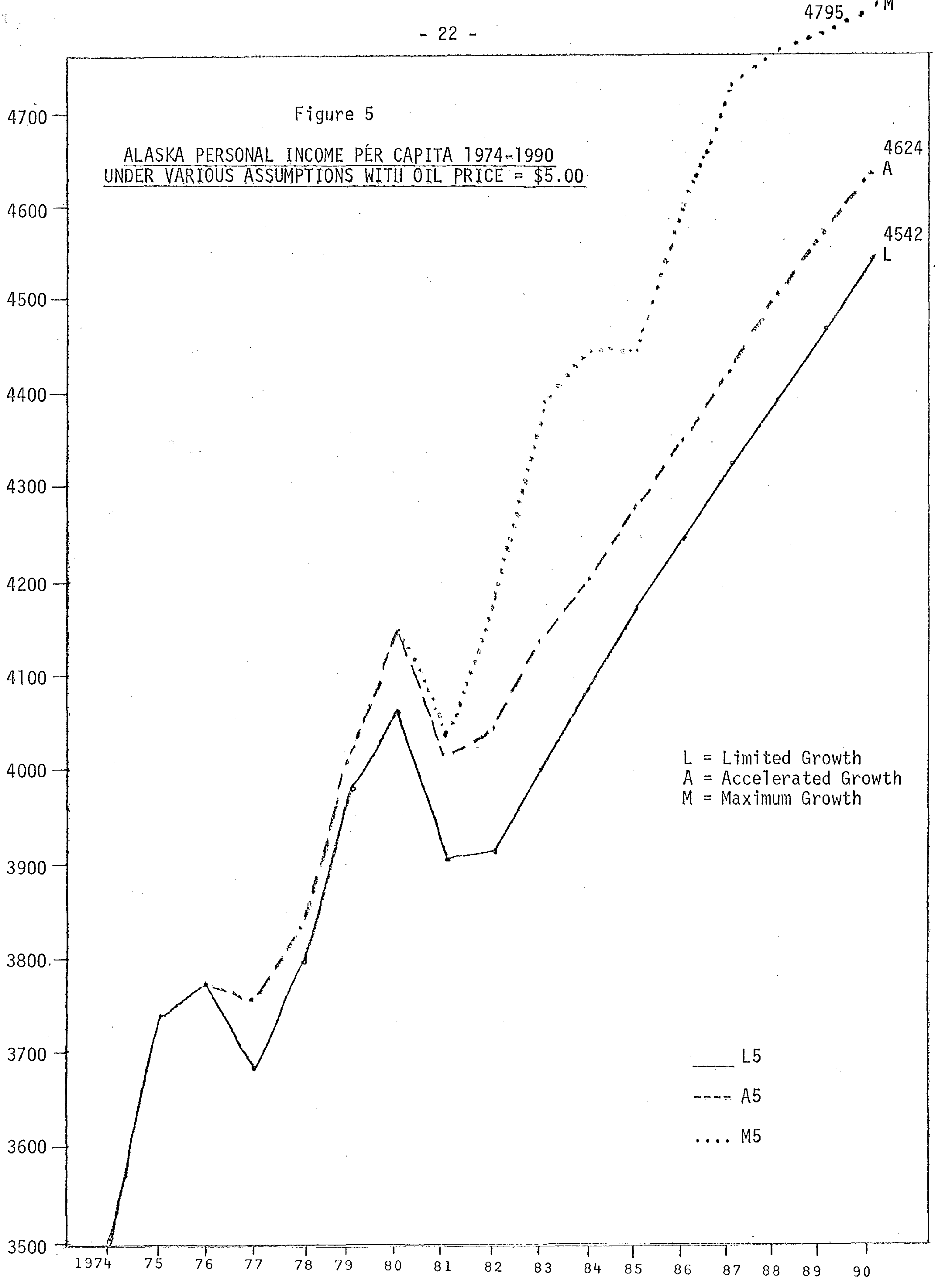


Figure 5
ALASKA PERSONAL INCOME PER CAPITA 1974-1990
UNDER VARIOUS ASSUMPTIONS WITH OIL PRICE = $5.00
4700
4600
4500
4400
4300
4200
4100
4000
3900
3800
3700
3600
3500
1974
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
4795 M
4624 A
4542 L
L = Limited Growth
A = Accelerated Growth
M = Maximum Growth
L5
A5
M5

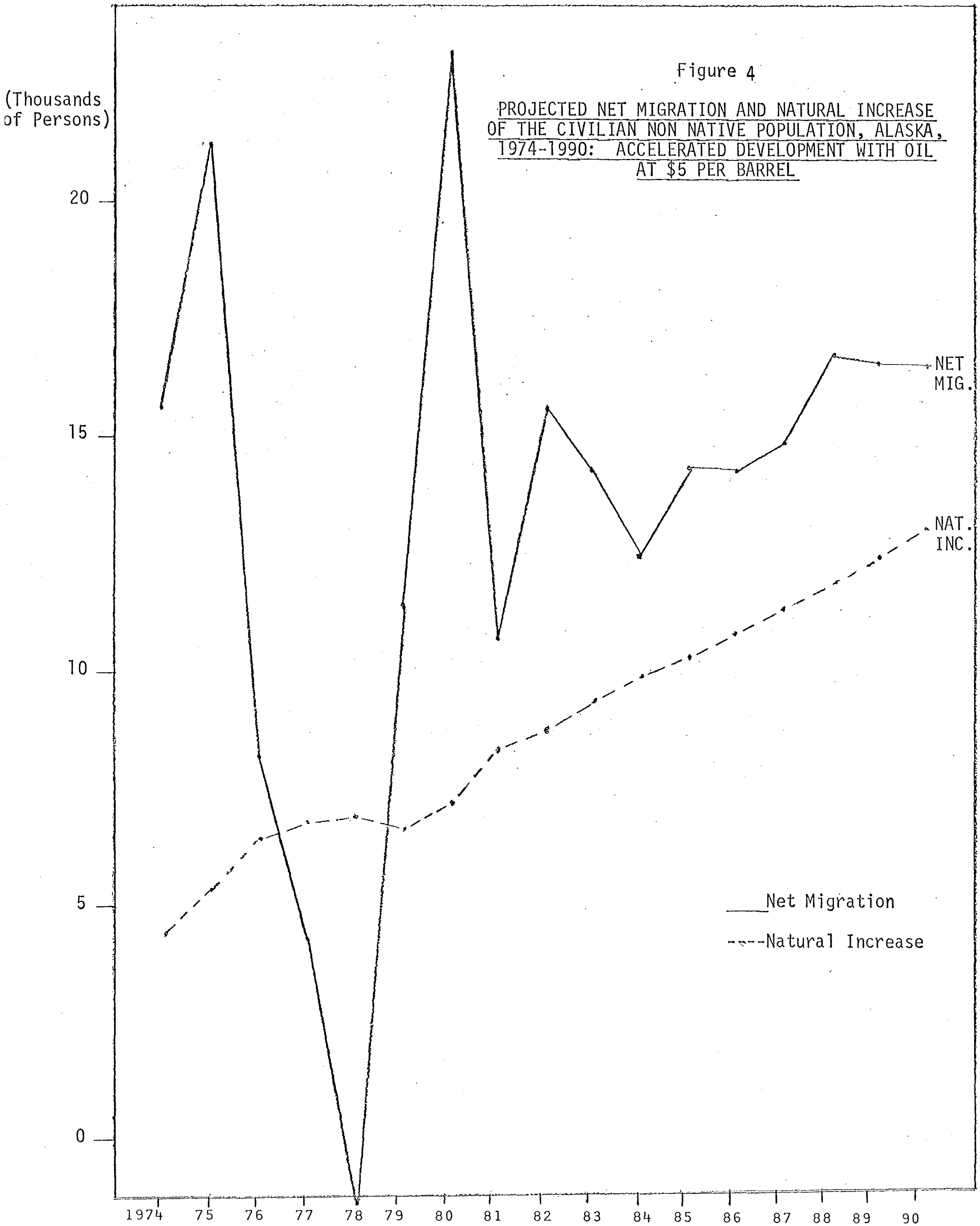
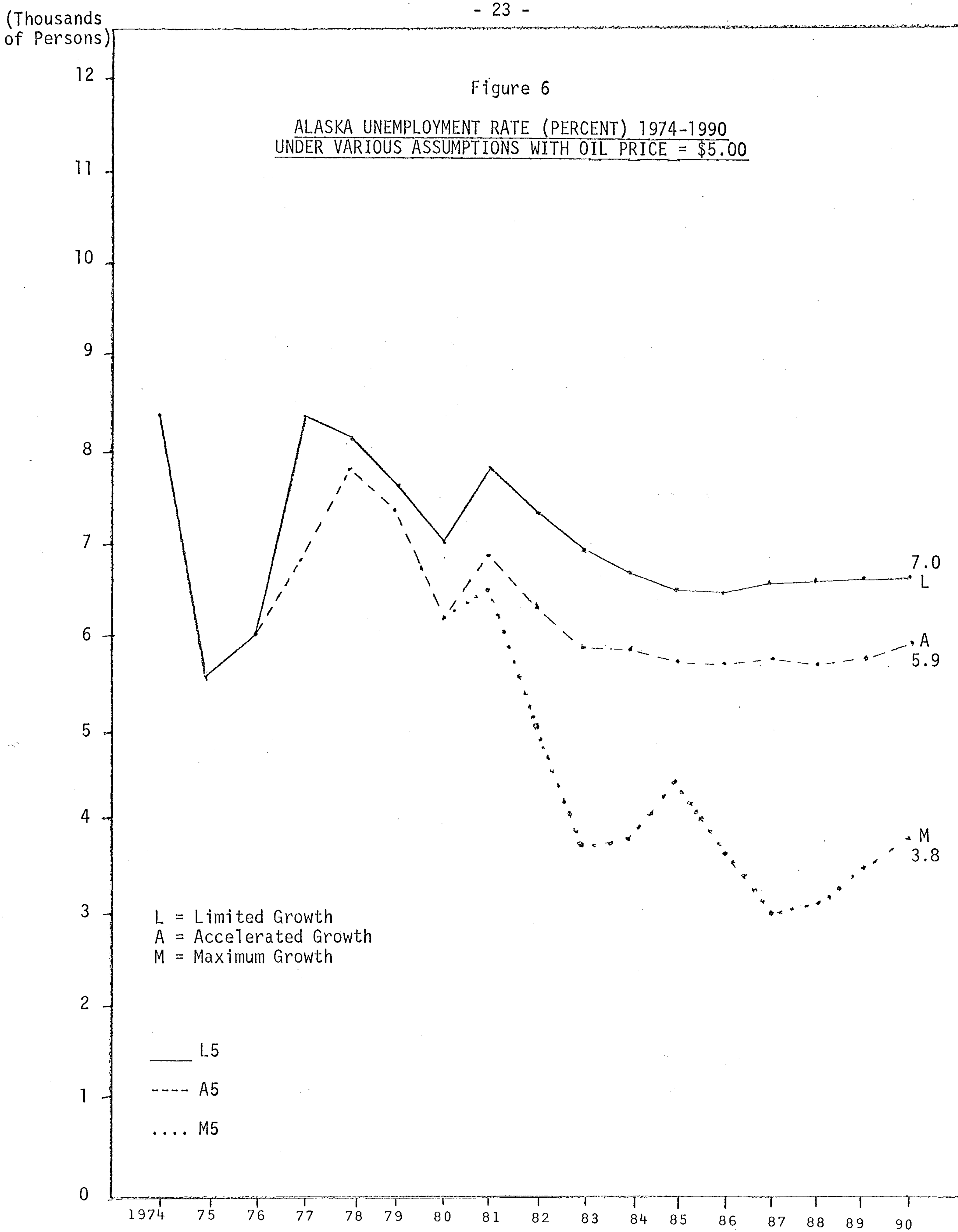


Figure 4
PROJECTED NET MIGRATION AND NATURAL INCREASE OF THE CIVILIAN NON NATIVE POPULATION, ALASKA, 1974-1990: ACCELERATED DEVELOPMENT WITH OIL AT $5 PER BARREL
(Thousands of Persons)
20
15
10
5
0
NET MIG.
NAT. INC.
Net Migration
Natural Increase
1974
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90

Figure 6

ALASKA UNEMPLOYMENT RATE (PERCENT) 1974-1990
UNDER VARIOUS ASSUMPTIONS WITH OIL PRICE = $5.00



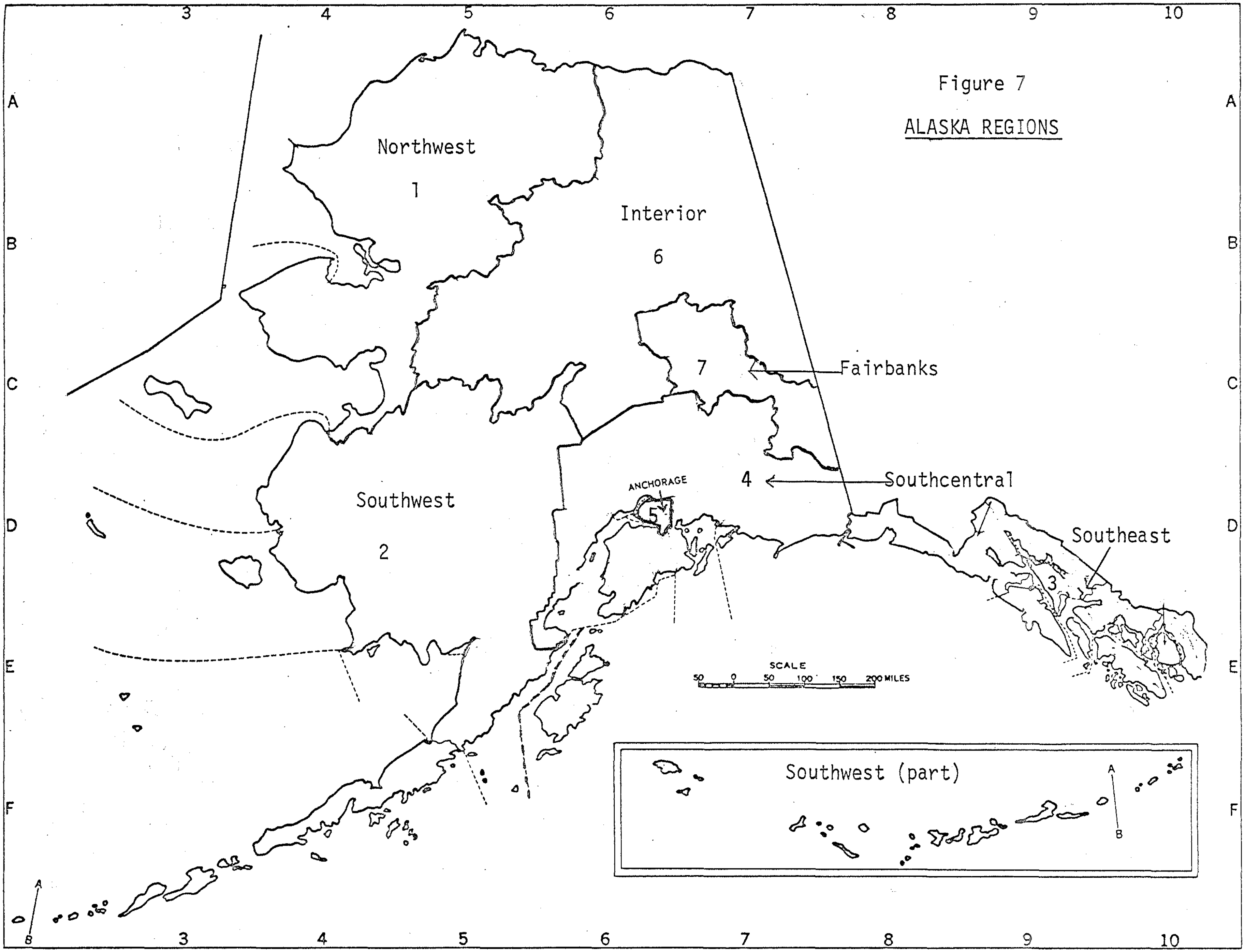


Figure 7

ALASKA REGIONS

Source: State map in U.S. Bureau of the Census [10], p. 3-201.

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