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AN INTERACTIVE MULTIREGIONAL MODEL OF A FRONTIER ECONOMY: ANCHORAGE AND THE STATE OF ALASKA

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I. Introduction

This paper describes an interactive model of the economy of Anchorage and the six surrounding regions which together constitute the state of Alaska. The model produces long-term economic and demographic projections for Anchorage, the only SMSA in the state; the other regions; and by bottom-up aggregation, the state as a whole. The primary feature of the model is its explicit specification of interregional linkages in both the market for goods and services and the market for labor. This specification is appropriate for a "frontier" economy such as Alaska where the primary activity is resource extraction rather than manufacturing. In such a case, links to the national economy inadequately explain the pattern of economic activity.

A model containing interregional links is appropriate for any regional economy with important trade and service links to surrounding regions and where labor is mobile across regions. Anchorage, the largest city in Alaska and the primary economic center of the state, is such a region. Thus, it is necessary to specify activity in surrounding regions as endogenous in order to model the Anchorage economy. Full model specification thus results in a complete model of the state with primary focus on Anchorge.

Demand drives most regional econometric models linked directly to the national economy (multistate regional models include Crow [10] and Ballard and Glickman [4]; state models include Bell [7] and L'Esperance [19]; SMSA models include Glickman [13], Hall and Licari [14], and Duobinis [12]; and city models include Chang [9] and Rubin and Erickson [26]).[1] Until recently, little attention has focused on the fact that trade among regions is an important determinant of the growth of a region, independent of national trends [22].

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[1] See Knapp, Fields, and Jerome, 1978, for a review of early models.

Interregional links may be ignored if the region is large relative to the national economy and primarily exports to a national or international market. In that case, national linkages will reflect the major determinants of external trade. However, when modeling smaller, more open economies, trade with the immediately surrounding regions is a much more important component of economic activity and cannot be ignored. In addition, the trade flows form feedback loops with surrounding regions. Although these loops can generally be ignored with regional economies primarily linked to the national economy, they should be identified explicitly when interregional trade is an important factor in the regional economy.

Explicit modeling of interregional linkages was suggested quite early [20] but has not been included in most modeling efforts. For example, the interregional trade coefficients tables of the multiregional input-output model describe the commodity trade links among regions in great detail]23]. But because these tables require large amounts of data, are costly to develop, are static in nature, and provide a description of only the interregional commodity demand links among regions, they are a method only rarely employed.

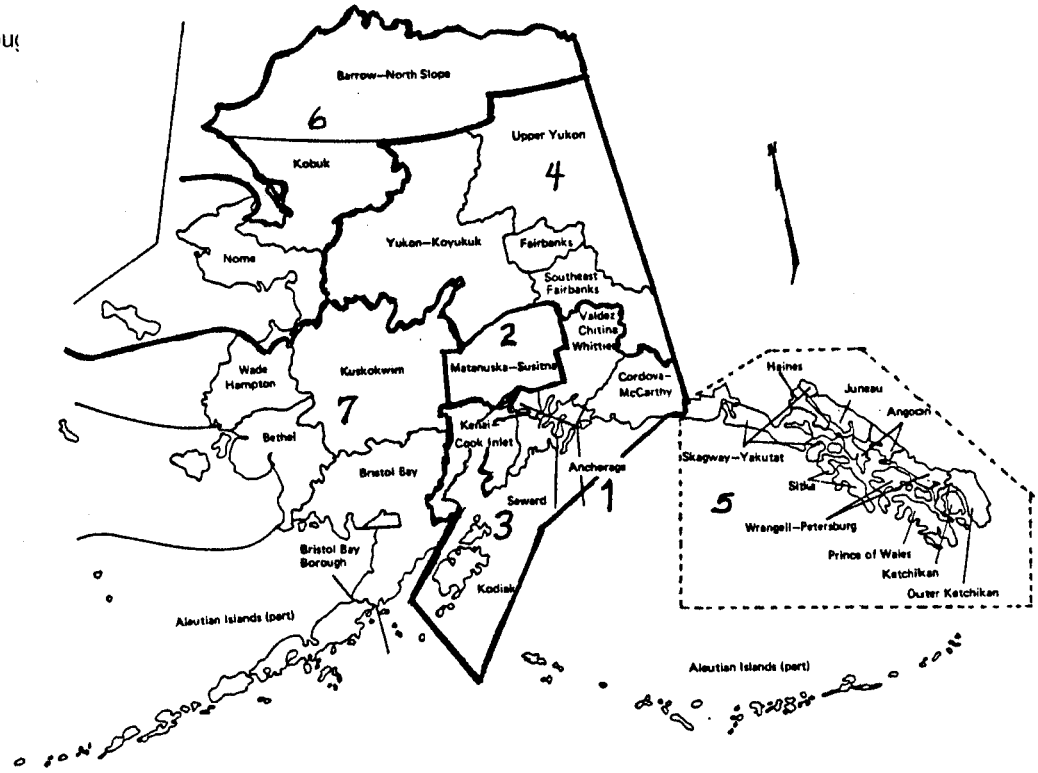
The development of multiregional econometric models [15,21,6,3] has resulted partly from the recognition of regional links. "Top-down" multiregional models, in which regional values are forced to aggregate to an independently determined multiregional total, deal with regional interactions implicitly in the equations used to allocate economic activity based upon comparative advantage [21]. "Bottom-up" models may include interregional linkages explicitly, generally through the demand equations. Ballard and Wendling [5] have developed a multiregional model of the U.S. economy in which each state is a separate region and the aggregate (or average) of the states is the national total. In their model, distance-weighted total-output levels in other states are included in certain manufacturing demand equations. Baird's [3] multiregional econometric model of Ohio includes the income of each Ohio SMSA in the output demand in other regions for nonmanufacturing sectors, and gross metropolitan product for each Ohio SMSA in the manufacturing equation.

The present model is an extension of this multiregional modeling work on the state level, based primarily on a "bottom-up" approach but including elements of "top-down" modeling where appropriate. It incorporates interregional demands for goods and labor into the determination of economic activity in the region and successfully measures the differential impacts on the city of Anchorage of economic activities occurring in the different regions surrounding the primary city of the state.

The rest of this paper is divided into five sections. First, several specific features of the economy are described which motivate the interregional modeling approach. This section is followed by a description of the model. After presenting results of model validation tests, two model simulations are presented which demonstrate the ability of the model to distinguish economic activity based upon the interregional links among surrounding regions. Conclusions are presented in a final section.

FIGURE 1. ALASKA AND ITS REGIONS

1. Anchorage
2. Matanuska-Susitna Borou
3. Southcentral
4. Interior
5. Southeast
6. North
7. Southwest



II. Characteristics of the Region

Three important characteristics of the Anchorage economy highlight the importance of including interregional links in modeling its structure. They reflect the fact that Anchorage serves as the entrepot for a frontier economy which, in addition to itself, includes several small, underdeveloped regional economies collectively labeled the hinterland (see map of Alaska in Figure 1).

(a) Hinterland Residentiary and Business Support Center. Anchorage is the statewide center for consumer goods suppliers, ranging from department stores to grocers who supply "bush" communities, and for services such as education, medicine, and entertainment. Consequently, consumer demand in the hinterland regions will affect activity in these industries in Anchorage. The strength of this effect will vary across regions depending upon the size of regional centers and alternative sources of supply. In like manner, Anchorage also supplies business goods and services for much of the state, such as financial services, legal services, wholesaling, and construction. Consequently, the level of activity generated directly and indirectly by the extractive industries in the hinterland — mining, petroleum, fishing, timber, and the military — will affect the Anchorage economy. This pattern is confirmed by selected location quotients (based on employment) for Anchorage relative to Alaska presented as Table 1.

TABLE 1.
SELECTED LOCATION QUOTIENTS FOR ANCHORAGE RELATIVE TO ALASKA

Mining	.31
Manufacturing	.34
Finance, Insurance, Real Estate	1.19
Contract Construction	1.29
Wholesale Trade	1.37
Personal Services	1.23
Business Services	1.45
Amusement Services	1.31
Legal Services	1.27

SOURCE: U.S. Department of Commerce, *County Business Patterns,* 1978.

(b) Weak Direct Links to National Economy. In most regional economies, manufacturing is a significant industry, and output is closely linked to national manufacturing by sector. In contrast to the nationwide average of 22 percent of employment in manufacturing, Anchorage employment in manufacturing is only 2 percent, primarily for the local market. The largest sector directly affected by national decisions, but not by the business cycle, is the Federal government sector (civilian and military) which accounts for 20 percent of total employment. The primary economic function of Anchorage is to serve as the support center for the rural areas of the state, which produce primary goods

and require residentiary services. Consequently, the effect on Anchorage of fluctuations in the national economy is less direct than in other states. This is demonstrated by the fact that the correlation coefficient between U.S. and Alaska employment from 1961 to 1982, after elimination of trend, is -.45.

(c) Multiregional Labor Pool. Although the natural resources which support the Alaska economy are located in the hinterland, a portion of the labor used in exploration, development, extraction, and processing of these resources choose to reside in Anchorage or other locations away from the work site because of the severe living conditions at the work site. Table 2, comparing wages paid by place of work with income earned by place of residence for each of the regions of the state, shows that here are significant net flows of earnings out of all regions except one. Portions of the commuting labor force live in Anchorage and its immediate surrounding areas because of the amenities its large market size provides, and thus the net flows of Table 2 mask significan earnings inflows into these communities from the hinterlands. Typically, an employee will work at the work site for two weeks and be off two weeks. Thus commuter labor force generates support service demands in Anchorage and other regions independent of local basic employment.

TABLE 2. WAGES PAID BY LOCATION AND WAGES EARNED BY RESIDENTS IN 1978 (million $)

Region	(1) Wages Paid	(2) Wages Reported by Residents	(2)-(1) Net Inflo (Outflo)	(3)/(1) Wages Reported as Percent of Wages Paid
Anchorage	$1,737.3	$1,513.2	$(224.1)	87%
Matanuska-Susitna	52.5	110.4	57.9	210
Southcentral	316.7	297.0	(19.7)	94
Interior	618.6	517.2	101.4	84
Southeast	453.4	383.3	(70.1)	85
North	285.4	75.8	(209.6)	27
Southwest	170.5	80.8	(89.7)	47
Total Alaska	3,634.4	2,977.9	(656.5)	82
United States	1,102,062.0	1,092,000.0	(10,062.0)	99

SOURCE: See appendix.

The reverse is also true, particularly for Anchorage. The growth of the city has caused expansion beyond its boundaries so that an increasing percentage of employment is filled by daily commuters. In suburbs just north of the city (the Matanuska-Susitna Census Area), there are six residents for each job, and a significant proportion of the labor force is employed in Anchorage.

In addition, because of its position as the dominant city in the frontier, Anchorage serves as the magnet for migrants seeking job opportunities both from outside the state and from the hinterland regions of the state. The former are largely non-Natives while the latter are primarily Natives from rural Alaska. Anchorage serves as a staging area for labor moving both into the hinterland and to the lower 48.

III. Model Structure

In this model, the primary region of interest is Anchorage, a small SMSA which accounts for over half of the employment, income, and population of the state of Alaska. The Anchorage economy is closely linked to the surrounding rural parts of the state and very dependent upon activity in those regions. Activity in the hinterland regions, in turn, is based upon natural resource extraction activities and state government investment. In order to model economic activity for Anchorage, it is thus necessary to model the links with the other regional economies. The resulting model includes seven regions which sum to the total for the state. Anchorage activity is modeled in considerable detail while all other regions are treated in more aggregate fashion. The boundaries for each region are aggregates of census areas based upon the identification of coherent market areas with different links to Anchorage. The regional structure of the model is shown in Figure 2.A.

The links to the national economy in this model are limited to the general price level, wage rate level, and the national unemployment rate. These national economic variables either pass directly to each of the seven regions or filter through variables determined at the state level. Because of the virtual absence of a manufacturing sector, no links exist between national manufcturing levels and the share attributable to firms in the state. Basic industry output, which is primarily resource extraction, is best determined by a set of exogenous assumptions.

Some variables, including the entire demographic component, are determined at the state level and allocated to the regions in the fashion of a "top-down" multiregional model. The price level is determined for the state as a whole while state government spending is set exogenously and allocated among regions. For the primary economic variables, including employment by sector and personal income, the model follows a "bottom-up" approach in which regional values are summed to arrive at a state total.

Finally, there are four types of interregional links incorporated into the model. These links reflect how economic activity occurring in any of the six hinterland regions affects Anchorage as well as how activity in one hinterland region affects another hinterland region and thus, indirectly, affects Anchorage. The model contains feedbacks so that economic activity in Anchorage affects the hinterland regions, which then indirectly impacts Anchorage again. These interregional links are shown in Figure 2.B.

FIGURE 2A.
Hierarchial Structure of Anchorage Model

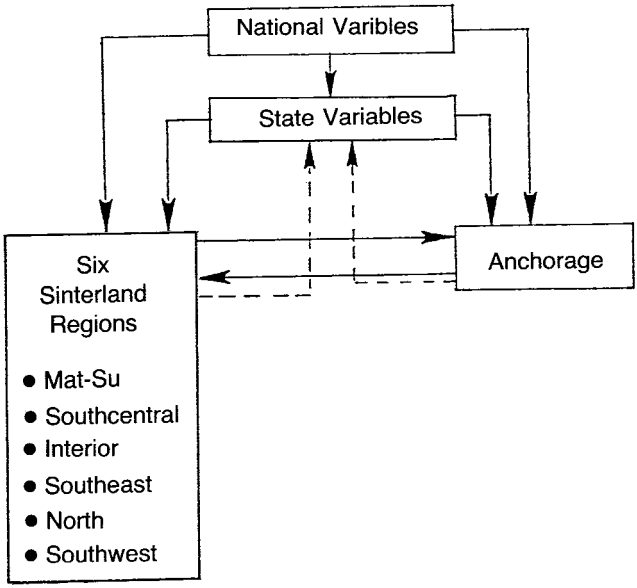


FIGURE 2B.
Interregional Links within Anchorage Model

HINTERLAND REGIONS		ANCHORAGE
• Resource Extraction	→	• Resource Extraction Headquarters
• Business Activity	→	• Business Support
• Residentiary Activity	→	• Residentiary Support
• Labor Market	⇄	• Labor Market

The first link reflects headquarters activities in Anchorage associated with resource extraction occurring in the hinterlands. This is best exemplified by the several hundred employees of Alyeska pipeline company who work in Anchorage, many hundred miles from the pipeline itself. The second and third links reflect Anchorage as a support center for population and business in the state and to a much lesser extent, the existence of support centers in other regions. The fourth link reflects the fact that the labor market is essentially statewide. Employment opportunities in the hinterland draw commuters from Anchorage and other hinterland regions. Simultaneously, jobs in Anchorage are filled by commuters from suburban communities.

The model structure is similar in each region except with much more detail for Anchorage.[2] Basic and government employment are exogenous in each region of the state. Support employment is a function of income and wealth within the region as well as in other regions. Wage rates in each region are influenced by national economic variables and also by activity in the state labor market. Income is the sum of residence-adjusted wages and other nonwage components of income. Regional economic variables are aggregated to produce state totals.

For Anchorage, employment and wages and salaries are determined at the two-digit SIC code level, and the nonwage components of income are modeled in detail. For each hinterland region, only five industrial aggregates are defined. They are high wage basic (i.e., petroleum), low wage basic (i.e., fish processing), support, government, and proprietors.

State and Anchorage populations are modeled in parallel, with aggregate population in the six hinterland regions calculated as the residual. Population is the sum of natural increase, calculated from a cohort-component model, and net migration, dependent upon conditions in both local and national labor markets.

The remainder of this section discusses the three most important links within the model.[3]

(a) Interregional Support Employment Links

For Anchorage, employment (EM_{Ak}) in each two-digit support industry (k) is a function of real income within Anchorage (YA), real per capita wealth in Anchorage (WA), and in some industries, real income arising in the hinterland regions (YH).

$$EM_{Ak} = f_k\,(YA, WA, YH) \qquad (1)$$

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[2] The conceptualization of model structure owes much to the prior development of the Alaska Econometric Model, described in Kresge, Morehouse, and Rogers [13], 1977.

[3] A more detailed description of the model structure is available from the authors (ISER, 1982).

These and all other stochastic equations are estimated by OLS or, where appropriate, single equation GLS, correcting for autocorrelations.

In each of the six hinterland regions, support sector employment in the aggregate is a function of demand (income) in all regions except Anchorage.[4] Thus, the model recognizes that support employment in Anchorage may be a function of income produced by employment in the Fairbanks region which is, in turn, the result of petroleum export demand generated on Alaska's North Slope.

Support sector employment in each of the hinterland regions is a function of real income given by an interregional support sector demand matrix (S).

$$EM = S'Y \tag{2}$$

where EM and Y are vectors of hinterland region support sector employment and income, respectively. Each element (S_{ij}) of the matrix represents the number of jobs (in thousands) in the support sector in region i, created by an increase in real income of one million dollars (real) in region j. These interregional links are similar to the treatment in Baird [1983].

The parameters used in the model for the S_{ij} were derived by a multistep procedure. First, support sector employment was regressed on own region income. Next, the zero elements of the matrix were set by assumption. Finally, the own-region coefficient values were distributed on a proportional basis among all other regions assumed to utilize the region as a support center.[5] The Appendix contains a discussion of the alternative methods attempted to estimate the values of the interregional support sector matrix.

(b) Labor Market Linkages

Wages earned in any region may accrue to residents living in any other region in the state or may flow outside the state.[6] In small regional economies, these flows are a function not only of relative wages and unemployment levels but also of the source of supply of skilled labor to perform specific functions. Thus in Alaska, Anchorge and the immediate surrounding area are the primary sources of skilled labor. The model allocates wages and employment by type (low-wage basic, high-wage basic, support, government, and proprietor) from place of work to place of residence:

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[4] By assumption, the Anchorage economy generates no support industry demand in the six hinterland regions.

[5] The results for Anchorage proved to be relatively insensitive to the values chosen for the off-diagonal matrix elements; however, the results for individual hinterland regions are affected by variation in these values.

[6] Wage flows into the state are assumed to be zero.

$$WRES = B'W \quad (3)$$

$$EMRES = B'EM \quad (4)$$

Where W is the matrix of wages paid in region j in industry group k

WRES is the matrix of wages of residents in region i in industry group k

EM is the matrix of employment in region j in industry group k

EMRES is the matrix of employed residents in region i in industry group k.

Each matrix element (b_{ij}) is the proportion of wages paid or employment occurring in region j which is allocated to region i.

Data limitations prohibited construction of separate matrices by category of employment. Employment flows were assumed to be proportional to wage flows. Thus, a single interregional wage and employee flow matrix was used. The Appendis describes the coefficients estimated for this matrix and discusses the estimation methods.

Regional wage rates were not a factor in the determination of employment flows. Both Anchorage real wage rates by two-digit SIC code industry and hinterland real wage rates (WR_{ik}) by aggregate industry categories were specified as a function of both national trends in employe compensation and statewide labor market conditions.

$$WR_{ik} = g_k \text{ (average US earnings, INDEX, RU)} \quad (5)$$

Here, WINDEX is the Alaskan wage in petroleum relative to U.S. average earnings — a measure of labor demand — and RU is the Alaskan unemployment rate relative to the national average — a measure of labor supply.

(c) Top-down links from the state to region

The demographic component of the model has a modified top-down structure. Total and detailed population characteristics are calculated independently for the state as a whole and for Anchorage, using a basic cohort-component structure. Hinterland population (the six regions combined) is the residual. In each case, total population in a year is the sum of four distinct components — civilian non-Native, civilian Native, active-duty military and their dependents, and civilian migration — each with its own age-sex distribution. Each of these four population groups has a distinct location distribution between Anchorage and the hinterlands.

Net civilian migration flows to Alaska and to Anchorage are each determined simultaneously with regional unemployment rates and real wage

levels, given national labor market conditions.[7] The equations are specified as follows for both Alaska and Anchorage:

$$POPMIGi = m_i (RUi, RWRi, DELEMPi) \quad (6)$$

where POPMIGi is net migration; RUi is the ratio of local to U.S. civilian resident unemployment rates; RWRi is the percentage change in the ratio of local real wage to U.S. real earnings; and DELEMPi is the change in total employment.

The Alaska resident labor force depends directly on the population aged 15-64. Unemployment in both the Anchorage labor market and in the state as a whole is total labor force less total employment. Attempts to include relative real wages and unemployment rates between Anchorage and other parts of the state as determinants of migration were unsuccessful. Thus, the model assumes that net migration to Anchorage depends only on local labor market conditions relative to national conditions.

Additional jobs generated in a hinterland region affect migration to Anchorage directly, however, since some of these jobs are filled by Anchorage residents.

The Anchorage labor force also includes a proportion of the suburban population (residents of the Matanuska-Susitna Borough) which is assumed to remain in the Anchorage labor market but resides outside the city limits. This commuting labor force is determined by an exogenous rate of emigration from the Anchorage population and is assumed to have demographic and labor market characteristics similar to those of the Anchorage population.

In addition to the demographic model, the regional distribution of economic activity either exogenous to the state or determined at the state level is a top-down allocation. This is done to assure that the allocation of extractive industry employment and economic activity generated by state government expenditures on operations, capital, and transfers is carried out in a regionally consistent manner. Identification of the regional location of these activities is important for calculation of their aggregate impact on the state as well as the size of their impact on Anchorage.

The components of the Anchorage consumer price index (ACPIm) are a function of current and lagged demand conditions in the statewide labor market reflected by WINDEX as well as movements of the national index (USCPI).

$$ACPI_m = k_m(WINDEX, USCPI) \quad (7)$$

Interregional cost differentials are not included in the model.

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[7] The military populations for Anchorage and the hinterlands are assumed to retain the same age-sex distribution over time and fluctuate in proportion to military employment. Accordingly, there is no need to compute military births, deaths, or migration flows.

IV. Model Validation

The model[8] was simulated over the historical period from 1969 through 1979. This was a period of dramatic change and growth of the Anchorage economy, as is illustrated in Figure 3. Table 3 shows the root mean square error (RMSE) and mean absolute percent error (MAPE) for the four most important aggregate economic variables. The model replicates both the accelerated growth in the mid-1970s in response to Alyeska oil pipeline construction taking place in the hinterland and the subsequent deceleration which followed its completion. The error is larger in the latter years, however, than in the smooth growth period of the earlier 1970s.

FIGURE 3
ANCHORAGE EMPLOYMENT
ACTUAL COMPARED TO HISTORICAL SIMULATION

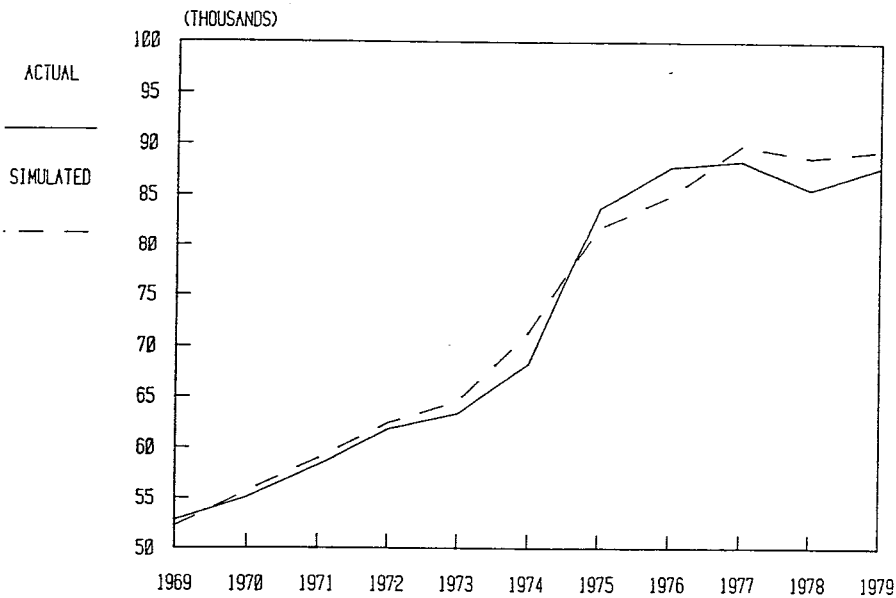

TABLE 3. HISTORICAL SIMULATION RESULTS

Variable	RMSE	MAPE
Employment		
Anchorage	2.35	.88
State	3.16	1.94
Real Income		
Anchorage	6.27	3.55
State	4.81	2.69

[8] The demographic model was exogenous in the historical simulation.

NOTES: RMSE = root mean squared error
MAPE = mean absolute percent error

Historical simulation of economic model covering the period 1969 through 1979; population exogenous.

V. Model Use

The primary purpose of the model is to produce long-run projections and impact analyses of population and economic activity for Anchorage. The model simultaneously produces more aggregate results for each of the six hinterland regions and for the state in aggregate. Since future economic growth in Anchorage will, to a large extent, be determined by resource development and infrastructure construction in the hinterland, the ability of the model to trace out the differential impacts on Anchorage of different types of resource-based or public projects occurring primarily in the hinterland is of particular interest. In this section, two impact analyses which emphasize the interregional links in the model are presented.

Petrochemicals. Construction of a world-scale petrochemical plant would have a substantial effect on the state economy. During construction, peak employment would be six thousand; the plant itself would employ over one thousand. Several different locations have been considered, and the choice of a site would determine the impact upon both Anchorage and the state as a whole. Table 4 presents the employment and population impacts upon Anchorage of two alternative locations for the plant — Anchorage and a site in a hinterland region (Valdez).

If the plant were built adjacent to the city of Anchorage, both construction and operation phase impacts on the city would be substantial. Employment would peak at 8.7 thousand jobs and stabilize at 1.6 thousand during the operational phase. A site outside of Anchorage, in the hinterland, would have a small direct impact, limited to a headquarters office of 100 employees. The indirect employment would be considerable, however. During construction, 2.3 thousand jobs in total would be created, and population would increase by 4.4 thousand. Comparing the state aggregate population impact profiles for the two locations shows that a site in the hinterland would result in a smaller impact which would peak and decline more rapidly than an urban location. This is because of the different location of support activities in the two cases. In the peak construction year, the Anchorage site would generate 9.9 thousand jobs compared to 9.6 thousand for the Valdez site. The inclusion of interregional linkages captures two effects. First, it shows that the location of natural resource production activity does matter. Secondly, even when the activity occurs outside of Anchorage, its role as a support center creates a significant impact in Anchorage.

Capital Relocation. The second analysis involves the relocation of an activity currently taking place within Alaska from one location to another. For many years, Alaska has debated the merits of moving the capital from its relatively inaccessible location in Juneau (Southeast) to a spot closer to the

TABLE 4. IMPACT ON ANCHORAGE OF WORLD-SCALE PETROCHEMICALS

(thousand)

	Location	
	Hinterland (Valdez[a])	Adjacent to Anchorage (Fire Island)
	Change in Employment	
1984	0	0
1985	.054	.195
1986	.115	.277
1987	.344	1.133
1988	2.348	6.521
1989	2.026	8.748
1990	1.125	3.912
1991	.606	2.056
1992	.465	1.553
1993	.217	.971
1994	.104	.451
1995	.155	.576
2000	.278	1.631
	Change in Population	
1984	0	0
1985	.102	0
1986	.210	.525
1987	.644	2.138
1988	4.450	12.270
1989	3.960	16.652
1990	4.045	17.068
1991	2.527	13.923
1992	1.061	10.077
1993	.440	6.707
1994	.168	2.126
1995	.258	.805
2000	.498	2.955

[a] About 350 road miles from Anchorage

population center of the state in the Southcentral part of the state. This model can project the impact on Anchorage of a shift in the location of economic activity from one region outside of Anchorage to another region closer to but still outside of the city. In this case, there is no net change in statewide basic sector activity (defined to include government). The relocation of 3.4 thousand state and government jobs from Juneau to the new capital site comprises the primary shift in the location of basic sector activity. Anchorage is directly affected by a capital relocation to a site north of the city in two ways. A portion of construction employment, declining with time, is supplied by An-

chorage firms. After completion of the new capital, a number of state government jobs, eventually reaching 1.3 thousand, is relocated from Anchorage to the new capital site.

The employment and population impacts for anchorage and the state are contrasted in Table 5. During construction of the new capital site, there is a modest expansion of employment and population, both statewide and in Anchorage. After relocation is complete, total statewide activity returns to a level close to the no-move base case. Population is slightly higher as a legacy of the construction boom, and employment is slightly lower as a legacy of the slightly higher price level associated with the boom. Anchorage residents share in a portion of the construction activity in the early years, initially drawing population in from the hinterland to supplement the labor force already there. After construction, the employment level in Anchorage falls below the no-move case. The net employment decline is slightly in excess of the state employees relocated from Anchorage to the new capital site. Anchorage gains in indirect support employment from the workers relocated from Juneau almost as much as it loses directly from the relocation of state employees from Anchorage to the new capital site.

TABLE 5. IMPACT OF CAPITAL RELOCATION

(thousands)

	Anchorage		State of Alaska	
	Employment	**Population**	**Employment**	**Population**
1984	0	0	0	0
1985	.168	.302	.291	.750
1986	.439	.805	.750	.823
1987	.618	1.140	1.170	1.507
1988	.865	1.593	1.566	2.294
1989	.375	.750	.669	1.858
1990	.462	.758	.932	1.872
1991	.169	.362	.402	1.422
1992	.016	.085	1.093	1.927
1993	- .591	- .765	.321	1.266
1994	-1.495	-2.653	.214	1.027
1995	-1.608	-2.913	- .187	.523
2000	-1.572	-2.860	- .097	.110

VI. Conclusion

This paper describes an econometric model of a small regional economy imbedded within its larger market area. The model extends the traditional demand-driven regional economic model to a small frontier economy with an extractive industry base. To capture the important factors controlling growth in the economy, the model incorporates a series of interregional linkages among the seven regions to the state. By recognizing that the economy of Anchorage