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THE SPATIAL AND TEMPORAL ECONOMIC IMPACT OF A NUCLEAR ENERGY CENTER - A METHODOLOGICAL DISCOURSE AND APPLICATION TO A SOUTHERN REGIONAL SITE

by

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Presented at AAEA meetings, Ur Bana-Champaign
July 27-30, 1980

Introduction

The question of the relative advantages and disadvantages of a cluster of 12 1200 megawatt nuclear electric generating plants in a single geographic area vis a vis geographic dispersal of plants has been the subject of several recent studies. These studies have indicated that nuclear energy centers do not involve technical issues that would inhibit their construction and operation. Indeed, it is the potential savings in construction costs that provide some of the appeal of the NEC relative to dispersal of sites. However, it has been noted that in regard to the NEC concept, "The more difficult issues appear to be institutional and revolve around land use planning, land requisition, taxation and equitable revenue distribution, ownership, and management of NEC's, the legal and regulatory aspects of transmitting electricity across state boundaries, and the roles of the various levels of government in all of the above." [2, p. 1-11].

These institutional issues must be addressed at the regional level where the region of interest is the area to be impacted by the construction and operation of a NEC [3]. The question of the socioeconomic impact of a NEC may be addressed by reference to the now widely used economic-demographic models of large scale construction [see 3, 4, 5 for excellent examples of how these models might be applied to nuclear energy plants]. However, economic-demographic models can only be a starting point for the socioeconomic impact of a NEC. These models forecast population, employment, government revenues and expenditures in a spatial and temporal context. Accordingly, the forecasts provided are vital sources of information to the local political subdivisions that make social overhead capital investment decisions. Better forecasts provide the opportunity for a wiser

investment strategy by public and private decision makers as they respectively attempt to maximize community satisfaction or maximize profits over time.

In summary, the purposes of this paper are to provide a methodology that is generally applicable for the assessment of the regional impact of a NEC, and to apply the methodology to the Anderson County, South Carolina site. Regional impact is defined for these purposes to include the employment, population and income impacts on the region of interest and the spatial allocation of these variables within the study region. Of course, from the perspective of the local policy makers, estimates of revenue and expenditures in the public sector are important considerations. Thus, the public sector analysis needs to be carried out once the economic-demographic impacts are known. Fortunately, there are many fiscal impact models available; a review of some are presented in Burchell and Listokin [6].

The Study Region

Although the proposed NEC would be located in Anderson County, South Carolina, the area impacted by the construction and operation of a NEC goes beyond the county borders. The impact is a 12 county area in South Carolina and Georgia.

The impact area was defined to include the counties of residence for workers that commute to Anderson County, South Carolina. It is assumed that a NEC in Anderson County will draw workers, at least, from those counties that were supplying labor to Anderson County as of 1970. This is a conservative estimate of the size of the regional labor pool for a project as large as a NEC.

The Regional Economic Forecasting Model

The model used to forecast output, employment and income for the region is a nonsurvey input-output (IO) technique developed by Mulkey and Hite[7]. This model may be employed to forecast regional economic activity for any region in the U.S. for which sectoral employment data exist.[1] The model may be employed to forecast both a baseline level of activity for the region (without the NEC) and an impact scenario (the NEC impact). (See the Appendix for model derivation)

The NEC Impact

The NEC impact is estimated in three steps. First, direct employment and income effects from the construction and operation of a NEC are considered. Second, indirect jobs and income generated from material purchases and payrolls during NEC construction and operation are estimated. Third, the spatial distribution of the employment, income and population changes associated with the NEC is estimated for a 12 county impact region.

Estimates of the NEC Impact

Given the final demand vectors (estimated from engineering data [13]), the indirect effects follow from the procedures described below:

(1) $\Delta X^r = (I - A^r)^{-1} \Delta Y^r$

(2) $\Delta I^r = a^r \Delta X^r$

(3) $\Delta E^r = p^r \Delta X^r$

where: ΔX^r = change in regional output vector, nxl,

ΔY^r = change in regional final demand associated with the NEC, nxl,

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1. A note of caution is needed here. Nonsurvey techniques have been subjected to criticism (see Miernyk [20] for a recent example). Moreover, small regions (e.g., one county) have large and unstable import coefficients.

a^r = household row coefficient vector, 1xn, in the regionalized matrix A^r,

ΔE^r = change in regional employment vector, nx1,

p^r = productivity (employment/output) ratios vector, 1xn, trended to the forecast year.

A review of prior studies [16-21] led to the assumption of a 35 percent rate of inmigration for construction workers and 10 percent for operating and maintenance workers. Indirect workers were assumed to be supplied locally after consideration of the ability of the regional labor force to provide the regional indirect workers (see Henry [29]). Table 1 reveals the 12 county employment impact of the NEC. The population impact is then determined from applying an average family size to inmigrating workers (see Henry [29]. Once this region-wide impact is determined, the spatial allocation of the new employees and population follows.

Spatial Allocation Model

The region-wide forecasts of employment and population are next disaggregated to the county, County Census Division and municipal level. This stage of the analysis is likely the most difficult in terms of accuracy but the need for forecasts at the community level are necessary if the fiscal impact of a NEC is to be estimated. County and municipal officials need estimates of the likely change in employment and population in their areas if they are to plan effectively for the provision of public services.

Spatial Allocation of NEC Impact Population, Employment and Income

People moving into the region to work at the NEC will consider two major facets of the particular area they select as a residence. Ceteris

TABLE 1

Local and Non-Local NEC Employment Impacts - 12 County Area

Year	Construction[a]		Operation[b]		Indirect[c]		Sum Project Related: Local[d]		% Projected Lab Force	
	Total	Local	Total	Local	Total	Local	Total	Local	LF	%
1984	800	520	0	0	919	.	1719	1439		
1985	1800	1170	0	0	1859	.	3659	3029	412,313	0.73
1986	3100	2015	0	0	3120	.	6220	5135		
1987	4200	2730	0	0	4038	.	8238	6768		
1988	5400	3510	0	0	5158	.	10558	8668		
1989	5900	3835	0	0	5670	.	11570	9505		
1990	5500	3575	147	132	5040	.	10687	8747	458,749	1.90
1991	5300	3445	221	199	4918	.	10439	8562		
1992	5600	3640	294	265	5306	.	11200	9211		
1993	5650	3677	441	397	5423	.	11514	9497		
1994	5400	3510	515	463	5269	.	11184	9242		
1995	5500	3575	588	529	5491	.	11579	9595	501,744	1.90
1996	5300	3445	735	661	5384	.	11419	9490		
1997	5400	3510	809	728	5569	.	11778	9807		
1998	5800	3770	882	794	6045	.	12727	10609		
1999	5400	3510	1029	926	5774	.	12203	10210		
2000	5300	3445	1103	993	5814	.	12217	10252	542,945	1.90
2001	5600	3640	1176	1058	6269	.	13045	10967		

Continued

TABLE 1

(Continued) Local and Non-Local NEC Employment Impacts -
12 County Area

Year	Construction[a]		Operation[b]		Indirect[c]		Sum Project Related: Local[d]		% Projected Lab Force	
	Total	Local	Total	Local	Total	Local	Total	Local	LF	%
2002	5400	3510	1323	1191	6157	.	12880	10858		
2003	5300	3445	1397	1257	6201	.	12898	10903	.	
2004	2700	1755	1470	1323	3736	.	7906	6814		
2005	1200	780	1617	1455	2298	.	5115	4533	583,628	0.78
2006	500	325	1764	1588	1736	.	4000	3649		
2007	0	0	1764	1588	1159	.	2923	2747		

[a] EBASCO [13] and assumes 65% is locally supplied.

[b] Derived from EBASCO [3] and assumes 90% is locally supplied.

[c] IO Model Projections: assumes 100% is locally supplied.

[d] Baseline employment projection from IO model are multiplied by 1.05 to reflect labor force available.

paribus, it can be expected that people will desire to locate near the site so as to minimize transportation costs.[2] At the same time, people are likely to be attracted to a place that provides a wide range of private and public goods. Population of a place provides a proxy for the availability of these goods. Gravity models have been employed in economic-demographic impact models to allocate project-related in-movers associated with large scale construction projects of fossil fuel electric generating plants in western North Dakota [25].

Of course, places that are similar in population and distance to site may differ in their attractiveness for a variety of reasons. Housing costs and availability, shopping facilities, etc., may differ enough so that one of these places is preferred by in-movers. Thus, local knowledge of such variables as the local housing market allows some further local judgement to be incorporated into the spatial allocation process [see 24 for a general discussion of the gravity model].

In general, the spatial allocation procedure to be employed is:

$$Bi = W \; Pi^{\alpha}/Di^{\beta}$$

$$Ai = Bi / \sum_{i=1}^{n} Bi$$

where: Bi = number of movers to place i,

Pi = population of place i,

Di = distance of place i from the site,

W = constant to be empirically estimated,

Ai = proportion of inmigrants to be allocated to place i,

α = population elasticity to be estimated,

2. When in-movers to Duke Power Company's Catawba Plant were asked to note their reasons for locating in a particular place, "Being close to work" was very important to 53 percent of the in-movers, "Cost of Housing" was very important to 12 percent of the in-movers, "Availability of Housing" was very important to 19 percent of the in-movers, "Quality of Schools" was very important to 6 percent of the in-movers, and "Good Recreation" was very important to 7 percent of the in-movers.

β = distance elasticity to be estimated.

The elasticity measures, α and β are expected to differ for construction in-movers and non-movers to the site and are estimated from Duke Power Company survey data for the Catawba Nuclear Plants in South Carolina.[3] Using CCD's as the geographical units, the α and β parameters were found using ordinary least squares: $\log Bi = \gamma + \alpha \log Pi + \beta \log Di$, where $\gamma = \log W$. Empirical results are summarized in Table 2.

TABLE 2

Gravity Model Estimates for In-movers[a] and Non-movers[b] for the Catawba Nuclear Plant

	Number of CCD's	γ	α	β	R^2	F-Statistic
In-movers	25	4.12 (3.97)*	.409 (4.12)*	-1.896 (-9.87)*	0.81	50.0*
Non-movers	73	1.56 (1.34)	.545 (5.29)*	-1.322 (-8.28)*	0.59	52.0*

Note: t valuesare shown in parenthesis

* Statistically significant at the 1% level

[a]In-movers are defined to be employees that have moved their place of residence in order to work at the construction site

[b]Non-movers are constuction workers from the region that did not move to the site but commute

3. For example, in North Dakota, the distance parameter was -1.5 for construction workers, -2.9 for operating workers, and -1.6 for project related indirect workers [25, p. 72].

In-movers associated with the peak years of impact 1988-2003 will comprise about two percent of the expected labor force. The year 1989 represents the peak construction labor force year with a total of 5,900 workers and 2,065 in-movers. With about 40 additional in-movers for operation, a total of about 2,100 in-movers is expected. Once this inmigration has occurred, little additional inmigration is expected from the NEC project as these workers are expected to become long-term residents. The additional inmigration of operating workers is more than offset by eventual reduction in construction in-movers[4] (see Table 1). Thus, the problem is to distribute these employees to each of the cities in the region. After the employees have been located, the number of in-movers with families, average family size, and number of school age children, as determined from previous nuclear plant impact studies in the area [15-20], may be used to estimate the total population impact for specific communities. Spatial allocation of income is based on the resulting residential spatial allocation.

Spatial allocation of non-movers is the remaining question in terms of disaggregation of the regional impact of the NEC. Three groups of non-movers are affected by the NEC; construction, operating and indirect workers.

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4. It is assumed here that when construction jobs finish that outmigration will result for those workers that moved to the area. However, an equally plausible assumption is that there will not be a wave of outmigration as the NEC construction jobs end. The reason is that the NEC construction jobs may last 15 years rather than 2 to 3 years with other nuclear plant construction. Once a person lives in an area for 15 years, it is quite likely he will remain in the area after the NEC construction phase ends.

Construction

Commuter patterns of non-mover constuction workers at other nuclear plants are analyzed using the Duke Power Company survey data. As noted in Table 2 the spatial elasticities are $\alpha = .55$ and $\beta = -1.32$ for non-mover construction workers. The absolute value of the distance elasticity is smaller for non-movers than in-movers, indicating that current residents of the region are willing to commute further to work than in-movers ($\beta = -1.90$). This smaller distance elasticity is expected since residents within commuting distance have social and economic ties to their current places of residence and need not move to the work site whereas in-movers have made the decision to move to the region and are expected to be more strongly affected by the distance parameters as they make their residential decision.

Operating

Operating workforces are expected to be less willing to commute long distances than construction workers since the operators generally have longer term employment than construction workers. Accordingly, it would be expected that the distance elasticity for operating workers would exceed that of construction workers [see footnote 3 for example]. However, the NEC construction phase (18 years) is a long-term construction job and thus the operation and construction workforces can both be expected to behave in a similar fashion with respect to their evaluation of the friction of distance. Thus, the assumption is made that operating and construction commuters will have the same distance elasticity.[5]

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5. Further evidence of a high distance elasticity is the expected effect of rising transportation costs on residential location preferences. In the Alonso framework, increases in commuting costs will result in steeper bid price curves for residential users of land and result in location closer into the work site [27, p. 111].

Indirect

The indirect labor force associated with the project is distributed to counties and CCD's according to the distribution of the construction and operating workforces. Table 3 lists the 1980 NEC related employment and income changes for each of the 93 CCD's and 12 counties of the impact region.[6] NEC population impacts may be estimated by multiplying the in-movers column by 2.41, the average family size.

Summary and Conclusion

The thrust of this research has been to integrate several socioeconomic models (IO, gravity) with various demographic assumptions (inmigration patterns, average family size, etc.) based on prior studies to arrive at a framework for estimating the economic impact of a NEC in a rural area of South Carolina. Clearly, there are many areas where improvements could be made given the resources. First, population forecasts with demographic detail for age and sex are desirable for many public decision makers. A cohort-survival model seems appropriate, [see 5]. The IO model needs to be adjusted for changes in technology and relative prices expected during the forecast year [see 28].

Key behavioral assumptions regarding in-movers and commuting patterns may be reconsidered from the perspective of the desirability of living near a NEC. Unfortunately, even very large socioeconomic research budgets may not be sufficient to shed light on the magnitude of parameters such as the percentage of in-movers for a NEC in Anderson County, South Carolina.

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6. Tables for each year of the project are available from the author.

Finally, the results of the research show that an NEC in Anderson County will maintain the regional economy at near full employment throughout the construction period. A maximum of about 2,000 workers will immigrate during the construction phase. An associated population change of about 5,000 is expected. The total employment impact represents about two percent of the forecasted regional labor force. These positive economic-demographic expectations would be expected to put upward pressures on real wages in the region and demands for local government services. The smaller CCD's such as Starr in Anderson County would be expected to feel strain on their public services. Starr's population would increase by about 21 percent from 1985 to 1989.[7] Although this is a large percentage change, it occurs over a four-year period and the area should have time to adjust. In other words, the boom town condition of some energy development towns in the west does not appear to be an appropriate model for a NEC development in Anderson County, South Carolina.

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[7]Based on a 1985 projected population of 5084 for Starr CCD and a NEC population change of 1,075 by 1989.

TABLE 3

GRAVITY MODEL ALLOCATING MOVERS & COMMUTERS & DIRECT & INDIRECT INCOME & INDIRECT EMPLOYMENT IN ANDERSON NEC AREA FOR 1979

GRS	CCD	CCDNO	CO	DIST	NEWMOV	COMMUT	DCCDINC	ICCDINC	TCCDINC	INDEMP
1	ANDERSON	1	ANDERSN	12.8	115	226	5964.4	2983.72	8945.1	326
2	ANDERSON NORTH	2	ANDERSN	17.2	41	83	2176.0	1067.68	3243.5	119
3	ANDERSON SOUTH	3	ANDERSN	8.9	183	278	8125.0	4059.49	12182.4	444
4	BELTON	4	ANDERSN	19.8	25	51	1345.5	672.41	2017.9	73
5	BELTON EAST	5	ANDERSN	22.2	10	17	470.4	235.08	705.5	26
6	BELTON WEST	6	ANDERSN	17.6	29	54	1464.2	731.76	2196.0	80
7	BRUSHY CREEK	7	ANDERSN	28.2	15	33	815.1	407.37	1222.5	45
8	FORK	8	ANDERSN	13.3	33	47	1412.2	705.76	2118.0	77
9	HONEAPATH	9	ANDERSN	22.6	22	50	1262.3	630.85	1893.2	69
10	IVA	10	ANDERSN	7.3	156	172	5848.0	2922.56	8770.5	319
11	PELZER	11	ANDERSN	26.0	14	32	801.6	400.62	1202.3	44
12	PENDLETON EAST	12	ANDERSN	19.8	23	47	1236.2	617.81	1854.1	68
13	PENDLETON WEST	13	ANDERSN	19.6	23	45	1195.3	597.34	1792.6	65
14	STARR	14	ANDERSN	4.0	446	349	13972.2	6982.66	20954.8	763
15	WILLIAMSTON	15	ANDERSN	24.3	15	34	860.7	430.16	1290.9	47
16	WILLIAMSTON RUR	16	ANDERSN	22.2	16	31	822.6	411.12	1233.8	45
17	ABBEVILLE	17	ABBEVIL	25.9	19	50	1228.9	614.15	1843.1	67
18	ANDRE-LONDESVIL	18	ABBEVIL	14.0	34	52	1519.4	759.35	2278.7	83
19	CALHOUNFALLS	19	ABBEVIL	21.8	17	33	914.8	457.16	1371.9	50
20	DONALDS	20	ABBEVIL	23.8	13	27	698.6	349.15	1047.8	38
21	DUEWEST	21	ABBEVIL	22.0	17	35	933.8	466.69	1370.5	50
22	CORESTEE	22	GVILLE	36.4	9	25	597.5	298.63	896.2	33
23	FOUNTAININN	23	GVILLE	39.6	6	18	433.2	216.50	649.7	24
24	HIGHLAND	24	GVILLE	36.7	8	22	527.9	263.84	791.8	29
25	GREENVILLE	25	GVILLE	39.4	19	79	1715.6	857.38	2573.0	94
26	GREENVILLE EAST	26	GVILLE	42.1	10	40	878.8	439.21	1318.0	48
27	GREENVILLE NORT	27	GVILLE	42.5	10	37	830.0	414.81	1244.8	45
28	GREENVILLE SWES	28	GVILLE	35.4	19	70	1560.1	779.67	2339.8	85
29	GREER	29	GVILLE	49.5	6	24	534.0	266.86	800.8	29
30	PARIS	30	GVILLE	44.3	7	27	604.7	302.21	906.9	33
31	PIEDMONT	31	GVILLE	28.7	14	37	891.7	445.63	1337.3	49
32	RIVERSIDE	32	GVILLE	42.3	10	40	881.2	440.38	1321.6	48
33	SIMPSONVILLE	33	GVILLE	38.8	8	26	600.4	300.07	900.5	33
34	SLATER	34	GVILLE	48.5	6	13	291.0	145.41	436.4	16
35	TAYLORS	35	GVILLE	44.9	7	24	549.1	274.39	823.4	30
36	TIGERVILLE	36	GVILLE	30.8	9	25	527.5	263.61	791.1	29
37	TRAVELERS REST	37	GVILLE	45.5	6	21	486.1	242.94	729.1	27
38	WOODVILLE	38	GVILLE	29.3	10	26	634.3	316.97	951.2	35
39	GREENWOOD	39	GRNWOOD	37.0	14	48	1081.5	540.46	1621.9	59
40	GREENWOOD EAST	40	GRNWOOD	39.8	5	14	339.6	169.73	509.4	19
41	GREENWOOD NORTH	41	GRNWOOD	37.0	7	22	513.3	256.52	769.9	28
42	GREENWOOD WEST	42	GRNWOOD	34.8	9	25	594.0	296.85	890.8	32
43	HODGES	43	GRNWOOD	30.0	13	35	831.9	415.75	1247.6	45
44	KINSEY	44	GRNWOOD	47.8	3	8	194.0	96.94	290.9	11
45	NINETYSIX	45	GRNWOOD	43.7	6	18	420.5	210.15	630.6	22
46	TROY	46	GRNWOOD	30.5	7	16	394.6	197.22	591.8	22
47	CLINTON	47	LAURENS	50.8	7	28	605.1	302.91	909.0	33
48	CROSS HILL	48	LAURENS	44.0	4	13	305.2	152.52	457.7	17
49	CERY COUNT	49	LAURENS	40.8	7	21	482.7	241.23	723.9	26
50	JOANNA	50	LAURENS	54.3	3	10	221.2	110.63	331.9	12
51	LAURENS	51	LAURENS	43.7	7	26	567.5	283.60	851.1	32
52	LAURENS RURAL	52	LAURENS	41.4	5	16	367.0	183.40	550.4	20
53	PRINCETON	53	LAURENS	33.9	9	23	566.4	284.07	852.5	31
54	WATTSMILL	54	LAURENS	45.2	5	14	332.61	166.22	498.83	18
55	MCCORMICK	55	MCCORM	41.8	6	18	418.40	209.10	627.50	23
56	MICARREL	56	MCCORM	28.1	8	17	429.63	214.71	644.35	23
57	PARKSVILLE	57	MCCORM	51.1	3	8	186.37	93.14	279.51	10
58	LONGCREEK	58	OCONEE	39.8	4	10	238.07	118.48	357.05	13
59	MOUNTAINREST	59	OCONEE	40.8	3	9	213.92	106.91	320.83	12
60	OAKWAY	60	OCONEE	22.1	18	37	955.93	477.73	1433.66	52
61	SALEM	61	OCONEE	37.8	5	15	357.13	178.48	535.60	20
62	SENECA	62	OCONEE	24.2	18	42	1066.10	532.79	1598.89	58
63	SENECA NORTH	63	OCONEE	27.8	11	27	664.40	332.04	996.43	36
64	SENECA SOUTH	64	OCONEE	20.3	24	49	1284.71	642.04	1926.75	70
65	WALHALLA	65	OCONEE	44.9	5	14	331.94	165.89	497.82	18
66	WALHALLA NORTH	66	OCONEE	41.6	5	17	396.70	198.25	594.95	21
67	WALHALLA SOUTH	67	OCONEE	46.7	4	12	271.58	135.72	407.30	15
68	WESTMINSTER	68	OCONEE	27.5	15	38	935.30	467.42	1402.72	51
69	CENTRAL	69	PICKENS	24.2	17	39	954.24	476.88	1431.12	52
70	CLEMSON	70	PICKENS	22.0	29	70	1740.07	869.61	2609.68	95
71	EASLEY	71	PICKENS	33.6	13	39	898.36	448.96	1347.32	49
72	EASLEY EAST	72	PICKENS	38.1	5	14	334.52	167.18	501.70	18
73	EASLEY RURAL	73	PICKENS	31.1	12	33	787.45	393.53	1180.99	43
74	FOREST	74	PICKENS	46.5	3	8	194.28	97.09	291.37	11
75	LIBERTY	75	PICKENS	29.0	12	30	737.33	368.48	1105.81	40
76	PICKENS EAST	76	PICKENS	42.3	5	14	323.69	161.77	485.46	18
77	PICKENS WEST	77	PICKENS	35.8	9	29	668.92	334.30	1003.22	37
78	SIX MILE	78	PICKENS	30.1	11	28	692.25	345.95	1038.20	38
79	POWPAN	79	ELBERT	19.1	19	33	905.77	452.66	1358.43	49
80	COLDWATERCREEK	80	ELBERT	13.8	33	49	1446.30	722.79	2169.09	79
81	ELMEEPTON	81	ELBERT	18.2	32	64	1491.50	745.33	2236.83	82
82	ROYCEPEEL	82	ELBERT	21.8	9	14	404.26	202.08	606.45	22
83	MIDDLETON	83	ELBERT	18.4	27	53	1411.60	705.60	2117.50	77
84	CARNESVILLE	84	FRKLN	26.6	12	27	694.46	347.06	1041.52	38
85	LAVONIA	85	FRKLN	19.6	23	45	1200.90	600.15	1801.05	66
86	ROYSTONA	86	FRKLN	20.8	20	42	1091.08	545.27	1636.35	60
87	SANDYCROSS	87	FRKLN	27.2	8	16	413.09	206.45	619.54	23
88	ROWERSVILE	88	HART	18.1	20	33	925.52	462.53	1388.05	51
89	HARTWELL N E S	89	HART	19.0	38	85	2166.73	1082.83	3249.56	118
90	ROYSTONB	92	HART	37.5	5	13	312.56	156.10	468.66	17
91	BROADRIVER	93	STEPHNS	28.4	15	36	882.58	441.07	1323.65	48
92	ROCKCREEK	94	STEPHNS	29.9	12	31	762.36	380.99	1143.35	42
93	TOCCOABT-CREEK	95	STEPHNS	28.9	15	42	1014.15	506.82	1520.97	55

Column Explanations:

DIST =CCD Centroid to NEC centroid distance in miles

NEWMOV = Construction + operation employees moving to CCD

COMMUT = Commuters from CCD to NEC site

DCCDINC = Construction + operating income earned by residents of CCD (thounds of 1973 dollars)

ICCDINC = Indirect workers income earned in CCD (thounds of 1973 dollars)

TCCDINC = DCCDINC + ICCDINC

Appendix

Regionalization of the National IO Model - Procedures Estimating Regional Transactions, Imports and Exports

First, location quotients are calculated for each sector in region (k) using the formula:

$$LQ_{ik} = (E_{ik} / \sum_{i=1}^{n} E_{ik}) \div (\sum_{k=1}^{m} E_{ik} / \sum_{i=1}^{n} \sum_{k=1}^{m} E_{ik}) \qquad (1)$$

where E_{ik} is the employment in the ith industry in region k and LQ_{ik} ik is the location quotient for industry i and region k in a nation with n industries and m regions. The location quotients for each regional industry i are then used to adjust national technical coefficients for that same industry so that:

$$k_{a_{ij}} = a_{ij} \text{ if } LQ_i \geq 1 \qquad (2)$$

$$\text{or} \quad k_{a_{ij}} = (a_{ij})\ (LQ_i) \text{ if } LQ_i < 1 \qquad (3)$$

where $k_{a_{ij}}$ is the adjusted technical coefficient for industry i in region k. In effect, if the regional location quotient for a given industry is less than unity, each coefficient in the row of the national matrix representing that industry is adjusted downward by multiplying industry technical coefficients by the industry location quotient. These new coefficients are then used with regional outputs totals $(kX_j)$to estimate regional transactions, or:

$$kX_{ij} = (kX_j)\ (k_{a_{ij}}),\ i=1 \ldots n,\ \text{all } j \qquad (4)$$

and each estimated transactions element (kX_{ij}) is then adjusted so that:

$$^{k}X_{ij} = {}^{k}X_{ij} \text{ if } \sum_{j} {}^{k}X_{ij} \leq {}^{k}X_{i}, \ ({}^{k}X_{i} = {}^{k}X_{j}), \tag{5}$$

$$\text{or} \quad {}^{k}\bar{X}_{ij} = {}^{k}X_{ij} \ ({}^{k}X_{i} / \sum_{j} {}^{k}X_{ij}) \text{ if } \sum_{j} {}^{k}X_{ij} \geq {}^{k}X_{i}, \tag{6}$$

where $^{k}X_{ij}$ is the estimated regional transactions element. Essentially, the adjustment in equations 5 and 6 prevents the in-region sales of a sector from exceeding the gross output of that sector.

The regional imports element, IM_{ij} (showing purchases by regional sector j from national sector i), is then estimated as a residual between total regional requirements and regional transactions, or:

$$IM_{ij} = ({}^{k}X_{j} \ . \ a_{ij}) - ({}^{k}\bar{X}_{ij}), \tag{7}$$

That is, total requirements from i to j in the region are calculated using the national coefficient (unadjusted) and imports are the difference between this figure and the regional transactions element $^{k}\bar{X}_{ij}$.

In estimating the regional exports matrix, exports for each regional sector i are estimated as the residual between the output of that sector and the estimated within-region sales of the sector. The resulting exports are then allocated to the national sector based on the assumption that regional sector exports are sold only in the form of interindustry purchases by the national sectors and that the sales patterns of each regional sector are the same as the interindustry sales of the corresponding national sector. These calculations are reflected by the formulae:

$$E_{i} = {}^{k}X_{j} - \sum_{j} {}^{k}X_{ij} \ , \tag{8}$$

$$\text{and} \quad EX_{ij} = (E_{i}) \ \ (X_{ij} / \sum_{j} X_{ij}), \tag{9}$$

where EX_{ij} expresses the sales of the i^{th} regional sector to national sector j, and $(X_{ij} / \sum_{j} X_{ij})$ expresses the sales of national sector i to

national sector j as a percentage of total interindustry sales of sector i.

At this juncture, the regional transactions matrix, AA, regional exports matrix AB, and regional imports matrix BA have been calculated. To complete the interregional matrix system, (see Figure A-1 - the U.S. transactions matrix less the Region, BB, is calculated as:

$$bb_{ij} = X_{ij} - {}^{k}X_{ij} \text{ for all } i, j \qquad (10)$$

where bb_{ij} is an element of the matrix BB.

Figure A-1

Interregional Flows Matrix

Regional Transactions Matrix (Interindustry) AA	Regional sales to U.S. (Regional exports) AB
U. S. Sales to Region (Regional Imports) BA	U. S. Transactions Matrix less Region BB

From Mulkey-Hite [7]

To convert this accounting framework into a forecasting tool, the BA and AB matrices are collapsed into column and row vectors $\overline{BA}$ and $\overline{AB}$. The $\overline{AB}$ row vector represents the purchases by the U. S. from S. C. industries and is thus equivalent to a S. C. export vector.

After adjusting national output totals to exclude within region output only, a matrix B is formed by augmenting BB by the additiona of the $\overline{AB}$ and $\overline{BA}$ vectors. Then, by dividing each column element by the column sum the direct input coefficients matrix A is found. The Leontief inverse, $(I-A)^{-1}$ may then be found.

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