# A COMPARISON OF ENERGY SELF-RELIANCE AND INDUSTRIAL DEVELOPMENT USING AN INPUT-OUTPUT MODEL

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Thesis submitted to the Faculty of the

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree of

MASTERS

in

Urban and Regional Planning

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January, 1984
Blacksburg, Virginia

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(ABSTRACT)

This thesis compares the benefits of energy self-reliance strategies with the benefits of industrial development strategies to determine which strategies create greater benefits as a method of economic development. A critical factor, which is examined, is the probability of success for industrial development strategies as opposed to the near certain benefits from the self-reliance strategies.

The methodology employs a Virginia input-output model using a regional purchase coefficient technique to regionalize the model for the New River Valley Region of Virginia. The strategies are developed based on two distinct expenditure levels, acting as resource constraints on the strategy selection, in order to compare the return on additional expenditures.

ACKNOWLEDGEMENTS

Towards the completion of this thesis, I was neither full of energy nor totally self-reliant, but was dependent on the encouragement and assistance of numerous other people. Family, friends, and faculty have all contributed in generally shaping my thoughts, guiding my research, and giving me the encouragement to continue.

Rick Simon, acting as my program advisor, thesis chairperson, and friend, deserves the most thanks. He helped in improving the quality of this thesis, by making suggestions, offering criticism, and steering me back on track when I invariably lost sight of the principle research question. He also offered encouragement and support for the topic that I wished to pursue.

Specifically, I would like to thank Richard Weisskoff, whose research on alternative development strategies in Puerto Rico, led me to pursue this specific question and methodology.

Benjamin Stevens and the Regional Science Research Institute, who had developed the original input-output model, provided me with assistance in applying their regionalization technique.

The Agricultural Economics Department at VPI&SU, and especially Andy Bernat, provided access to and additional assistance for using the model.

The Institute for Local Self-Reliance provided me with ideas in their publications and generally provide some of the leading examples of community self-reliance in the U.S. today.

The computer work involved in developing and writing this thesis represents one of the most valuable facets of experience that I gained during my Master's program. The Environmental and Urban Systems Department, and especially Len Simutis, are to be thanked for providing me with the opportunity to become computer literate.

The faculty and students of EUS provided a challenging and enjoyable environment in which to study and learn. In particular, John Levy and John Randolph, are to be thanked for their stimulating teaching in economics and energy and for serving on my thesis committee.

My wife, Becky, has provided loving support throughout the difficult process of writing this thesis. I can't imagine having accomplished this without her. In addition, she proved to be a good source of information as her related thesis was completed half a year prior to mine.

Finally, I would like to acknowledge my parents for their many contributions. They have endowed me with the ability and desire to pursue this research and have on countless occasions assisted with the more mundane aspect of finances. Though no one could foresee it, their assistance over four years ago with the purchase of our trusty diesal Rabbit has been an extra blessing as my wife and I have commuted back and forth between Richmond and Blacksburg to complete our degrees.

To Mom and Dad, who have waited so long, I dedicate this thesis.

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# Chapter I

# LOCAL ECONOMIC DEVELOPMENT

## 1.1 INTRODUCTION

In the pursuit of local economic development, the overwhelming majority of communities rely on strategies to attract or retain industry, but their efforts are met with varying degrees of success. The large number of communities competing for a relatively smaller number of new and expanding industry prevents a positive outcome for all communities. The limited success or failure that some communities face, suggests that there may be better alternatives than industrial development in which communities can invest their resources. The alternative proposed here is self-reliance strategies and specifically community energy planning. Borrowing from import substitution theories of development, self-reliance strategies seek to decrease the leakage of money from the local economy and generally employ a more direct method of intervention than do export-led development strategies.

The expected benefits of energy self-reliance strategies include direct and indirect job creation, higher real incomes (disposable income), a larger multiplier from increased linkages in the local economy, and more local

economic stability, expressed either in terms of cyclical sensitivity or in terms of local control of economic resources. Industrial development strategies can also provide these same benefits, but they do not always succeed. The question at issue is whether the energy self-reliance benefits, which can be predicted with some accuracy are greater than those benefits from industrial development which are assumed to be much greater in terms of job creation, but have a smaller probability of being realized.

## 1.2 CRITIQUE OF INDUSTRIAL DEVELOPMENT

Local economic development strategies traditionally have relied heavily on the export base theory of development and specifically on industrial development. Industrial development programs are the most politically expedient type of economic development program at all levels of government, due in part to the relative ease with which the underlying theory can be understood, the potentially high, direct benefits, and society's bias towards industrial growth. At the local level, these programs are expensive and highly competitive with little guarantee of success and at the national level the programs create a zero-sum situation, in which only the industries stand to gain.

Industrial development programs are touted as providing jobs, increasing income, improving the local tax base, diversifying the local economy, and generally improving the business climate. Strategies employed by these programs include community promotion, industrial development bonds, tax incentives, site development, provision of utilities, and land use or zoning incentives.

Criticism of industrial development strategies and refutation of the successful claims of proponents are well documented in development literature.[1] Research concerning the effectiveness of industrial development strategies dates back to the fifties and covers all aspects of industrial development from inexpensive promotion campaigns to industrial development bonds to site preparation. Doubts have been raised about the effectiveness of most of the various techniques, and the criticism ranges from simple ineffectiveness at the local level to attract industry to

[1] The following articles offer a perspective of the criticism leveled at industrial development programs:
David Mulkey and B. L. Dillman, "Location Effects of State and Local Industrial Development Subsidies," Growth and Change, vol 7, no. 2, (April, 1976), pp. 37-43.
Thomas P. Bergin and W. F. Eagan, "How Effective Are Industrial Development Programs?" Michigan Business Review, vol 12, (January, 1960), pp. 23-28.
Charles P. Rahe, "Industrial Development Agencies and the Location of New Plants," Growth and Change, vol 3, no. 4, (October, 1972), pp. 3-8.
John F. Due, "Studies of State-Local Tax Influences on Location of Industry," National Tax Journal, vol 14, no. 2, (June, 1961), pp. 163-173.

overall ineffectiveness at the national level, described as a zero sum situation. Research has included surveys of businesses concerning location decisions and statistical analysis of plant locations across the country.

The conclusions reached by much of the research is that industrial incentives and promotion are of secondary importance if any and are highly competitive and therefore more costly because the incentives are bid against each other. In the case of industrial development bonds (IDB's), the federal government pays the price in lost tax revenues and the local governments indirectly suffer from the competition, created by IDB's in the bond market, with their own municipal bonds, which drives up the rate of interest that they must offer to successfully market a municipal bond issue.[2]

Explanations offered by the critics of industrial development, for the continuing use of industrial development strategies include "bandwagon" effects and a "keeping up with the Joneses" attitude. "Since all of the neighboring communities are pursuing industrial development, then it must be right for our community," is the attitude that many communities take. Other communities initiate

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[2] Robert M. Bleiberg, "Sup With the Devil: 'Corporate Food Stamps' Do More Harm Than Good," editorial commentary in Barrons, (August 16, 1982), p. 9.

industrial development to compete with their neighbors. A tremendous competition has been created for attracting industry and it has placed communities in the position of joining the competition, because either they do not bother to question the decision or they feel that they must join just to stay even with their neighbors. The decision to pursue economic development and the decision of what method to employ are public policy decisions and should be recognized as such. They should not be circumvented by routinely electing to pursue industrial development.

Ineffectiveness at the local level is the most damaging criticism of industrial development. If some communities cannot expect to achieve success, then they should seek alternative methods of economic development. This thesis will present a head to head comparison of industrial development and energy self-reliance, taking into account the uncertainty associated with the former strategies' benefits.

The second important criticism, the zero sum situation, can be leveled at both types of strategies. Economists have taken the Physics principle, "for every action there is an equal and opposite reaction," and created a similar, albeit less strict, Economic principle, "there is no such thing as a free lunch." Using the "no free lunch" concept,

economists can reduce any situation to a zero sum game. But a zero sum game can have positive benefits, if the benefits gained are felt to be worth the costs imposed.

This thesis does not attempt to provide a thorough analysis of the zero sum situation and the positive and negative impacts of industrial development and energy self-reliance strategies. A brief discussion of the industrial development strategies and the zero sum situation follows and the next section offers a description of self-reliance strategies and the zero sum situation.

Industrial development strategies are criticized as zero sum, because jobs gained in one region means jobs lost in another region. Benefits from a local perspective accrue to the "winning" communities with costs imposed on the "losers." The wins and losses sum to zero. If the regional shift was intended by policy makers then the zero sum situation has positive externalities (at a price), but the competitive situation that exists among communities does not heed national policy. From a national perspective, benefits do accrue to industry, which may result in more total jobs. But if such a policy is desired, it would be more efficiently and equitably handled through the appropriate tax code, e.g. new or expanding business could receive more federal tax breaks on the cost of expansion. Such a tax

policy would offer the same job creation benefits without creating unintended, regional shifts in employment.

## 1.3 ALTERNATIVE ECONOMIC DEVELOPMENT

Alternative economic development methods have largely been ignored even though traditional methods may be ineffective. These methods are generally described in this thesis as self-reliance, but have aspects which are variously described in other literature as self-sufficiency and self-determination among others. Each of these terms alludes to a general concept of economic self-reliance, but each has a slightly different emphasis. They are described in the next sections.

While this thesis is primarily concerned with the local effects of self-reliance strategies, various benefits of these strategies are important when viewing the results from a national perspective. The zero sum situation is again present with some regions gaining employment and others losing employment. But rather than business benefitting, consumers and workers benefit instead. In either case additional jobs may be created, but the self-reliance strategies have other potential benefits as well, e.g. energy conservation and income effects of energy savings. These potential benefits should be very appropriate as a national policy.

Shifts in employment might occur with self-reliance strategies, but they are not perpetual strategies. Industrial development strategies can be employed forever with firms moving around among regions, but self-reliance strategies would be employed only until a general equilibrium was created, with each community and region providing those goods and services that it can economically support. The benefits of self-sufficiency and self-determination will cause each community and region to become more stable as industry and jobs shift less often.

### 1.3.1 Self-Sufficiency

Self-sufficiency analysis is described by Schaffer as a method to determine what sectors of a state or regional economy are not being provided by local production and represent "missing links".[3] Schaffer defines self-sufficiency output as "the outputs necessary to completely satisfy the direct and indirect requirements of domestic final-demand sectors".[4] Any sector of the economy, in which the local output is less than the self-sufficiency output, is identified as a "missing link". Industries in these

[3] William A. Schaffer, ed., On the Use of Input-Output Models for Regional Planning Studies in Applied Regional Science. (London: Martinus Nijhoff Social Science Division, 1976), pp. 79-91.

[4] Ibid., (pp. 80, 86).

sectors are potentially easier to attract and should be specifically targeted. Industrial development strategies could target these sectors, and some do, but they generally don't make the attempt. Alternatively, these "missing links" could be targeted by direct creation of industry. The industrial development strategies can use promotions, incentives, and perhaps a prepared market analysis for the targeted industry, but cannot be certain that an industry will locate there. The energy self-reliance strategies, described later, create additional demand for insulation and solar hot water heater components, which are then targeted by direct intervention strategies, to create manufacturing firms of plate glass and steel water tanks. The importance of stressing self-sufficiency is that the multiplier effect of future impacts will be greater after "filling the missing links", since the linkages of the local economy are strengthened.

A related characteristic of self-sufficiency that is never addressed by traditional industrial development strategies is "disintermediation", which is defined by Paul Hawken as the "elimination of middlemen and other intermediary people, processes, and functions."[5] Disintermediation is a return to a particular type of self-

[5] Paul Hawken, The Next Economy, (New York: Holt, Rinehart and Winston, 1983), p. 160.

sufficiency, which stresses quality of goods and services and eliminates those intermediary functions in an economy that do not contribute to the quality of the good, but do raise the price. Energy conservation and "soft" energy production are examples of disintermediation by which energy is provided directly by the household rather than by an electric utility with a distant generating plant which requires specialized planning, engineering and construction, specialized workforce to operate, and special government regulations to control it. Hawken describes intermediation as a child of growth or an expansionary economy and as our economic growth slows or reverses, the process of intermediation reverses.[6] Most examples of self-reliance strategies are an implementation of disintermediation.

### 1.3.2 Self-Determination

Self-determination essentially refers to the ability of the local citizenry to have some degree of control over their economy rather than being affected by national economic trends and by the decisions of outside owners of local industry, land, and other resources. Obviously total self-determination is impossible, short of isolation and nationalization, but there is a trend toward employee

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[6] Ibid., (pp. 18,19).

ownership of firms and a community could, particularly with the backing of local banks, promote local ownership and management of businesses, rather than allowing itself to be overrun with industry and businesses with outside ownership. Self-determination of businesses would prevent the closing of important local businesses simply because the national conglomerate found a slightly more profitable venture elsewhere and would prevent the undesirable movement of industries from North to South and back again as the large scale regional economic trends shift around.

In The Last Entrepreneurs, Robert Goodman describes the regional battle that is taking place by states and localities to attract industry and the ways in which industry takes advantage of the battle, to reduce the power of labor organizations as well as receive windfall location incentives.[7] The "entrepreneurs" alluded to in the title are the states and localities as they attempt to buy industry for their region. In another sense, he is referring to the decrease of risk-taking by private business, and the pleas for help from businesses that claim they can't continue on their own and will have to close or relocate unless they receive assistance. Goodman observes that the competition will not cease by mutual agreement of the more than 15,000

[7] Robert Goodman, The Last Entrepreneurs, (New York: Simon and Schuster, 1979).

promotional agencies, but by communities taking control of their resources. The competition is too keen for a general cessation of industrial development activity, but some individual communities can drop out of the game by taking control of ownership, and in some cases management of certain local business.

Another facet of self-determination is the cyclical sensitivity of the local economy to the national economy. An economy is said to be cyclically sensitive if the local economy follows with greater fluctuation the up and down trends of the national economy. A stable economy is usually a goal for most communities, meaning the community must be insensitive to the cyclical trends of the national economy. There are only two ways of becoming cyclically insensitive; to become independent of the national economy which is not practical, and to develop a diversified economy, where some industries are cyclically sensitive, others are counter-cyclical and still others might be totally insensitive so as to create an overall insensitive economy. Michael Conroy proposes that the latter can be done and draws an analogy to a diversified stock portfolio, where the goal is not simply to acquire as many different kinds of stocks (or industries) as possible, but to acquire them in such a way as to produce

a stable return on investment (or a stable economy).[8] While complete independence is not desirable or possible, the self-sufficiency aspects of self-reliance strategies might contribute to a decrease in dependence and to a decrease in the cyclical sensitivity. Attempting to follow Conroy's strategy might prove considerably easier, if the economy was less dependent to begin with.

### 1.3.3 Self-Reliance

Self-reliance is defined here as encompassing both of the previous concepts and indeed as they are not mutually exclusive, they have many common attributes. One of the added dimensions of all three concepts, and one that is of particular importance to the concept of self-reliance is that of eliminating or significantly decreasing the amount of income leaking from a local economy to the outside. In other terms, self-reliance is a form of import substitution. Self-reliance seeks to decrease the dependence on outside imports, not to become independent and isolationist, but to decrease the amount of money that leaks from within the local economy to the outside. Nations are concerned with this and speak in terms of the balance of trade, and

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[8] Michael E. Conroy, Regional Economic Growth: Diversification and Control. New York: Praeger Publishers, Inc., 1975.

undeveloped countries are still caught in a debate between export-led development and import substitution. Many localities and small regions are in comparable positions with their diversified, urban neighbors, as undeveloped nations are with the developed countries.

In a study on economic development in Puerto Rico, Richard Weisskoff compared historical development trends, which relied on exports, with a series of import substitution strategies.[9] The simulations resulted in increases of 8.2% to 25.8% in employment and 8.1% and 26.8% increases in income. The lower increases resulted from restricting household consumption of imports by 20%, while the higher increases restricted all consumption, including interindustry procurement, by 20%. Slightly higher results were obtained by targeting certain domestic industries like food and clothing and eliminating most imports. These simulations took place in a period of growth and emphasize the benefits of a self-sufficient economy that occur through the multiplier effect.

Self-reliance strategies are defined as providing a degree of independence from outside economic forces and a greater degree of self-determination with the benefits and

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[9] Richard Weisskoff, "Income Distribution and Export Promotion in Puerto Rico," in Advances in Input-Output Analysis, ed. Karen Polenske (Cambridge, MA: Ballinger Publishing Company, 1976), pp. 205-223.

costs of that control accruing directly to the community, rather than leaking out as imports and corporate profits. Self-reliance is not anti-growth nor is it inconsistent with a growing economy; it is simply a different approach to encouraging growth. More importantly, however, it does not depend on a growing economy to be successful. As Hawken points out, it is the absence of a growing economy that makes the traditional methods obsolete and the alternative, disintermediation or self-reliance, more appropriate.[10]

Self-reliance is offered as an alternative to industrial development, but industrial development practices can also be altered to incorporate many of the goals of self-reliance. Self-sufficiency can clearly be a part of an industrial development strategy, but in practice, the necessary analysis is usually not undertaken. Self-reliance and industrial development strategies are not mutually exclusive. The goals of self-reliance specifically include additional benefits like self-sufficiency and self-determination as well as externalities like energy saving. The strategies are likewise more specifically targeted than are those of industrial development.

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[10] Paul Hawken, The Next Economy, (New York: Holt, Rinehart and Winston, 1983), pp. 21,22.

### 1.3.4 Self-Reliance Strategies

Finally an example of a possible self-reliance strategy will help to extend the concept. Energy self-reliance is a popular and well understood concept but won't be elaborated on at this point since it will be dealt with later. But many other areas exist including food, housing, health care, resource or business ownership, finance, and insurance. A number of small, community based organizations have sprung up to address all of these needs and there is a growing body of literature and resources to assist in establishing such programs. But the widespread acceptance of these strategies, particularly as a tool for local government, still does not exist.

A self-reliance insurance program may be one of the best examples of a strategy to produce jobs, generate income, stop money leakages and increase local control of resources. A community based insurance plan would be established to cover property and casualty (auto and homeowners) insurance. Rather than residents paying premiums to 50 different companies across the country, they would pay premiums to a local, non-profit insurance or financial institution, established as a stock company (which could then pay back dividends). The local institution being owned and managed by residents of the community would then have a strong

incentive to take action to decrease risks, by funding better police, fire and rescue squads and by taking a more active role in educating residents and assisting residents in preventive actions. Excess premiums paid could be used in these ways and/or could be paid directly back to the residents. Insurance companies do make profits. They are then invested to make more profits, which do help to maintain low premiums, but they are not invested back in the local community. Community based insurance plans address all of the goals of economic development. It is an unusual strategy, but it has been used and has been proposed in other areas.

## 1.4 RATIONALE

The choice of economic development strategies is a matter of public policy and should not be made without careful consideration of the local economic needs. To automatically choose to pursue one strategy because the majority of communities employ it, is likely to result in a waste of money and ignores the unique character and individual needs of the locality. Industrial development has been employed in this fashion, and is now a very competitive and expensive strategy.

Before a community embarks on any economic development plan, it should be convinced of the effectiveness of the plan. Given the successes of some communities with industrial development, other communities feel justified in pursuing those same strategies, but there is a limited amount of new, expanding, and relocating industry and not every community will be able to attract or retain the industry, particularly in times of slow national economic growth. Self-reliance strategies are not commonly employed by communities although there are some examples of such strategies that have been successfully employed. Because they are not widely used and because they do not normally produce large immediate impacts, as do large industrial plants, they have not received the attention that is due them. Communities have to be convinced that self-reliance strategies can produce as much or greater benefits for their local economies than industrial development.

Energy self-reliance in the form of community energy planning has been promoted as a solution to local and national energy problems, but the total economic benefits have largely been ignored by policy makers and analysts.[11]

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[11] Rebecca L. Flora, Economic Evaluation in Energy Planning: The Experiences of Communities in the United States, (Blacksburg, VA: masters thesis submitted to Virginia Polytechnic Institute and State University, 1983), pp. 73-75.

This thesis seeks to go beyond the energy conservation benefits of energy self-reliance, and examine the potential application of energy planning as as economic development tool under the theory of import substitution and economic self-reliance.

This study will compare the effects of self-reliance strategies and industrial development strategies on a local economy. Specifically this thesis will attempt to show that energy self-reliance strategies are more effective than industrial development in providing a selected area, the New River Valley of Virginia, and similar non-metropolitan regions with jobs and higher real incomes. If self-reliance proves to be as effective or more effective than industrial development, then localities should consider self-reliance strategies as a viable, alternative method of development and federal state programs should provide equal access to grant money for self-reliance.

# Chapter II

# DESCRIPTION OF METHODOLOGY

## 2.1 OVERVIEW

This study uses an input-output model to analyze the economic effects of an energy self-reliance plan and an industrial development plan to determine which provides the greater positive impact on jobs, income, the multiplier, and local economic stability. An input-output model provides a means to simulate the effects of both plans on a regional economy and to measure and compare the effects. The choice of an input-output model as an analytical tool was based on the high degree of detail that the model provides and the accessibility to a suitable model. The first section of this chapter describes the rationale for using an input-output model, the assumptions and underlying theory of input-output models, and the analytical output of the input-output model.

The input-output model that was available was for the state of Virginia and not a regional model, but by employing a non-survey, regionalization technique on the existing state input-output model, a regional model for the New River Valley Planning District (NRV) was created. By using a non-survey technique to modify the state input-output model,

both time and expense were kept to a minimum and the research was feasible, while maintaining a reasonable degree of accuracy. The methodology used to regionalize the input-output model will be described in the second section of this chapter and in Appendices A and B.

The simulation of the two alternative economic development plans required that there exist some basis for comparing them fairly. Towards this end, possible strategies for each type of plan were reviewed and comparable strategies, in terms of fiscal resources at two different expenditure levels, were selected to be simulated with the input-output model. The selection of comparable strategies and the modification of the input-output model to simulate the strategies are described in the third section of this chapter and in Appendix C.

## 2.2 INPUT-OUTPUT ANALYSIS

An input-output model was chosen as the analytical tool to use for measuring the economic impact of the various development strategies. Input-output analysis utilizes a matrix format to display the interdependencies of each sector with other sectors of the economy and with sectors outside the economy. These interdependencies are expressed as the transactions of goods and services necessary for

production in a given sector (inputs), and as the distribution of goods and services from a given sector to the rest of the economy, (outputs). The economy can represent any geographical scale including nations, states, regions, and individual localities.

Input-output analysis has at its roots the Tableau Economique published by Francois Quesnay in 1758, which stressed the interdependence of economic activities by depicting the operation of a single farm and showing the successive rounds of wealth generated by a given increment of output.[12] In 1874, Leon Walras published Elements d'economie politique pure which contributed a general theory of economic equilibrium to the development of input-output analysis.[13] Finally in 1941, Wassily Leontief published The Structure of American Economy, 1919-1939, which included his general theory of production and the first input-output table for the U.S. economy, consisting of 46 sectors.[14] Since then and with the advent of computers to assist with

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[12] Marguerite Kuczynski and Ronald Meek, ed. Quesnay's Tableau Economique (Glasgow: Robert Maclehose and Co Ltd., 1972)

[13] Leon Walras, Translated by William Jaffe, Elements of Pure Economics or the Theory of Social Wealth, (Fairfield, NJ: Augustus M. Kelley, 1977)

[14] Wassily Leontief, The Structure of American Economy, 1919-1939 (1941; rpt. New York: Oxford University Press, 1951)

the massive computational requirements of highly disaggregated models, input-output analysis has been applied for a variety of purposes including interindustry impact analysis.

### 2.2.1 Choice of Input-Output

Input-Output analysis is one of three basic categories of economic impact analysis models which also include economic base and econometric models.[15] Advantages and disadvantages of each model make the selection of these models dependent on the nature of the problem and the resources available. The time frame to be observed and the industry detail that is desired are important aspects of the problem that affect the selection of a model. Also the data required and the time and money available to the analyst will affect the selection. The principal reasons for selecting an input-output model for this methodology was the large amount of industry detail that the model provides and the availability of both a working model and the appropriate data. Industry detail is important to this study because of the need to compare the overall economic effects of changes in a variety of individual industry sectors.

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[15] Saul Pleeter, ed., Economic Impact Analysis: Methodology and Applications (Boston: Martinus Nijhoff Publishing, 1980), pp. 7,8.

Economic base models are far simpler to construct and implement than input-output models but they lack the analytical detail of the input-output model. The economic base model can utilize disaggregated data to produce its multipliers, but it can only express a relationship between export activity and local activity, while ignoring the relationships between individual sectors of the economy. Consequently the multipliers derived by economic base models are average multipliers representing the expected impact of an output change in the general economy, but they are not necessarily accurate to apply for output changes in a specific industry. Likewise the effects on a specific industry of an output change cannot be directly measured although the general effects on the economy can be observed.[16] Because of the need to observe and compare the economic effects of output changes in specific industries, economic base models were not adequate for this study.

Econometric models can be as simple or as complex as the analyst wishes, can take advantage of whatever data is available, and are the most appropriate model for long run impact studies, but if they are to be good regional models

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[16] Bureau of Economic Analysis, U.S. Department of Commerce, RIMS II: Regional Input-Output Modelling System: Estimation, Evaluation, and Application of a Disaggregated Regional Impact Model (Washington, D.C.: U.S. Government Printing Office, 1981), p. 4.

and not rely too heavily on national econometric relationships, then they must be substantially more complex and thus require extensive data at the regional level.[17] Good econometric models are highly individualistic and tailored to the needs of both the region and the study, thus they are not easily transferred to other applications in other places. While long run impact analysis is appropriate for this study, the lack of access to an existing regional econometric model and the complexity involved with developing a model favored the selection of input-output analysis.

Input-output models can provide a large degree of sector detail, allowing the analyst to trace the effects of output changes in one sector throughout all of the sectors of the economy. Input-output models, that are not dynamic, i.e. not long run models, represent a static or short run analysis; however the results may be indicative of long run results and are nevertheless important for influencing political decisions. The approximate time frame to be considered by the analysis in this study is five years, although the input-output model treats the study as a snapshot or a static point in time. Data requirements can

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[17] Saul Pleeter, ed., Economic Impact Analysis: Methodology and Applications (Boston: Martinus Nijhoff Publishing, 1980), pp. 18-21.

be extensive for input-output models, but access to a Virginia state model with 502 sectors was available and through regionalizing, required far less data than for a survey-based, input-output model, which requires extensive resources to construct. In summary the input-output model provided the best degree of analytical sophistication with the most reasonable amount of effort.

### 2.2.2 Use of Input-Output

The input-output model employed in this study is a regional adaptation of a computer model developed by the Regional Science Research Institute.[18] The original model consisted of a 501 sector technology matrix adapted from the 1972 Bureau of Economic Analysis (BEA) Input-Output Technology Matrix, a state-specific data set of coefficients, and a computer program written in ANSI Standard FORTRAN IV. For use in the NRV study, the state-specific data set of coefficients and the FORTRAN program were modified, but the technology matrix remained unaltered.

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[18] Benjamin H. Stevens, et al. Basic Regional Input-Output for Transportation Impact Analysis: Handbook One of Regional Economic Analysis for Transportation Planning (Amherst, MA: Regional Science Research Institute, Revised Draft, March 1981).

The limitations of the methodology used in this thesis rest largely with the assumptions underlying input-output analysis, as well as with some aspects of the data used in the model. The basic theory, techniques, and assumptions of input-output analysis, as they apply to the problem at hand, are briefly reviewed in the following section.

2.2.2.1 Economic Sectors

Input-output analysis is essentially an accounting framework of all the transactions of goods, services, money, and labor passing among the sectors within an economy and outside the economy. Figure 1 depicts the major types of intersectoral transactions or flows as they are represented in a regional input-output model. The five groups of sectors depicted are described below:[19]

1. Intermediate sectors encompass all private business activity within the region and they are the main focus of input-output models in terms of interindustry detail,

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[19] James E. Pratt, Dennis K. Smith, and M. C. Conner, Input-Output Analysis: An Introductory Self-Learning Package (Blacksburg, VA: Department of Agricultural Economics, Virginia Polytechnic Institute and State University, Staff Paper SP-76-14, October, 1976), pp. 5,6.

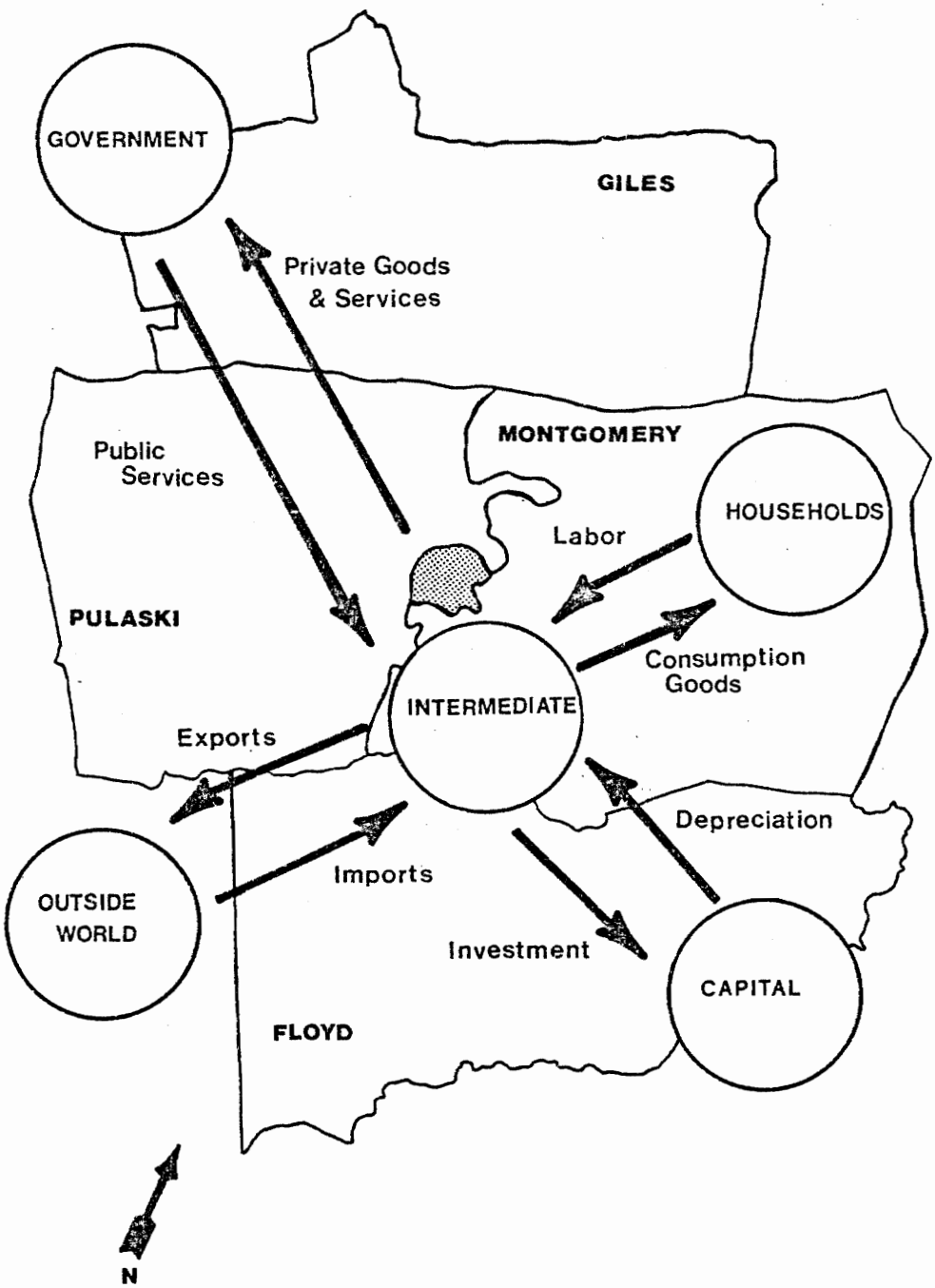


Figure 1: Major Intersectoral Flows in the NRV

2. Household sectors (usually simulated by just one sector) includes individuals and families residing within the region and the focus of the model is on the labor supply from this sector and the personal consumption of the sector from the other sectors,
3. Government sectors include all local, state, and national governments within or outside the region that provide to, or consume goods and services from the region,
4. Capital sectors include the use of money for investment and are stressed more when a dynamic input-output model is developed, but are largely ignored with static models, and
5. the Outside world includes all other types of transactions from outside the region, including imports from and exports to the outside.

These five groups of sectors, particularly the intermediate sectors are broken down further in an attempt to identify unique sectors in which all economic activity of that sector shares identical input requirements, identical production processes, and produces the same products. While an ideal sectoral breakdown of economic activity is

impossible, the compensating approach used most often is to use the Standard Industrial Classification (SIC) Codes which attempt to assign activity to groups according to the principal product of the activity. Problems of industries with multiple products, different production processes, and different input requirements will remain however.

The model employed in this study utilizes 494 sectors of 501 total sectors for the intermediate group. These are further broken down as follows:

| Sectors | |
|---|---|
| 1 - 10 | => agriculture, forestry and fisheries, |
| 11 - 14 | => mining, |
| 15 - 21 | => construction, |
| 22 - 388 | => manufacturing, |
| 389 - 400 | => transportation, communication and utilities, |
| 401 - 432 | => wholesale trade, |
| 433 - 468 | => retail trade, |
| 469 - 475 | => finance, insurance and real estate, and |
| 476 - 494 | => services. |

Sectors 495 through 500 are government sectors and sector 501 is a special sector for administrative and auxiliary offices, which represents primarily corporate headquarters located away from the production plants. Household sectors and the outside world (exports and imports) are each represented in this model by special coefficients: household consumption coefficients (HHC) and regional purchase coefficients (RPC), respectively. Capital sectors, which are often used in dynamic models for long term investment impacts, are not directly included in this model.

#### 2.2.2.2 Transactions Matrix

Once the economic activity has been grouped into sectors, a transactions matrix is developed with each sector represented by a row and a column as depicted in Figure 2. The rows represent selling sectors, i.e. the numbers in each row are sales or output from the row sector to the column sector. The columns represent purchasing sectors, i.e. the numbers in each column are purchases or inputs from the row sector to the column sector. So for any given sector of economic activity, its inputs are read from its respective column and its outputs are read from its respective row. Each cell of the transactions matrix represents the dollar amount of the row sector that is sold to or purchased by the column sector.

For each "processing sector", which includes the intermediate and the household sectors, the total inputs of the column are equal to the total outputs of the row. The remaining row sectors are defined as "payments sectors" which include imports, depreciation or capital consumption, and government, which represents government services to the other sectors. The remaining column sectors are defined as "final demand sectors" which include exports, investment, and government which represents the accumulation of tax revenues. Unlike the processing sectors, the sum of the

| | | Processing Sector | | | | | | Final Demand Sector | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | INPUTS ↓ / OUTPUTS → | Agriculture | Manufacturing | Transportation | Wholesale & Retail | Services | Households | Exports | Investment | Government | Total Sales |
| Processing Sector | Agriculture | 34 | 290 | 0 | 0 | 0 | 7 | 137 | 0 | 1 | 469 |
| | Manufacturing | 25 | 1134 | 5 | 13 | 188 | 607 | 12303 | 27 | 10 | 14312 |
| | Transportation | 6 | 304 | 54 | 25 | 80 | 22 | 111 | 5 | 3 | 610 |
| | Wholesale & Retail | 13 | 490 | 18 | 45 | 156 | 1171 | 723 | 29 | 11 | 2656 |
| | Services | 35 | 472 | 53 | 258 | 418 | 1387 | 816 | 573 | 229 | 4241 |
| | Households | 208 | 3242 | 252 | 881 | 1816 | 869 | 1203 | 0 | 244 | 8715 |
| Payments Sector | Imports | 77 | 5712 | 83 | 456 | 892 | 2539 | +/- 16425 | | | |
| | Depreciation | 24 | 2157 | 129 | 805 | 446 | 489 | | | | |
| | Government | 47 | 511 | 16 | 173 | 245 | 1624 | | | | |
| | Total Purchases | 469 | 14312 | 610 | 2656 | 4241 | 8715 | | | | |

Figure 2: Hypothetical Transactions Matrix

inputs and outputs of the row and column equivalents, e.g. exports and imports, do not have to be equal, however the total outputs of all of the payments sectors must equal the total inputs for all of the final demand sectors. This equality is necessary to preserve the general equilibrium of the model.

2.2.2.3 Technical Coefficients Matrix

The next step in developing an input-output model is to transform the transactions matrix into a technical coefficients matrix, also called a direct requirements matrix (see Figure 3). This is simply done by dividing each column entry of the processing sectors only, by the column total for that sector. The payments sectors and final demand sectors are not a part of the technical coefficients matrix, although the payments sectors contribute to the column totals of the processing sectors. The resulting cells of the technical coefficients matrix represent the dollars of output from the row sector required as a direct input to produce one dollar of output of the column sector.

In Figure 3 a technical coefficients matrix is shown which is representative of the matrix used by the model for this study. To better relate the actual model with the theory recall that the model consists of a 501 sector

| | Agriculture | Manufacturing | Transportation | Wholesale & Retail | Services | Households |
|---|---|---|---|---|---|---|
| Agriculture | .073 | .020 | .000 | .000 | .000 | .001 |
| Manufacturing | .053 | .079 | .008 | .005 | .044 | .070 |
| Transportation | .013 | .021 | .089 | .009 | .019 | .003 |
| Wholesale & Retail | .028 | .034 | .030 | .017 | .037 | .134 |
| Services | .075 | .033 | .087 | .097 | .099 | .159 |
| Households | .443 | .227 | .413 | .332 | .428 | .100 |
| Imports | .164 | .399 | .136 | .172 | .210 | .291 |
| Depreciation | .051 | .151 | .211 | .303 | .105 | .056 |
| Government | .100 | .036 | .026 | .065 | .058 | .186 |
| Total Purchases | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Figure 3: Hypothetical Technical Coefficients Matrix

technical coefficients matrix and a set of state-specific coefficients. The matrix provided by the model, based on the national technical coefficients matrix and identical for all states, relates to the theoretical model depicted in Figure 3, except for the household sector which is missing from the actual model's matrix. The actual model supplies a household consumption coefficient (HHC) for each state which represents the column vector of households, i.e. those purchases by or inputs to the typical Virginia household from the rest of the economy. In addition the model supplies wages per thousand dollars of output (WPV)[20] for each state, which represents the row vector of households, i.e. the income received for supplying labor as an input to the rest of the economy. HHC and WPV become the 502nd sector of the technical coefficients matrix in Figure 3.

2.2.2.4 Interdependency Coefficients Matrix (Leontief Inverse)

The final step to produce the interdependency coefficient matrix, also called the Leontief inverse, is the point at which the actual model diverges slightly from theory. Theory suggests that the technical coefficients matrix be subtracted from an identity matrix to attain the "Leontief

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[20] WPV includes wages, salaries, and proprietors' income, but not corporate profits.

matrix" and then to invert the Leontief matrix to attain the Leontief inverse matrix, shown in Figure 4. The resulting matrix displays in each cell the dollar amount of the row sector that is required to produce one dollar of output of the column sector. Like the technical coefficients matrix, this includes direct requirements, but it also includes indirect requirements and induced requirements.[21]

The sum of each column is the multiplier, which represents the total direct, indirect, and induced effects of a change in final demand for the sector represented by that column. Essentially, each cell is also a multiplier representing the total effect on the row sector of a change in final demand of the column sector. The interindustry detail, alluded to earlier as an advantage of input-output analysis, is clearly evident at this point.

The actual model diverges from the theory by choosing to calculate ten successive rounds of indirect and induced effects rather than calculating the Leontief inverse. In practice, this approach achieves essentially the same results, since in the tenth round, the additional effects

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[21] Indirect requirements or effects refer to the additional output of a sector that is generated in subsequent "rounds" to supply the increased demand from the direct requirements. Induced requirements or effects refer to the additional output of a sector that is generated in subsequent "rounds" to supply the increased demand from the household sector.

| | Agriculture | Manufacturing | Transportation | Wholesale & Retail | Services | Households |
|---|---|---|---|---|---|---|
| Agriculture | 1.082 | .025 | .002 | .002 | .003 | .004 |
| Manufacturing | .132 | 1.126 | .076 | .057 | .114 | .116 |
| Transportation | .027 | .031 | 1.107 | .019 | .032 | .014 |
| Wholesale & Retail | .148 | .102 | .141 | 1.101 | .147 | .199 |
| Services | .245 | .129 | .248 | .216 | 1.256 | .265 |
| Households | .749 | .409 | .698 | .532 | .697 | 1.347 |
| Total Purchases | 2.383 | 1.822 | 2.272 | 1.927 | 2.249 | 1.945 |

Figure 4: Hypothetical Interdependency Coefficients Matrix

have generally dwindled to zero. An advantage of using the round by round approach, is that calculations are made only for those sectors that are in the final demand disturbance vector, i.e. if output or final demand changes in the industrial chemicals sector, then only those changes are traced through the economy. Solving for the Leontief inverse entails a solution for all of the sectors of the economy, when only a few may be necessary.

2.2.2.5 Assumptions

The most frequently cited, limiting assumption of input-output analysis is that the production coefficients remain constant. Constant production coefficients assumes no technological change, no relative price changes among goods and services, no substitution of inputs, and no economies of scale in production. These assumptions are more limiting as the time frame of the modelling increases because technology and relative prices are more likely to change in the long run. They are also more limiting in regional models than national models, because of the openness of the regional economy, which permits imports and exports to flow freely. Substitution of inputs within the economy is not as damaging to the usefulness of the model as substitution of inputs that involves a change in import or export levels.

A second limiting assumption involves the homogeneity of the production techniques and product mix, i.e. input and output, of each sector in the economy. This problem is aggravated by highly aggregated models, since aggregation groups sectors together and creates a wider diversity of input mix and product mix within each sector. Even firms producing the same product will not use exactly the same production techniques and will therefore have different inputs. Disaggregated models and careful assignment of firms to their appropriate sectors is valuable for a good model, but is complicated by the fact that some firms produce more than one output.

Another important assumption of the input-output model used in this study entails the treatment of the household sector as endogenous, i.e. the use of a closed model. An endogenous household sector was important to this study to simulate the changes in local household consumption, especially in the energy sectors. Also for most regions and especially those regions with little manufacturing activity like the NRV, the household sector represents the major portion of indirect and induced effects which would not be observed with the household sector exogenous to the model. One problem with the household sector is that it assumes a constant marginal propensity to consume over all income

levels so that changes in income and any associated changes in consumption patterns cannot normally be accounted for by the model. In addition, data requirements are difficult to fulfill for this sector, particularly at the sub-state regional level, since most consumption pattern data is collected only at the multi-state regional level or at the state level. For this study, Virginia state household consumption coefficients were used as an estimate for the actual regional coefficients.

These assumptions, common to all input-output models and essentially unavoidable, are nevertheless important to keep in mind when reviewing the results of the analysis. The first assumption of constant production coefficients is tempered somewhat by the intermediate time frame (five years) being considered. The model used in this methodology is highly disaggregated with 501 sectors which lessens the problem of homogeneity of the product mix, and the data requirements of the endogenous household sector are fulfilled by using state household coefficients. Other assumptions relating to the technique used to regionalize the model are also important and are discussed in Section 2.3.

### 2.2.3 Input-Output Results

The input-output model employed for this study predicts income, jobs, and output effects from which the respective multipliers are derived. The model also calculates state and local taxes generated, other value added, and a value added multiplier. To compare the two alternative economic development strategies, a closer examination of the employment and income effects is made. Also the impact of the strategies on the region's self-sufficiency and self-control is discussed.

Multipliers from an input-output model with households endogenous to the model, measure the direct, indirect, and induced impacts of changes in final demand. The determination of employment multipliers requires a set of direct employment coefficients which for this model is expressed in total employment per thousand dollars of output (EPV), which is another state-specific coefficient. The multipliers are calculated as the total direct, indirect and induced impact divided by the direct impact. The income multipliers are derived in the same manner as employment multipliers, except income is expressed using the wages per thousand dollars of output (WPV) coefficient.

Multipliers express the relative strength or weakness of changes in output and final demand for a given sector, but

if the magnitude of the direct change for two "comparable" strategies is not equal, then the total, absolute change may be more important to compare. For example, suppose A and B, require an equal expenditure, and A produces 100 direct jobs and 300 total jobs for a multiplier of 3, while B produces 50 direct jobs and 200 total jobs for a multiplier of 4. Then A is the preferred strategy since it produces more jobs even though the multiplier effect is smaller than strategy B.

## 2.3 REGIONALIZING THE MODEL

Input-output analysis is the preferred analytical tool to use for this study, because of the accuracy and detail of the estimates. There exist two principle approaches, survey and nonsurvey, for developing input-output models for an area. It is important to understand the rationale for using a nonsurvey technique of developing an input-output model and more specifically to understand the rationale for using the regionalization methods described by the RSRI. The following section reviews the use of nonsurvey techniques for input-output models and specifically describes the RPC technique.

### 2.3.1 Nonsurvey Techniques for Input-Output Models

The survey approach is an expensive, time consuming method, which potentially provides the greatest degree of accuracy, but is relatively difficult to implement. The nonsurvey approach relies on existing models, usually national models, which can be regionalized by adjusting the national coefficients to reflect the differences between the national and the regional economy. The nonsurvey approach faces additional criticism due to the assumptions involved in using national coefficients, but the ease of implementation as compared to the survey approach and the ability to produce input-output models, whose results can be compared, provide a substantial advantage over the survey approach.

The nonsurvey techniques that have been employed still present a wide range of diversity with regards to development cost, since some of them require limited survey work and many require experienced research personnel. All of the techniques begin with the national input-output coefficients and then use a variety of survey and estimating techniques to develop regional coefficients for those sectors of the economy that are believed to differ. The RPC technique is one of the few techniques that requires no primary data or survey data to estimate the regional

coefficients. This particular technique avoids costly survey data and can be applied consistently to any number of areas thereby permitting interregional comparisons. For those sectors where the necessary data for the estimating equations are unavailable as will be the case for a small area, then a location quotient (LQ) technique is substituted. This technique is also relatively inexpensive and relies on readily available data.

### 2.3.2 Description of RPC Technique

The region in this study is the New River Valley Planning District (one of twenty-two sub-state regional planning agencies in the state of Virginia), which comprises the Counties of Floyd, Giles, Montgomery, Pulaski and the City of Radford. To regionalize the original model, making it applicable for the New River Valley, the state-specific set of coefficients was modified. The original coefficients were specific for the State of Virginia and included the following for each of the 501 sectors:

1. EPV = total employment per $1000 output;
2. AA = administrative and auxiliary wages, salaries and proprietor's incomes (WSPY) per dollar of total WSPY in the sector;
3. WPV = wages per dollar output;

4. RPC = regional purchase coefficients;
5. HHC = household consumption per dollar of WSPY received;
6. STPV = state taxes per dollar output (or per dollar WSPY for households);
7. LTPV = local taxes per dollar output (or per dollar WSPY for households); and
8. OTHPV = value added per dollar output not including wages or taxes.

While a thorough attempt at regionalizing the model would have considered all eight types of coefficients for possible modification, only the regional purchase coefficients were actually modified for this study.

The seven coefficients left unaltered are less crucial to the accuracy of the regionalized model. Unlike the RPC, the other seven coefficients are all ratios based on per dollar output and/or income, and they are not tied to the absolute amount of activity in a given sector. The model results are much more sensitive to the RPC than to any of the other seven coefficients. The regional coefficients might vary from the state coefficients based on different consumption patterns, different local tax policies, and different local technologies or resources, but the improvements possible in developing regional coefficients are not worth the effort to

do so. And given the lack of data available at the regional level, the state coefficients are the best available approximation for the region. For this study, then, the seven regional coefficients were assumed to be the same as the state specific coefficients. A more detailed description of the state specific coefficients is provided in Appendix A, including the method in which they were derived for the state model, the research necessary to be regionalized, and the implications of using state coefficients in a regional model.

The regional purchase coefficients are by far the single most important coefficient to adjust when regionalizing an input-output model. "An RPC has been defined by Stevens and Trainer as the proportion of a good or service used to fulfill intermediate and/or final demands in a region that is supplied by the region to itself rather than being imported."[22]

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[22] Benjamin H. Stevens, George I. Treyz and David J. Ehrlich, On the Estimation of Regional Purchase Coefficients, Export Employment, and Elasticities of Response for Regional Economic Models RSRI Discussion Paper Series: No. 114 (Philadelphia: Regional Science Research Institute, January 1980), p. 1.

The following equation is the estimating equation for the regional purchase coefficients in the manufacturing sectors, excluding printing:[23]

$$
\begin{aligned}
RPC(i) = {} & (en)^{2.012} && R^2 = 0.679 \\
& * (w(i)/W(i))^{-.488} \\
& * (e(i)/E(i))^{.683} \\
& * ((e(i)/E(i))/(e/E))^{.354} \\
& * [(.001)(T(i)/E(i)W(i))]^{.206} \\
& * (a/A)^{.10} \\
& * (en)^{.421} && [\text{if } i = \text{SIC } 20] \\
& * (en)^{.402} && [\text{if } i = \text{SIC } 23] \\
& * (en)^{.706} && [\text{if } i = \text{SIC } 24] \\
& * (en)^{.630} && [\text{if } i = \text{SIC } 32] \\
& * (en)^{-.270} && [\text{if } i = \text{SIC } 33] \\
& * (en)^{.388} && [\text{if } i = \text{SIC } 34] \\
& * (en)^{-.371} && [\text{if } i = \text{SIC } 36]
\end{aligned}
$$

where:

RPC = the regional purchase coefficient for good i in region L;
w(i) = the average wage in industry i for the region;
W(i) = the average wage in industry i for the nation;
e(i) = employment in industry i for the region;
e = total employment for the region;
E(i) = employment in industry i for the nation;
E = total employment for the nation;
T(i) = thousands of tons of i shipped among all origins and destinations in the U.S.;
a = land area of the region;
A = land area of the U.S.; and
en = base of natural logarithms.

The above equation was supplemented by a simple employment-generated location quotient for those non-manufacturing sectors of the economy, for which the estimating equation does not apply. The RPC's are by

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[23] Benjamin H. Stevens et al., Basic Regional Input-Output for Transportation Impact Analysis: Handbook One of Regional Economic Analysis for Transportation Planning, (Amherst, MA: Regional Science Research Institute, Revised Draft, 1981, p. IV-49.

definition constrained between 0 and 1, but at the suggestion of the model's developers, any value produced by the RPC estimating equation or the location quotient equation was limited to values no greater than 0.95. This assumption allows for the inevitable leakage of money from the local economy as a result of selective imports, i.e. while VPI and Radford Universities provide more higher education than can be consumed by local people, not all of the college and graduate students from the NRV attend these schools. Some local students select other schools, which essentially reduces the RPC for higher education. There is a certain degree of cross imports and exports that occurs in most sectors of the economy.

One other special sector involves the RPC for labor, which was derived from an examination of commuting patterns in the NRV. The RPC for this sector was set at 0.91 which represents the percentage of jobs within the region that are supplied by local labor. A more detailed description of the derivation of the RPC's for each group of input-output sectors is available in Appendix B.

### 2.3.3 Assumptions

The RPC estimating equation has five major components within the equation. The first, (w(i)/W(i)) with a negative exponent of 0.488, can be interpreted as representing the elasticity of response of an RPC to changes in relative wage costs, i.e. the relative share of a good produced in a region will increase as regional wages decrease relative to national wages. The equation, like the input-output model, is static and has no time lag, although a time lag would exist in reality. For example, if the cost of labor increases at a slower rate in the South, then industry will move to the South and the regional share of production in those industries will increase, but such industry movement does not occur quickly.

The second term in the equation, (e(i)/E(i)) with a positive exponent of 0.683, simply represents the share of labor in the region for a given industry relative to total national labor in that industry. The interpretation of this term relates to agglomeration economies, i.e. if economies of scale or agglomeration economies exist in a given industry, then a greater relative share of employment in that industry for a region, should indicate the existence of lower average costs and a comparative locational advantage for that region. For example, if a 100 employee dairy

produces $1,000,000 of sales, while a 50 employee dairy produces 400,000 of sales, then a larger sized dairy represents a share of the market which is greater than its proportional share.

A location quotient is used as the third term in the equation and represents the concentration of production in the region relative to the U.S. This has two possible, positive effects on the RPC as indicated by the 0.354 exponent. First a large relative concentration of employment could indicate a large number of establishments, which would increase the likelihood that purchases from within the region are made from establishments within the region rather than as imports. This assumes that there are many firms and that they are geographically spread out across the region. Since dairies are relatively widespread over most regions, then most regions do not import many dairy products. Soft drink bottlers, which are more concentrated, could all be located in the Eastern part of a region, forcing people in the Western part of the region to import soft drinks from a bottler just outside the region on the Western edge. Second, a large concentration of employment is more likely to indicate that the full range of products within an input-output sector are being produced, rather than just one product which is largely exported. If

a sector includes peanuts, peanut oil, and peanut butter and the employment concentration is relatively small, then the region likely only produces one of the three products, which means that the true RPC should be zero for two of the products. If the employment concentration is relatively large, then the region likely produces all three products with RPC's that should all be high. Since one RPC represents all three products, then a lower employment concentration should decrease the RPC.

The fourth term in the equation, [(.001)(T(i)/E(i)W(i))] with an exponent of 0.206, represents a weight per value ratio with total wages as a proxy for value. The positive exponent indicates that as the weight increases relative to the value or cost of the good, then the good will likely be shipped shorter distances, which would suggest that the good will be produced within the region. For example, most food products, except those restricted by climate, are produced locally and shipped relatively short distances, while computer products which are relatively expensive are shipped literally around the world.

The final term in the equation, (a/A) with a positive exponent of 0.10, simply indicates that as the area of the region increases, the regional share of production will likely increase. The reasoning is that outside producers

will be farther away and less able to compete in a large region than in a small region. New Jersey, for example, is relatively small and must compete with New York and Pennsylvania for its share of production throughout the entire state, while the greater part of Texas does not import much from outside the state.

### 2.3.4 Program Modifications

After calculating the RPC's for the New River Valley region, the RPC's were simply added to the end of the FORTRAN program as data statements and read into the program in place of the state RPC's. No other program modifications were necessary to regionalize the model and had any of the other coefficients been modified, they could have been handled in the same fashion. Other program modifications were made for the purpose of simulating the alternative economic development strategies and are described in the next section.

## 2.4 STRATEGY SELECTION

Comparing energy self-reliance strategies with industrial development strategies required not only an input-output model, but also a decision on which strategies from a variety of different strategies should be compared. Because

energy self-reliance strategies and industrial development strategies can take a variety of forms with varying degrees of impact, a resource constraint or budget level was chosen from which to develop the strategies. Establishing a resource constraint equates the plans and allows for a comparison to be made. The following section describes the assumptions made in choosing the strategies to be used in the simulation.

The first assumption used is that the localities in the NRVPDC face certain resource constraints and that either an energy self-reliance plan or the industrial development plan can be implemented, but not both. The amount of resources or capital that is available becomes the resource constraint and is crucial to the methodology. The effects of an implemented planning effort made with relatively little capital will differ substantially from an effort backed by large amounts of capital. But the increased benefits per additional dollar spent may not accrue in equal proportions between the energy and industrial plans. It is possible, for example, that energy self-reliance plans could provide more benefits than industrial development plans when resources are limited and yet provide less benefits than industrial development plans when resources are greater. This would be the case if there exists a critical level of

expenditure required to attract an industry, or if we reach a point of diminishing returns in energy expenditures. Therefore the amount of the resource constraint is a crucial assumption.

To avoid the problem mentioned above, two different levels of expenditures will be used in the simulations. The low level of expenditure is defined as the amount of money needed to fund a one staff-person effort, designed to research and develop an appropriate local economic development plan and to carry out any recommendations or strategies of the plan. These strategies could include providing workshops, providing loans, and changing local zoning and building code ordinances for the energy plans, or providing informational or promotional brochures, providing loans, and providing assistance to possible new business for the industrial plans. They would exclude any strategies of the plan that would cost substantially more money or require more personnel. The expected costs would include one staff salary and the normal overhead costs for an office and benefits plus some additional money for printing brochures or producing other informational or promotional media. For example, establishing a loan authority and enacting ordinances essentially don't require any substantial additional expenditures.

The high level of expenditure is defined to include the level one expenditures, and to add the additional cost of direct capital expenditures for such costs as provision or extension of utilities and industrial site development (for industrial development), or public sector job creation and municipal energy utilities (for energy self-reliance). A fixed dollar amount must be used for comparison purposes and was derived from a review of past industrial development cost figures. This amount was then used to estimate potential benefits from energy programs utilizing the same level of expenditure.

For simulation purposes, the low level of expenditures was estimated as $60,000 per year or $300,000 over a five year period for the entire NRV. The high level of expenditures was estimated as $666,000 per year or $3,300,000 over a five year period for the NRV. The basis for selecting these figures is derived from an examination of economic development efforts within the NRV (see Table 1). The region has positions, specifically geared toward promoting economic development. In addition, a considerable amount of staff time of NRVPDC has been expended for economic development efforts and local city, county, and town administrators and planners have been involved as well. The salaries of two local economic development positions

range from $15,000 to $30,000 with budgets from $20,000 to $60,000. Given the frequent use of consultant studies in economic development, the $60,000 per year was selected to represent a reasonable salary level and office budget with money left for special studies or promotions.

The high expenditure level was derived from the total amount spent in the region from 1978 through 1982 by federal, state and local funds for industrial development. Using the rough figure of $3,000,000 for the five year period, gives $600,000 per year plus the $60,000 for staff and studies. This figure may be conservative since only direct expenditures are accounted for and not industrial bonds or other incentives.

Given a fixed level of expenditures, the benefits for each development plan can be estimated. The estimation tool is the input-output model which requires the level of direct benefits as an input and which provides indirect and induced benefits as an output. The methodology for developing the direct benefits and employing the input-output model to simulate the different scenarios for each plan is discussed in the following section.

TABLE 1

Economic Development Expenditures in the NRVPDC

1978 to 1983

| | | | |
|---|---|---|---|
| Date: | 1978/1979 | | |
| Project: | Provision of water to industrial site. | | |
| Localities: | Town of Narrows | | |
| Source: | EDA | Amount: | $422400 |
| | ARC | | 422400 |
| | Town of Narrows | | 325300 |
| | Total | | $1170100 |
| Results: | Water was provided, but no industry came. | | |

---

| | | | |
|---|---|---|---|
| Date: | 1980/1981 | | |
| Project: | Upgrade water service for ind. expansion. | | |
| Localities: | City of Radford | | |
| Source: | Federal | Amount: | $296718 |
| | State | | 75000 |
| | City | | 221717 |
| | Total | | $593435 |
| Results: | Funds were used to upgrade the overall water system. One industry was retained. | | |

---

| | | | |
|---|---|---|---|
| Date: | 1981/1982 | | |
| Project: | Establish industrial park. | | |
| Localities: | Town of Pearisburg | | |
| Source: | State (CD funds) | Amount: | $232000 |
| | Town of Pearisburg | | 315900 |
| | Total | | $547900 |
| Results: | Some industry was attracted. | | |

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| | | | |
|---|---|---|---|
| Date: | 1982 | | |
| Project: | Establish industrial park. | | |
| Localities: | Pulaski County | | |
| Source: | State (CD funds) | Amount: | $700000 |
| | Total | | $700000 |
| Results: | Industrial park was established. One industry is committed. | | |

Total funds spent in the five year period: $3,011,400
Note: This does not include local expenditures by local governments of Chambers for promotion.
Data Source: New River Valley PDC

### 2.4.1 Industrial Development

The simulation of an industrial development plan is complicated by the unknown probabilities of success and the unpredictable size of success. A fully successful plan will not only result in a new industry locating in the region, but it will be an industry which has or generates many linkages within the regional economy and therefore has a large multiplier effect and it will also be an industry that would not have come without the encouragement or incentives of the industrial development plan.

To handle the problem of the type of industry, as defined by its linkages, that is attracted to the region, a worst case and a best case scenario were developed. These scenarios attempt to encompass a reasonable range of possibilities that could be expected as a result of a "successful" industrial development plan over a five year period. It is important to note that the worst case - best case distinction refers only to the linkage effects and wage effects and not to the probability question. This means that the actual benefits could be less than the worst case scenario, if the probability of success if low. The worst case scenario involves the entry of a group of small firms

with 500 employees, but the firms have little or no existing linkages nor do they generate any in the regional economy. The best case scenario involves the same size firm, but this time with many existing or generated linkages.

For the simulation, sectors were selected to represent the worst and the best case scenarios. These were chosen by examining the regional purchase coefficients and the technical purchase coefficients for various manufacturing sectors. A special FORTRAN program was written to sum the product of the RPC times the technical coefficient for each manufacturing sector that used an existing sector as an input or whose output was used by an existing sector as an input. The technical coefficients represent all of the possible linkages in the economy, while the RPC weights those linkages according to those sectors that actually exist in the local economy. The higher numbers represent greater linkages. In the selection of industrial sectors for the two scenarios, the employment per value of output (EPV) and wages per value (WPV) were also examined. Of those sectors with high linkages, the sectors with a high ratio of WPV to EPV (i.e. high wage industries) were considered better. Of the low linkages sectors a low ratio of WPV to EPV (low wage industries) was considered more representative as a worst case scenario.

TABLE 2

Industrial Linkages Analysis

High Linkage Sectors

| I-O# | Sector | Linkage | WPV/EPV | National Employment |
|---|---|---|---|---|
| *160 | Industrial Chemicals | 0.20247 | 13.46 | 230100 |
| 133 | Paper Mills | 0.13410 | 2.99 | 129900 |
| 132 | Pulp Mills | 0.12934 | 12.00 | 10600 |
| 88 | Nonwoven Fabrics | 0.08629 | - | 10800 |
| 77 | Narrow Fabric Mills | 0.06169 | 6.50 | 27100 |
| 187 | Misc. Plastic Products | 0.04649 | 10.53 | 346900 |
| 161 | Nit. & Phos. Fertilizer | 0.04316 | 7.74 | 24300 |
| 26 | Small Arms Ammo. | 0.03731 | 9.36 | 13900 |
| 247 | Metal Barrels & Pails | 0.03294 | 10.57 | 10200 |

Low Linkage Sectors

| I-O# | Sector | Linkage | WPV/EPV | National Employment |
|---|---|---|---|---|
| 58 | Malt | 0.0000056 | - | 1700 |
| 49 | Rice Milling | 0.0000297 | - | 4000 |
| 232 | Primary Copper | 0.0000643 | - | 17200 |
| 181 | Paving Mix & Block | 0.0000680 | 14.22 | 13900 |
| * 31 | Poultry & Egg Process. | 0.0000727 | 6.77 | 14600 |
| * 48 | Book Printing | 0.0000731 | 8.44 | 40900 |
| 234 | Primary Zinc | 0.0000762 | - | 6300 |
| *369 | Jewelry, Precious Metal | 0.0000855 | 9.69 | 32600 |
| *210 | Concrete Block & Brick | 0.0000872 | 9.44 | 22800 |
| 182 | Asphalt Felts & Coating | 0.0000957 | 9.47 | 15600 |
| 63 | Cottonseed Oil Mills | 0.0001011 | - | 5500 |
| 65 | Veg. Oil Mills, nec | 0.0001219 | 9.98 | 1100 |

* The asterisk indicates the selected sectors.

Table 2 shows the total linkages for the nine sectors with the highest linkages (sorted from high to low) and the twelve sectors with the lowest linkages (sorted from low to high). The ratio of WPV to EPV and the national employment for each sector are also shown. For the best case selection, the following criteria were used: high linkages, high ratio of WPV to EPV and high national employment. The high national employment was important because it seemed unreasonable to assume that 500 new jobs would be created in an industry that only had 10000 total employees. Nonwoven fabrics was eliminated because it had no EPV value and thus no ratio to compare. Sectors 26, 132, and 247 were eliminated because the national employment was relatively small. The industrial chemicals sector with 0.20 linkages and a 13.46 ratio of WPV to EPV, each the highest of the remaining sectors, was selected to represent the best case scenario.

The worst case scenario used the following criteria: low linkages, low WPV to EPV, and high national employment. For the worst case, most of the sectors had national employment of less than 15000, so the jobs were assigned to four different sectors with 125 jobs in each. Five of the low linkage sectors had no EPV value and therefore no ratio could be calculated. These sectors were dropped from

consideration. Sector 65 was dropped because of its small national employment. Sector 181 was dropped because of its high WPV/EPV ratio and sector 182 was dropped because of its relatively high linkages compared to the remaining four sectors. The worst case scenario is represented by the poultry and egg processing, book printing, concrete block and brick, and jewelry and precious metals sectors.

To resolve the unknown probability of whether a firm is attracted by an industrial development plan, the probability is assumed to be 100% as an input to the simulation, but if the potential benefits of the energy plan are less than the benefits of the industrial development plan, then a "breakeven" probability will be calculated. By comparing the ratio of the benefits of one plan to the other, we can determine what probability of success of attracting a plant is necessary for industrial development to remain a better alternative. If the benefits from an energy plan are 40% of the benefits from an industrial development plan, the "breakeven" probability, then the unknown probability of success must be greater than 40% for industrial development to be the better alternative.

To simulate the industrial development strategies using the input-output model, several steps were taken. In those cases where the industry represented a new sector in the

regional economy or represented increased activity in a sector with a regional purchase coefficient less than .95, the regional purchase coefficients were recalculated to simulate the entry of a new firm in the region. Then the new employment was placed in the final demand disturbance vector and the model was run. This has two implications for the model. First the sectors representing new activity will respond to later indirect demands which would have been lost, thus increasing the overall impacts. Second the inclusion of 500 more employees in a relatively small region will slightly decrease the RPC's of all the other sectors due to the location quotient term in the estimating equation. On balance there will be little change, and a test of the model's sensitivity to the RPC recalculations showed a very small increase as a result.

### 2.4.2 Energy Self-Reliance

Using the same expenditure levels of $60,000 and $600,000 per year, two regional energy plans were developed and simulated with the input-output model. The low expenditure plan includes four programs: a solar hot water system ordinance for new construction, increased energy standards for new construction in the building code, encouragement of solar hot water system retrofit of existing homes through

promotion and educational workshops, and increased energy standards for existing construction with inspections upon resale. The budget breakdown for this plan is as follows:

| | |
|---|---|
| Energy Planner | |
| Salary and benefits | $25,000 |
| Office overhead | 5,000 |
| Promotions and workshops | 5,000 |
| Inspector | |
| Salary and benefits | 20,000 |
| Office overhead | 5,000 |
| Total | $60,000 |

The high expenditure plan includes all of the same programs as the low expenditure plan plus $600,000 a year for investment in energy related businesses that will create strong linkages in the economy. The sectors that might be targeted include insulation, flat plate glass, and steel supports and tanks manufacturing. These three sectors experience the greatest direct final demand for output as a result of the low expenditure energy plan, and therefore hold the greatest potential for new business.

One feature of both plans, will be the creation of a loan mechanism through the electric utility or through local government to provide loans to individuals for the various energy programs. It is assumed for these programs that the loan money will be made available by the local utility and represents an investment to reduce their energy demand. With available loan money, there will be a greater incentive to undertake the retrofit of conservation measures and solar

hot water systems and the loans can be set with little or no interest for low income homes. Loans offered through the electric utility can be paid back as part of the regular electric bill, so that with the energy savings, the individual would not pay any front end costs, but would make monthly payments which would be less than the monthly energy savings.

The next five sections describe the five specific programs employed by the two energy plans. They give the primary assumptions behind each program, while the specific details of each are described in Appendix C.

2.4.2.1 Solar Hot Water Systems - New Construction

The first program involves an ordinance to require the use of solar hot water systems when feasible for all new construction. From a total of 5227 new housing starts in the five year period from 1972 through 1976 (excluding mobile homes), 75% or 3920 were assumed to install solar hot water systems as a result of the ordinance. The systems were estimated to cost $1457 (see Appendix C for this and other assumptions used here) each in 1972 dollars for both materials and labor. The direct impacts were broken out into ten different input-output sectors according to a Los Angeles input-output study which used a breakdown developed

by the Solar Energy Research Institute (SERI).[24] On the cost side, it was assumed that little additional time would be required of inspectors, since visits have to be made to new buildings anyway, but the energy planner would be responsible for assisting developers in appropriate solar site design and in reviewing and rewriting the zoning and subdivision ordinances to accommodate solar designs.

2.4.2.2 Energy Efficiency Standards - New Construction

The second program requires all new housing construction to follow a revised building code which would have stricter energy efficiency standards. These standards were assumed to apply to 100% of the 5227 new houses, but it was also assumed that 70% of the new housing was built on slab and 30% was built with a crawl space. For the housing on slab, the 1972 cost of additional insulation, caulking, and labor amounted to $137, while for housing with a crawl space, the 1972 cost was $520. These impacts were broken out into three input-output sectors. As for program costs, it was assumed that little additional cost would occur to either the inspectors or the energy planner.

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[24] Adam Rose et al., The Employment Impact of Energy Options on the Los Angeles City Economy, A research report submitted to the Los Angeles Mayor's Energy Office by the Regional Economics Group, (December 4, 1980), p. 12.

2.4.2.3 Solar Hot Water Systems - Existing Construction

This program entails a promotional and educational campaign to encourage the retrofit of domestic hot water systems in existing homes to solar systems. It was assumed that 3000 housing units or roughly 10% of all existing housing would change over to solar hot water systems in the five years. Again, the systems were estimated to cost $1457 each in 1972 dollars for both materials and labor and they comprised ten input-output sectors in the model. In this case the planner would be responsible for organizing promotions and workshops.

2.4.2.4 Energy Efficiency Standards - Existing Construction

The fourth program requires all existing housing to meet stricter energy efficiency standards in a revised building code upon the resale of the unit. It was assumed that 3000 or 10% of the 1970 housing stock would be sold over the five year period and would require weatherization. Additional ceiling insulation, caulking, storm windows and labor were included in the $498 estimate in 1972 dollars. Four input-output sectors were impacted by this program. With this program, a substantial amount of time must be budgeted for building inspectors to undertake additional inspections of housing that is up for sale.

2.4.2.5 Energy Related Business

The final program, employed at the high expenditure level, involves direct intervention in the local economy to establish one or more businesses with linkages to the demand created by the other four energy strategies. The establishment of these industries will be simulated by setting the RPC's to 0.95 in the appropriate sector. Table 3, shows the final demand disturbance vector for the first four energy programs and the normal RPC's for each sector with a direct change in final demand. The third column shows the initial round or the actual direct impact in the local economy of the change in final demand and can be calculated simply as final demand for a given sector times the respective RPC. The difference between the total final demand change and the total initial round impact represents the leakage from the local economy. By examining each individual sector, the greatest losses are in sector 198, flat plate glass, and sector 251, steel water tanks, which together account for nearly one third of total, final demand.

The establishment of energy related businesses within a region requires a feasibility analysis to determine whether the resources and the market potential exist to create a successful venture. Such a feasibility analysis has been

TABLE 3

Final Demand Disturbance Vector and Initial Round

| I-O# | Final Demand Vector | Normal RPC | Initial Round | Adjusted RPC | Initial Round |
|---|---|---|---|---|---|
| 16 | $4147.438 | 0.9500000 | $3940 | 0.9500000 | $3940 |
| 160 | 27.680 | 0.0049573 | 0 | 0.0049573 | 0 |
| 165 | 53.135 | 0.0000000 | 0 | 0.0000000 | 0 |
| 170 | 802.720 | 0.0309774 | 25 | 0.0309774 | 25 |
| 172 | 1073.678 | 0.7407793 | 795 | 0.7407793 | 795 |
| 198 | 1976.760 | 0.0078158 | 15 | 0.9500000 | 1878 |
| 249 | 380.600 | 0.0000000 | 0 | 0.0000000 | 0 |
| 250 | 781.960 | 0.0000000 | 0 | 0.0000000 | 0 |
| 251 | 2013.720 | 0.0000000 | 0 | 0.9500000 | 1913 |
| 257 | 685.080 | 0.0000000 | 0 | 0.0000000 | 0 |
| 296 | 622.800 | 0.0000000 | 0 | 0.0000000 | 0 |
| 391 | 318.320 | 0.3256081 | 107 | 0.3256081 | 107 |
| Total | $12883.891 | - | $4882 | - | $8658 |

Leakages =$12883.891 -$4882 =$8002 (low expenditure plan)
=$12883.891 -$8658 =$4226 (high expenditure plan)

done by the Institute for Local Self-Reliance (ILSR) for cellulose insulation manufacturing. In a feasibility and marketing study the ILSR concluded that a plant could be established with an initial capitalization of $450000, which could be leveraged with $70000 to $90000 using a Local Development Corporation and a SBA 7(a) loan.[25] Additional short term lines of credit would be needed for operation and could be secured through commercial banking institutions. One serious consideration involves the size of the market required to enable successful operation of the plant. The ILSR estimated that the needs of the Community Action Agencies weatherization program in New York City would be adequate. But because the insulation sector already has an RPC of 0.74 for the NRV and other sectors represent greater leakages or "missing links", it is not being used in the simulation.

Given that this plan has $600000 a year available for investment in community based businesses, which is well beyond the amount cited by the ILSR as necessary for the establishment of an insulation business, this study will assume that a flat plate glass manufacturing firm and a steel hot water tank firm is established in the region and

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[25] David Morris, A Technical Assistance Handbook for Community Based Cellulose Fabrication Plants, (Washington, D.C.: Institute for Local Self-Reliance).

serves to fill the demand created by the energy programs. A feasibility analysis would have to be performed in each case, but the assumption of establishing two businesses with three million dollars over a five year period appears very conservative in light of the ILSR analysis. To simulate this the RPC for the two sectors will be set at 0.95 from 0.0078158 and 0 for glass and steel tanks respectively. The fifth column of table 3 also shows the effects of the adjusted RPC's on the initial round as a result of the establishment of the glass and steel tank manufacturing. The reduction in the amount of leakage from the economy is equal to $8002 (leakage from the low expenditure plan) minus $4226 (leakage from the high expenditure plan), or $3776.

### 2.4.3 Program Modifications

One last word on the use of the input-output model to simulate the four scenarios is offered here. For each run of the model, a final demand vector must be specified. The final demand vector is composed of changes in demand for one or more sectors of the economy. The change can be represented in terms of employment or output. For the industrial development scenarios, the change was represented by employment, while the energy scenarios were represented by changes in output. The sectors of a final demand vector

do not all have to be represented by the same variable, i.e. all employment changes or all output changes, but could be mixed. The final demand vector for the worst case industrial development scenario is simply represented by 125 employees in sectors 31, 48, 210, and 369, while the best case scenario is represented by 500 employees in sector 160. The final demand vector for both energy scenarios was already shown in Table 3 The same vector is used for both scenarios. Only the RPC's for sectors 198 and 251 are changed for the high expenditure plan. The final demand vector for the energy scenarios represents the collective final demand for the four energy programs. These final demands were derived in Appendix C and are shown in Tables in the Appendix.

The other critical specification made during each model run is whether the final demand vector represents a change in demand or a change in output. The industrial development scenarios represent a change in output, since the assumption is that 500 employees are to be introduced into the economy and that total output will increase accordingly. The energy scenarios represent a change in demand, since the assumption is that demand in each sector is created, but the demand may not be met by local output in each sector. In terms of the workings of the model and the theory, this simply means that

the RPC's will be applied to the final demand vector to determine the initial round impacts in demand runs, but not in output runs. After the initial round, the RPC's are applied during each round of both runs.

## Chapter III

## PRESENTATION OF RESULTS AND ANALYSIS

The analysis of the output from the input-output model will concentrate on the income and employment effects on the local economy of each scenario with particular attention to the probabilities of success. In addition, two other considerations will be discussed which are: self-sufficiency effects or the income effects of energy savings and self-determination effects. Included is a presentation of the results of each scenario and a comparison with the other scenarios.

### 3.1 PROBABILITIES

In comparing the benefits of industrial development and energy self-reliance, one of the key issues is the probability of success to assign to each of the strategies. The energy self-reliance benefits are considered to be predictable with reasonable certainty, but the industrial development benefits have some probability associated with them. A recent study by Warren Kriesel, predicted probabilities of industrial location for rural areas of Virginia.[26] The model developed to predict the probabilities

[26] Warren Kriesel, Manufacturing Location in Rural Virginia: An Information System Approach, (Blacksburg, VA: draft

had four variables which were significant at the 0.05 level: DEVG - the existence of an industrial development group, INDEX - an industrial site quality index, MFGEMP - the number of manufacturing employees, and WAGE - the local average weekly wage. The first two are considered to be within the control of the local government and are therefore important to communities. The dependent variable, plant location, was a 1 if the jurisdiction had attracted at least one industry with 10 or more employees and was otherwise a 0.

Several observations can be made about the predictive capability of the model and about probabilities in general. First, the dependent variable restricts the overall usefulness of the model, since it represents an either/or situation and not the continuum of possibilities that actually exist. Montgomery County has a predicted probability of 99%, but would the probability be as high for a 500 employee plant as for a 10 employee plant? This aspect of the expected benefit of industrial development is crucial to making a comparison with energy self-reliance. Theoretically, if industrial plants totalling 500 employees can locate in a single region without interacting with of the independent variables, then the probability would be the

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of master's thesis submitted to Virginia Polytechnic Institute and State University, December, 1983).

same for the first 10 employees as for the last 10 employees, but this assumes that there exists a supply of industry equal to the total available sites. It is not clear that the probability can be applied to determine the amount of new industrial employment.

Another potential problem with the model and the resulting probabilities is whether they account for those firms who would have located regardless of any incentives. A plant location would cause the dependent variable to be set to 1, even though the firm may have simply moved to an area, solely on its own, without any assistance or they may have accepted assistance since it was available, even though they would have located anyway. The implications of this problem are that if a firm would have located anyway, then a sufficiently high probability already existed. The predicted probability overestimates the actual benefit of the industrial development strategy.

The relative change in probability as a result of additional industrial incentives is one of the more useful aspects of the probability model, because the model can be used to test the sensitivity of industrial location to different strategies. In addition the relative change in probability provides a more accurate estimate of the potential benefits from industrial development strategies

than does the absolute probability. While problems exist with the predicted probabilities especially as they apply to this thesis, they will provide a perspective to the probability question. The probabilities derived from the model were 30.34% for Giles, 48.01% for Radford, 99.05% for Montgomery, and 99.80% for Pulaski.[27]

Another perspective on the probabilities is available by looking at the success of the specific industrial development projects in the NRV. Table 1 in Chapter 3 listed four projects over a five year period. The first project in the Town of Narrows provided water to an industrial site at a total cost of $1,170,100 of which $325,300 was raised by the Town. Because EDA was involved, there was necessarily a commitment from an industry, but for their efforts, the Town now has an empty industrial site supplied with water. In Radford with a $593,435 total expenditure and a $221,717 local contribution, the City upgraded their water service to provide a slight increase in service to an existing industry on the pretense that they would not locate elsewhere and that they would expand. Estimates are that they expanded by about 15 employees, although the total employment is about 600 employees. The upgraded water system was needed for residential areas of

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[27] Ibid., (p. 110)

the City and this was at least an equally important reason for seeking the grants. An additional part of the incentives was that the City sold half of its landfill to the company for their plant site. The Town of Pearisburg has attracted one 75 employee industry and has a commitment for another 120 employee industry, but only after an additional expenditure of $500,000 for a shell building in an industrial park that already cost $547,900. The County of Pulaski spent $700,000 for an industrial park using State Community Development Funds and attracted one 50 employee firm, but the firm moved from elsewhere in the County. So far the $3,011,400 has netted the NRV 90 new jobs and possibly retained 600, though the 600 jobs would likely have stayed within the Region and only the plant site would have left the City for the County. Using the 90 jobs gained against the 500 jobs sought by the scenarios, an 18% probability is inferred.

## 3.2 EMPLOYMENT AND INCOME EFFECTS

Table 4 shows the output, employment, and income effects of each scenario for the initial round, the first round, and the total of all ten rounds plus the initial round or direct impact. The multipliers are generated by the model, but can simply be derived by dividing the total impacts by the

initial round impacts. The best case industrial development scenario offers the most benefits as would be expected with 848 jobs and $9,954,168 of income. The lowest benefits accrue to the low expenditure energy scenario with 200 jobs and $2,269,151 of income. Recall when comparing the worst case and the best case industrial development scenarios, that they are not tied directly to the low and high expenditure levels. Either case could occur, but the "breakeven" probability changes as well as the actual probability, e.g. if the actual probability at the low expenditure level for the worst case scenario is 30%, then the actual probability at the low expenditure level for the best case scenario to occur would be lower (perhaps 20%). The next section will compare the employment and income benefits of the scenarios, while considering the "breakeven" probability for the industrial scenarios.

At $60000 per year, the energy plan can be expected to create 200 new jobs, requiring a 28% "breakeven" probability (200 jobs/719 jobs) from the worst case and a 24% "breakeven" probability (200 jobs/848 jobs) from the best case industrial scenario. Spending $660000 per year the probabilities are 44% (315 jobs/719 jobs) and 37% (315 jobs/848 jobs) for the worst and best cases respectively. The "breakeven" probability can be considered as an all or

TABLE 4

Input-Output Model Results

Worst Case Industrial Scenario

| | Output ($000's) | Employment | Income ($000's) |
|---|---|---|---|
| Initial Round | 24364.145 | 500.000 | 4292.480 |
| First Round | 6673.125 | 137.523 | 2104.531 |
| Total (Ten Rounds[1]) | 32943.684 | 719.230 | 7118.832 |
| Multipliers | 1.352 | 1.438 | 1.658 |

Best Case Industrial Scenario

| | Output ($000's) | Employment | Income ($000's) |
|---|---|---|---|
| Initial Round | 50474.445 | 500.000 | 6730.918 |
| First Round | 7614.078 | 254.732 | 2372.379 |
| Total (Ten Rounds) | 60615.344 | 847.849 | 9954.168 |
| Multipliers | 1.201 | 1.696 | 1.479 |

Low Expenditure Energy Scenario

| | Output ($000's) | Employment | Income ($000's) |
|---|---|---|---|
| Initial Round | 4879.516 | 96.432 | 1238.840 |
| First Round | 1884.663 | 77.974 | 801.043 |
| Total (Ten Rounds) | 7313.387 | 199.870 | 2269.151 |
| Multipliers | 1.499 | 2.073 | 1.832 |

High Expenditure Energy Scenario

| | Output ($000's) | Employment | Income ($000's) |
|---|---|---|---|
| Initial Round | 8655.023 | 175.515 | 2027.633 |
| First Round | 2658.036 | 104.411 | 1040.409 |
| Total (Ten Rounds) | 12120.121 | 314.972 | 3383.459 |
| Multipliers | 1.400 | 1.795 | 1.669 |

[1]Ten rounds = initial round plus ten additional rounds.

nothing probability or as representing the percentage of success that will occur, i.e. an industrial development plan with a 20% probability would only attract 100 new jobs and thus not meet the 24% "breakeven" probability required to make it the optimal strategy.

The "breakeven" probabilities for the employment benefits range from 24% to 44%, as shown in Table 5, and clearly indicate that for some communities the energy self-reliance strategies would be the better method of economic development. For example, the 30.34% predicted probability for Giles County does not justify the money spent in the Town of Pearisburg, when the high expenditure "breakeven" point is 37-44%. If the money had not been spent for the industrial park (equivalent to moving from the high to low expenditure levels) then the predicted probability would be lower and again would likely not match the 24-28% needed at the low expenditure level. For the entire NRV, if the 18% observed probability is accurate, then the energy self-reliance strategies are justified.

Looking just at Montgomery or Pulaski County with their 99% predicted probability, recall that the predicted probability prior to the industrial development expenditures may have been as high as 70%, so that the actual benefits are a function of the change in the predicted probabilities.

For example, with the 99% probability, 99 jobs are created, while with the 70%, 70 jobs are created. If the industrial development strategies cause the probability to increase from 70% to 99%, then the benefits are only the additional 29 jobs and not the full 99 jobs. So the predicted probabilities are not the appropriate probabilities to use, but rather the relative change in probability is appropriate. Using the relative change in probability favors the energy self-reliance strategies, since they are smaller than the absolute probabilities.

For the income benefits, the "breakeven" probabilities required for the industrial plans are 32% ($2269/$7119) and 23% ($2269/$9954) for the worst and best case plans given the low expenditure level. At the high expenditure level, the probabilities are 48% ($3383/$7119) and 34% ($3383/$9954) for the worst and best case plans respectively. These probabilities indicate that a higher rate of success is required for the worst case industrial development then was required for employment totals, i.e. a community had better be even more confident of success to equal the success of the energy plan in generating income. The best case income probability was a percentage point better than the employment probability, but recall that the best case scenario was chosen as representing one of the

TABLE 5

Summary of Input-Output Analysis

$60,000 Expenditure/Year

| | Total Jobs | % | Total Income | % | Inc/Job |
|---|---|---|---|---|---|
| Energy Plan | 200 | - | $2269000 | - | $11,350 |
| Industrial Plan: | | | | | |
| Worst Case | 719 | 28 | $7119000 | 32 | $ 9,900 |
| Best Case | 848 | 24 | $9954000 | 23 | $11,740 |

$660,000 Expenditure/Year

| | Total Jobs | % | Total Income | % | Inc/Job |
|---|---|---|---|---|---|
| Energy Plan | 315 | - | $3383000 | - | $10,740 |
| Industrial Plan: | | | | | |
| Worst Case | 719 | 44 | $7119000 | 48 | $ 9,900 |
| Best Case | 848 | 37 | $9954000 | 34 | $11,740 |

Model's Predicted Probabilities:

| | | | |
|---|---|---|---|
| Giles | 30.34% | Radford | 48.01% |
| Montgomery | 99.05% | Pulaski | 99.80% |

NRVPDC Historical Probability 18%

highest wage industries available with the best linkages for the economy. It really represents the ideal industry (in terms of total jobs and total income). As with the employment benefits, the "breakeven" probabilities are high enough to make the energy self-reliance strategies the winner for some communities. Most communities will be faced with "breakeven" points of the worst case rather than the best case scenarios, which will require a relatively high probability of success for industrial development.

An alternative income measure is the income per employee, which is simply the total income generated divided by the total employment generated. The income is $9,900 and $11,740 for the worst case and best case industrial development plans and $11,350 and $10,740 for the low and high expenditure energy plans. The divergence between the two industrial plans was expected, since the industry wage was used in selecting them. Given the unlikely probability that the best case scenario would materialize, the income/employee measure favors the energy self-reliance scenarios.

The certainty of the benefits from energy self-reliance provides these strategies with a tremendous advantage over industrial development, whose benefits are subject to uncertainty. Many communities have spent large sums of

money, both their own and federal and state money, only to be left with an empty industrial park. Energy self-reliance and other types of self-reliance strategies can be implemented through such organizations as Community Development Corporations, which can receive government grant money, but which can also work as an independent non-profit agency. Such an arrangement allows for new forms of economic development by allowing new forms of direct intervention in the local economy. Even without such an organization, the low expenditure energy plans can be implemented.

A final point concerning the energy plans and especially the high expenditure energy plan, is that they may not have been designed as effectively as possible. The high expenditure plan in particular was a relatively conservative proposal and there are several other types of energy plans that could have been proposed, including municipal energy utilities, which might have produced significantly different results. With adequate research to maximize the potential benefits from community energy planning, the "breakeven" probabilities for the industrial strategies may have been pushed much higher.

## 3.3 SELF-SUFFICIENCY - INCOME EFFECTS FROM ENERGY SAVINGS

An additional benefit that the energy plans have, which the industrial development plans do not, is the income effects from the money not spent on energy due to the energy conservation and solar energy. In most localities a large percentage of the money spent on energy immediately leaves the local economy, rather than being circulated and creating a multiplier effect. By reducing the amount of household expenditures for energy, the energy plans permit that money to be spent on other goods and services. A portion of that money will be spent on goods and services provided locally and thus generate additional jobs and income in the local economy.

This income effect represents the import substitution theory of development and essentially stops some of the leakage from the economy. Import substitution effects are generally considered to be smaller than export base effects, but their importance in the energy plans are twofold. First they are not expected to be exceptionally large, but in conjunction with the jobs and income already created by the plans, they may provide an additional margin that increases the necessary probability of success the industrial plans. Second, the use of import substitution strategies are useful to apply prior to export-led strategies, precisely because

they stop leakages and create a more self-sufficient economy. This in turn means that as industrial development does occur in the future, the multiplier effect will be significantly greater.

This benefit is a factor weighing in the favor of the energy plans. Industrial development can offer import substitution strategies, but has no comparable benefits to the income effects from energy savings. One question that remains is how much self-sufficiency should be sought and in what terms should that self-sufficiency be defined? For example, large cities like New York are generally considered to be relatively self-sufficient with large complex economies, but New York City is so large that many areas within the City are highly dependent with tremendous amounts of money leaking out of the neighborhood or district. Self-sufficiency needs to be evaluated at a human scale.

## 3.4 SELF-DETERMINATION

The final additional factor to consider concerns the degree of self-determination that the locality has over its economy. The industrial development strategies offer no certain benefits in this area, while the energy self-reliance strategies decrease local dependence on a critical resource. Self-determination should not be a primary goal,

but it should not be overlooked either. Self-determination can entail simple independence over resources like energy and water and it can extend into more complex areas like ownership of critical businesses. Employee stock ownerships plans and employee buyouts of failing industries are representative of an assertion of self-control over ownership patterns. Such self-control is no small concern for small areas, which are heavily dependent on a few relatively large industries. As efficient as it may be from a corporate perspective to relocate from Buffalo to Houston, it remains relatively inefficient from a social cost perspective to leave hundreds of people unemployed from a plant that may have been profitable, but was marginally less profitable than the potential new plant. Increased local self-determination through local or community ownership of industry can restrict this costly practice.

A second facet of self-determination for a community is the decrease of cyclical sensitivity. As discussed in the introduction, self-reliance strategies may help to a certain degree by reducing the overall dependence of the local economy on the national economy. Cyclical sensitivity is frequently measured by comparing the trends of unemployment rates between the national and the local economy. Some local economies respond with large shifts in unemployment as

a result of lesser shifts in the national economy. If they are in the same direction, then the local economy is highly sensitive to the cyclical trends. If they are in the opposite direction, then they are still highly sensitive, but they are counter-cyclical. This generally applies only to specific industries and not to local economies. If the local economy does not respond at all or very little, then the economy is insensitive to the national trends, although the economy could have dramatic trends on its own.

There is a theoretical conflict involved with self-reliance strategies and cyclical sensitivity. Self-reliance strategies promote economic self-sufficiency, which according to theory will result in a higher multiplier and by definition increase internal linkages while decreasing exports and imports (at least relatively). But theory holds that a self-sufficient economy will approach the U.S. economy in terms of diversification implying that the local economy will be perfectly sensitive to the national economy with identical trends. At the same time, this self-sufficient economy has decreased its linkages and dependence on the national economy and should then theoretically not be as sensitive to the national trends. The cyclical sensitivity question cannot be resolved without more research. The other self-determination issue, while not

quantifiable, should be weighed on a subjective basis as a favorable result for the energy self-reliance plans.

## Chapter IV

## CONCLUSIONS

The results of this thesis have shown that for some communities, those which have little expectation of attracting industry through any effort of their own, there is an alternative means of economic development. Identifying those communities may not be possible with a general formula, but will likely require individual economic analysis and needs assessment. In addition, the results leave open the possibility that energy self-reliance can compete against industrial development methods in most communities similar to the NRV, particularly when additional considerations beyond employment and income are weighed as part of the decision making.

Several observations from this thesis make it clear that energy self-reliance would be a better method of economic development than industrial development for some communities. First, the industrial development literature suggests that most industrial development strategies are ineffective, indicating that any alternative might be better. The predicted probabilities of success derived by Kriesel's model indicate that for at least some communities energy self-reliance is the better method, while refinement

of the model would likely indicate a larger number of communities by using the relative probability rather than the absolute probability. The low, observed probability of success in the NRV lends even more support to the energy self-reliance alternative. With existing industrial sites already sitting empty in the NRV and in other areas the expectation of attracting an industry that would not have come anyway is very slim. A final factor is the national and international trends of slow economic growth which are occurring with more regularity. The slow growth trends will decrease the individual probabilities of success for attracting industry, by decreasing the overall expansion and growth of industry.

Given the distinct possibility that many communities will have a lower probability of success at industrial development than the "breakeven" probability, then these communities should consider energy self-reliance strategies. Even if a community can show an actual probability of attracting industry equal to the "breakeven" probability, then the community may still benefit from employing energy self-reliance strategies, because of the unquantifiable benefits of self-reliance. If the community can show a higher probability of success in attracting industry than the "breakeven" probability, then the community may reasonably choose to pursue industrial development.

## 4.1 LOCAL IMPLICATIONS

The results of this thesis provide compelling evidence that communities should more carefully assess their needs before formulating goals and plans for economic development. They need to break away from the traditional thinking that has guided economic development efforts to industrial development. Many communities will find that self-reliance strategies and in particular energy self-reliance strategies, will more adequately fulfill their goals and in some cases will provide more benefits than industrial development strategies. For those communities with a good likelihood of benefiting from industrial development, there still exists a need to better understand the local needs and local economy to assist in attracting (targeting) or creating those industries that would most benefit the economy and satisfy the local needs.

## 4.2 NATIONAL AND STATE IMPLICATIONS

In addition to the implications of this research for local communities, there are important implications for the national and state governments. Most of the economic development programs that are created in this country are rooted in federal and state policy. Local governments, regional planning agencies, and private consultants all go

where the money is, and as long as industrial development proposals can win grants from the administering agencies, then that is the avenue that local decision makers will take. The programs and tools that are offered to local governments should be reevaluated to determine if they should be eliminated, maintained as is, or broadened to include alternative methods of economic development. For example, if the decision is made to renew the industrial development bond legislation, then it should be enabled to be used to establish a loan program for residents under an energy program. One of the key factors in making the self-reliance strategies a strong program is allowing them to be established with the same monetary support that industrial development maintains. The bias toward industrial development should be eliminated.

As an example, the State of Virginia.currently supports a community certification program that requires communities to meet 31 criteria in 7 categories, before they will be recognized by the State Division of Industrial Development. The program has established a "competition" with winners and losers in that unrecognized communities will not receive support from the Division. But the real loss will occur where a community tries to become certified, spending a considerable sum of money to do so, and then fails. The

criteria are stiff and many communities feel they should participate despite the fact that they have little chance of meeting the criteria or of attracting industry. The program is not poorly constructed in that for some communities, it spells out a sensible course of action. But there is no alternative program and the state fails to recognize the need for alternatives.

## 4.3 FUTURE RESEARCH

This thesis suggests several areas for future research. Three broad categories of research are: improvements in the input-output model and the regionalization technique, research of the related factors of economic development, such as, community leakages, income effects, occupational skills, and industrial development success probabilities, and thirdly, research into the feasibility of various possible self-reliance strategies.

The input-output model can be improved by developing better estimates of the regional purchase coefficients, as well as examining the other region specific coefficients. Dynamic input-output models and interregional input-output models also improve certain capabilities of the modelling process, but these take a considerable amount of effort. Developing better estimates of the RPC's by gathering more

accurate data probably offers the biggest improvement to the model.

In comparing industrial development and energy self-reliance, several additional questions were raised. How can we best measure and what are the impacts of money leaking from a community? What are the income effects of providing local alternative energy, food or other goods? Can any generalizations be made about the occupational skills required by self-reliance strategies as opposed to industrial development strategies? What are the impacts of self-reliance on the cyclical sensitivity of an economy? And how can we determine the probability of success for a community employing an industrial development strategy? Each of these questions requires more detailed research and would contribute to the understanding of this thesis question.

The third category of research involves the identification of other potential self-reliance strategies. After identifying areas of the economy, plans must be developed and the feasibility of the plans must be evaluated. Research should begin to examine the many grass roots efforts at community self-reliance and develop adaptations for the economic development of entire communities and regions. An awareness of the human scale of

grass roots efforts and of self-reliance attitudes must be kept in mind so as not to inappropriately apply a successful neighborhood program to a large city. This area of research is probably the most needed as research has only recently begun to examine these alternatives from a local government perspective.

## Appendix A

## STATE SPECIFIC COEFFICIENTS

The eight state specific coefficients are the key components of the input-output model in any attempt to regionalize the model. It is unclear at this point just how sensitive the model is to changes in the coefficients, but the RPC's are clearly the most important. For the other seven coefficients, it was decided not to attempt to develop regional estimates, but to use the state estimates. However it is suggested that future research consider developing regional estimates for sector coefficients that are believed to be different than the state coefficients. Emphasis should be placed primarily on the obvious sectors, rather than developing estimates for all 501 sectors of the model, i.e. if the cost of food is significantly less in the region relative to the state and relative to other household consumption, then the HHC for food sectors should be estimated for the region. This appendix provides a detailed description of the seven coefficients not changed in this study, the method used by the model to develop the coefficients, the method and data necessary to adjust them to regional coefficients, and the implications of using state rather than regional coefficients in a regional model.

## A.1 EPV - EMPLOYMENT PER VALUE OF OUTPUT

The EPV coefficient represents for each sector of the economy, the employment required (in person years) in that sector to produce a thousand dollars of output. EPV is not specifically required to generate indirect or induced effects, but is used to translate the generated indirect and induced output effects into employment effects, so that the employment impacts can be evaluated. No explanation of the methodology used to generate the EPV coefficients is provided in the model's handbook, but most likely the EPV coefficients were not varied by state, but are national estimates. EPV estimates will vary somewhat among states and regions and the data necessary to make the distinction would include employment and output by sector. Two estimation methodologies are possible, one being an estimate from aggregate employment and output data, and another being an estimate from sample businesses in each sector. The methodology using the aggregate would suffer from data inadequacies and from matching annual output to an appropriate average annual employment figure. The latter sampling methodology would suffer from normal statistical error, and both methodologies could suffer from using data during a period of abnormal economic fluctuations either at the individual business level, regional level, or national level.

One final important note about the EPV coefficients is that several of the EPV coefficients provided by the model are zero, particularly in areas of government where output is difficult to quantify. This implies that the model will not permit the designation of these sectors with an EPV of zero as part of the demand disturbance vector, while using employment as the disturbance variable. This means that the impacts of increased employment in most government sectors, can not be modelled. Also when final total employment impacts are calculated, those sectors with an EPV of zero will not show any employment even though they show an increase in output.

## A.2 WPV - WAGES, SALARIES, AND PROPRIETOR'S INCOME (WSPY)

This coefficient represents the wages, salaries, and proprietor's income for each dollar of output in each sector and essentially acts as the household income in the endogenous input-output model. The 501 WPV coefficients become the 502nd row of the technology matrix. These coefficients were derived from state specific data by multiplying state wage/value added ratios and national value added/output ratios. Regional differences would reflect different wage rates and are an important consideration. There would be substantial data availability problems in an

attempt to develop regional estimates of wage/value added ratios and would likely require a survey effort to identify sectors that diverged from the state ratio. While the regional estimates would be cumbersome, this coefficient is one of the more important, along with the HHC, and merits some attention in future studies.

### A.3 AA - ADMINISTRATIVE & AUXILIARY WSPY

This coefficient represents the proportion of wages, salaries, and proprietor's income accruing to administrative and auxiliary components in each sector. It refers primarily to the WSPY found in corporate headquarters and similar centralized offices that serve branch locations in their respective economic sector. The model provides a switch to enable and disable the consideration of this factor in each run. If switched off, this sector is treated as exogenous to the model. For all of the scenarios used in this study, this coefficient was not utilized. Again, no mention of the derivation of these coefficients are provided in the handbook, but they are very likely national estimates and there is little likelihood that a regional estimate will provide any significant improvement to the model, particularly for smaller areas, which do not attract corporate headquarters.

## A.4 HHC - HOUSEHOLD CONSUMPTION PER DOLLAR OF WSPY

This coefficient, like WPV, is one of the most critical coefficients to the accuracy of the model. It represents the expenditures in each sector of the economy for each dollar of household income (WSPY). This set of 501 coefficients becomes the 502nd column of the technology matrix and acts as the household "inputs" in contrast to the WPV "outputs" in the endogenous input-output model. An important assumption behind the use of HHC's is that household consumption patterns are assumed to remain constant over various and changing income levels. The HHC's are used to represent an average household consumption pattern and as income increases in a region, the consumption expenditures increase proportionally over all sectors of the economy. One important consideration of the HHC's is that the expenditure for a particular good is divided among the manufacturing, wholesale, transportation, and/or retail sectors that are involved in providing that good. The derivation of these coefficients entail the use of the Bureau of Labor Statistics' Consumer Expenditure Surveys. These surveys only report consumption data on four major regions of the U.S. This data is manipulated to account for all expenditures shown, and then reduced by the amount of federal, state, and local taxes estimated on a state by

state basis. Because of the nature of their derivation, these coefficients can only be easily improved at the regional level by adjusting the local taxes. An additional, more complex improvement would be to develop consumption pattern data at the local level, but this would require detailed survey efforts.

## A.5 STPV & LTPV - STATE & LOCAL TAXES PER DOLLAR OF OUTPUT

These two coefficients represent the state and local taxes generated per dollar of output (per dollar of WSPY for households). They do not feedback into the model and generate additional effects, but they are of interest by themselves. In developing the HHC's the federal taxes, state taxes, and local taxes were subtracted out of the expenditure totals. The federal taxes are ignored, but the state and local taxes are used to derive STPV and LTPV. These coefficients represent state averages and could be improved as regional estimates only to the extent that the local tax rate differs substantially from the average local tax rate for that state. These coefficients warrant less attention than RPC, HHC, and WPV, but if additional resources are available after examining the former coefficients, then some improvements could certainly be made.

## A.6 OTHPV - OTHER VALUE ADDED PER DOLLAR OF OUTPUT

This coefficient represents any remaining value added that is generated for each dollar of output, i.e. it is equal to total value added less WSPY, STPV, and LTPV. The model includes the concept, but the coefficients were all set to zero, and therefore the model essentially ignores it. Given that the model developers were satisfied to ignore this component for the time being, there seems little reason to dwell on its inclusion.

## Appendix B

## TECHNICAL DESCRIPTION OF RPC DATA REQUIREMENTS

The calculation of the regional purchase coefficients, described in Chapter Two, required employment data to derive location quotients for each sector at both the regional and the national levels. In addition, wage data and transportation of goods data was required to fit the estimating equation for all the manufacturing sectors, excluding ordnance, ice, printing, and secondary, nonferrous metals. This data was obtained from a variety of sources and required that some assumptions be made. This appendix describes the sources of the data and the necessary assumptions that were made to meet the data requirements of the regional purchase coefficients. The data is described for the following sectors: agriculture, forestry, and fisheries; mining; construction; manufacturing; transportation, communications, and utilities; wholesale trade and retail trade; finance, insurance, and real estate; services; government; administrative and auxiliary; and household.

The data sources used different reporting practices and different time periods on which they reported. The five major sources of data were 1972 Virginia Employment

Commission (VEC) records,[28] the 1972 County Business Patterns, the 1972 Economic Census reports, the 1974 Census of Agriculture, and the 1970 General Census reports. The VEC data, used as the primary source for the region's employment, represents the 1972 third quarter average and is reported by place of work. The 1972 County Business Patterns uses a mid March reporting period and also reports employment by place of work. The 1972 Economic Census reports, covering mining, construction, manufacturing, transportation, wholesale trade, retail trade, and selected services, use a variety of reporting periods, but all report employment by place of work. The 1974 Census of Agriculture reports average, annual employment by place of work. Finally the 1970 General Census reports use mid March employment by place of residence. The annual average is the average of March 12, May 12, August 12, and November 12. In some cases, the sources use the sum of the annual average for the "blue collar workers", i.e. the production workers, plus a March 12th or mid March figure for other employees.

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[28] Employment and wage data (Detailed Industry Data) for Floyd, Giles, Montgomery, Pulaski Counties and the City of Radford, covering the third quarter of 1972, was obtained from the Virginia Employment Commission.

## B.1 AGRICULTURE, FORESTRY, AND FISHERIES

Employment data for the agricultural sectors was the hardest to obtain, but by using the 1974 census and by making several assumptions, estimates for both the regional[29] and national[30] employment in each sector were developed. The basic methodology was to determine total employment for all the agricultural sectors as a group for the New River Valley and the United States. The total employment was defined as all farm owners who list farming as their principal occupation plus all hired workers, working twenty-five days or more per year. The U.S. summary had employment and output data broken out by sectors, but the county summaries for the region only had output data

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[29] United States Bureau of the Census, Census of Agriculture, 1974 "Volume 1, Part 46, Virginia: State and County Data,"
Table 2. Farm Operators - Tenure and Characteristics: 1974 and 1969
Table 3. Market Value of Agricultural Products Sold: 1974 and 1969
Table 15. Payroll and Employment for Farms with Sales of $2500 and Over: 1974 and 1969
(Washington, D.C.: U.S. Government Printing Office, July, 1977).

[30] United States Bureau of the Census, Census of Agriculture, 1974 "Volume 1, Part 51, United States: Summary and State Data,"
Table 26. Value of Agricultural Products Sold by Commodity Group and Total Value of Sales: 1974 and 1969
Table 32. Summary by Standard Industrial Classification of Farms: 1974
(Washington, D.C.: U.S. Government Printing Office, December, 1977), pp. 1-25, 1-78 to 1-81.

broken out by sectors. The ratio of employment to output at the national level was applied to the output at the local level to obtain local employment, but the sum of these figures was less than the total developed earlier. Using the earlier total as a control figure all the local sector employment was increased proportionally until their sum equaled the control total.

The above methodology was used for sectors one through eight, but sectors 9 and 10 used other data sources. Sector 9, forestry and fishery products, and sector 10, agriculture, forestry, and fishery services, used figures from the VEC and from County Business Patterns[31] for regional and national data respectively.

## B.2 MINING

Employment for the NRV was taken directly from the VEC records with no modifications. The national mining employment[32] was modified by subtracting the employment

[31] U.S. Bureau of the Census, County Business Patterns, 1972, Virginia CBP-72-48, Table 1B. United States, by Industry: 1972, (Washington, D.C.: U.S. Government Printing Office, 1973), pp. 14-27

[32] U.S. Bureau of the Census, Census of Mineral Industry, 1972 "Subject, Industry, and Area Statistics,"
Table 2. General Statistics by Industry Group and Industry: 1972 and 1967
Table 12. Employment at Central Administrative Offices and Related Facilities by Industry Group and Industry: 1972 and 1967

listed as central administrative offices from the total in each of the four mining sectors and assigning it to the administrative and auxiliary sector (sector 501) of the input-output model.

## B.3 CONSTRUCTION

Construction employment was taken directly from the VEC records and from the census information[33] with two modifications. The model included a maintenance and repair sector which comprised a small percentage of each of the other construction sectors. The percentages were calculated from Table B8 in the census reports to be .05, .10, and .18 for general, heavy, and special trade construction categories, respectively. Each sector of new construction for both the NRV and the U.S. was adjusted downward with the difference being added to the repair and maintenance sector. Also the Census of Construction lists subdividers and

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(Washington, D.C.: U.S. Government Printing Office, 1976), pp. 1-4, 1-98.

[33] U.S. Bureau of the Census, Census of Construction Industries, 1972 "Volume I. Industry and Special Statistics,"
Table B1. General Statistics by Industry Group and Industry, for Establishments with Payroll: 1972 and 1967
Table B8. Construction Receipts Showing Distribution by Class of Construction and by Ownership of Construction Projects, for Establishments with Payroll: 1972
(Washington, D.C.: U.S. Government Printing Office, 1976), pp. 1-8, 1-19.

developers (SIC 6552), but this was added to the model under real estate (sector 475).

## B.4 MANUFACTURING

For the NRV employment and wages in the manufacturing sectors, the average employment and average weekly wage for the third quarter of 1972 were used. Because the model often disaggregated the sectors to the 4-digit SIC code level and the 1972 VEC records were only broken down to the 3-digit SIC code level, some of the industries had to be assigned to a particular sector based on personal knowledge.

For the U.S., the census[34] had broken the industries out to the 4-digit level, so the data merely had to be aggregated into the appropriate sectors for the input-output model. The census calculated employment as the sum of the annual, average employment of production workers plus the employment of all other workers during the week of May 12. The payroll data was listed as an annual total from which the average weekly wage was derived, to be consistent with the VEC data. Central administrative office employment was listed separately in the census and assigned to sector 501

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[34] U.S. Bureau of the Census, Census of Manufactures, 1972 "Volume I. Subject and Special Statistics," Table 3. General Statistics for Establishments by Industry Group and Industry: 1972 and 1967 (Washington, D.C.: U.S. Government Printing Office, 1976), pp. 6-20.

of the model.

In addition to employment and wages, data was required for the manufacturing sectors of thousands of tons of the good shipped and the land area of the NRV and the U.S. The land area was simply gathered from the County and City Data Book,[35] the U.S. being 3,536,855 square miles and the NRV being 1,473 square miles. The transportation data for each manufacturing good was gathered from the Census of Transportation[36] which uses Transportation Commodity Classification (TCC) codes rather than the SIC code. This difference in reporting required some tedious conversions of the TCC codes to the SIC codes and several assumptions in situations where the two classification systems were inconsistent with each other. Of the 389 manufacturing sectors, 22 were not covered by the TCC codes. These include 6 ordnance sectors for security reasons, ice, 15 printing sectors, and secondary nonferrous metals. The

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[35] U.S. Bureau of the Census, County and City Data Book, 1972, (A Statistical Abstract Supplement),
Table 1. Census Regions, Divisions, and States
Table 2. Counties
(Washington, D.C.: U.S. Government Printing Office, 1976), pp. 2,486,498

[36] U.S. Bureau of the Census, Census of Transportation, 1972, "Volume III. Commodity Transportation Survey, Part 3. Area Statistics, South and West Regions and U.S. Summary," Table 1. Percent Distribution of Commodities Shipped to Geographic Divisions, by Means of Transport: 1972, A. Tons of Shipments, (Washington, D.C.: U.S. Government Printing Office, 1976), pp. 8-4 to 8-13.

latter were excluded because they are generally only shipped locally, therefore their RPC's are assigned as .95. The ordnance sectors which had no reported employment in the region (the arsenal is accounted for in the chemical sector) were assigned RPC's of 0. Of the 367 sectors remaining, 70, or about one-fifth, required knowledgeable but somewhat arbitrary assumptions to arrive at the SIC equivalents of the TCC codes.

## B.5 TRANSPORTATION, COMMUNICATIONS, AND UTILITIES

With the exception of sector 389, railroads and related services, the data for this group was obtained from the VEC and the County Business Patterns. For the railroad sector, which is excluded from the former sources, the 1970 census was used for both the local[37] and the national[38] data.

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[37] U.S. Bureau of the Census, General Social and Economic Characteristics "Volume 48, Virginia," Table 123. Industry of Employed Persons and Occupation of Experienced Unemployed Persons for Counties and Independent Cities: 1970, (Washington, D.C.: U.S. Government Printing Office, 1976), pp. 48-450 to 48-459.

[38] U.S. Bureau of the Census, United States Summary Detailed Characteristics "Volume I. United States," Table 235. Detailed Industry of the Experienced Civilian Labor Force and Employed Persons, by Sex: 1970 and 1960, (Washington, D.C.: U.S. Government Printing Office, 1976), pp. 1-798 to 1-800.

The energy sectors, electricity, and gas utilities, which are especially important to this study, suffer in accuracy from the use of employment generated location quotients. Energy sectors are very capital intensive, therefore the RPC should be based on the relative share of capital in the region rather than employment. Because a large number of the jobs in energy sectors involve distribution, then the location quotient is higher than intuition would lead one to believe based on the distribution of the capital expenditures in the energy sectors. Future studies should include improved methods of estimating the energy sector RPC's.

## B.6 WHOLESALE TRADE AND RETAIL TRADE

The data for these two groups of sectors was collected in essentially the same way. The employment data for the NRV was taken from the VEC records, and as with manufacturing, the data occasionally had to be assigned to a model sector in those instances where the model was more disaggregated than the 3-digit VEC records. This was especially a problem for the wholesale trade sectors. The U.S. data was taken directly from the census sources.[39] The only other

[39] U.S. Bureau of the Census, Census of Wholesale Trade, 1972 "Volume I. Summary and Subject Statistics," Table 1. United States by Kind of Business: 1972 (Washington, D.C.: U.S. Government Printing Office, 1976), pp. 8-10.

peculiarity is that the eating and drinking establishments normally listed with retail trade by the VEC and the census, is listed with services for the input-output model.

B.7 FINANCE, INSURANCE & REAL ESTATE

These sectors simply used the VEC data and the County Business Patterns. One peculiarity with them is that sector 474, owner-occupied dwellings, is essentially ignored by the input-output model, which assigns household consumption of owner-occupied housing to the appropriate sectors that comprise the mortgage, insurance, taxes, maintenance and other housing expenses. Therefore no data was necessary for sector 474, but because the computer model uses it, a 0 was used for the regional employment and a 1 was used for the nation. Another peculiarity is that employment for subdividers and developers from the Census of Construction is added to sector 475.

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U.S. Bureau of the Census, Census of Retail Trade, 1972 "Volume I. Summary and Subject Statistics," Table 1. United States by Kind of Business: 1972 (Washington, D.C.: U.S. Government Printing Office, 1976), pp. 7,8.

## B.8 SERVICES

The employment data for the services sectors was gathered primarily from the VEC and the County Business Patterns, but in several cases where the reported employment was significantly lower than the reported employment from the 1972 census, then the 1972 census figures were used.[40] The latter situation occurred with sectors 477, 478, 481, and 489, which represent personal and repair services, beauty and barber shops, miscellaneous professional services, and education, respectively. Sectors 477 and 478 were aggregated with several other sectors in the census at the local level and so these were broken out as a proportion of the national total.

An additional assumption was made for the education employment data to include employment in both private and public schools in the sector rather than putting the public school employment with the government sectors. The literature, particularly the literature accompanying the model, was unclear as to which method should be used and since input-output models assume homogeneity of the product, the former method was used. The final assumption for this group of sectors involved sectors 490 through 494, job

[40] U.S. Bureau of the Census, Census of Selected Services, 1972, "Volume I. Summary and Subject Statistics," Table 1. United States by Kind of Business: 1972 (Washington, D.C.: U.S. Government Printing Office, 1976), pp. 7-9.

training, child care, residential care, and social services. There was insufficient employment data from any source for these sectors, but the nature of the sectors allowed for assigning the RPC to be .95 since there would be very little means of importing these services to the region.

## B.9 GOVERNMENT

Local employment in the government sectors was derived by using the 1970 census employment in public administration as a control total. Local government employment from the 1972 Census of Governments,[41] less education, was assigned to sectors 498-500 and the total was subtracted from the 1970 control total to give Federal employment which was allocated to sectors 495 and 497 based on the national ratio between the two. Sector 496, federal electric utilities was assigned to be zero as was sector 498, local transit (bus service). National employment data was derived from the 1972 Census of Governments[42] and assigned to the appropriate

[41] U.S. Bureau of the Census, Census of Governments, 1972, "Volume 3, Public Employment, No. 2: Compendium of Public Employment," Table 17. Local Government Employment and Payroll for Individual County Areas: October, 1972 (Washington, D.C.: U.S. Government Printing Office, 1974), pp. 298-303.

[42] U.S. Bureau of the Census, Census of Governments, 1972, "Volume 3, Public Employment, No. 2: Compendium of Public Employment,"
Table 4. Summary of Public Employment and Payrolls, by Function: October, 1972

sectors.

B.10 ADMINISTRATIVE AND AUXILIARY

The administrative and auxiliary sector is a special sector that includes employment in the central administrative offices of corporations, where the work does not involve the direct production of the good or service normally produced by that firm, but involves a support service to several branch locations of the firm. The NRV has no employment in this sector though if there was it would not show up in the VEC data. The County Business Patterns reported employment for this sector at the end of each major group of sectors and a total was simply derived from adding each occurrence. The administrative and auxiliary sector can be included or excluded from the use of this input-output model at the discretion of the analyst each time the model is run. This was done to allow the analyst to make the assumption as to whether there is any feedback between the local economy and corporate offices, but inclusion is of little significance in small, rural areas. For the simulations presented here, it is assumed that there is not any feedback.

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Table 5. Employment and Payrolls of State and Local Governments by Function: October, 1972 (Washington, D.C.: U.S. Government Printing Office, 1974), pp. 14,15.

B.11 HOUSEHOLDS

The RPC for this sector was set to .91 which is the percentage of jobs within the region that are supplied by local labor. This percentage was derived from commuting data for the region[43] and represents the proportion of wages, salaries, and proprietors' income that is generated by activity within the region and is paid to residents within the region.

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[43] DATA SUMMARY: Floyd "Work Residence Information, (1960 data)," (Richmond, VA: Division of State Planning and Community Affairs, April, 1972), p. 12.

DATA SUMMARY: Giles "Work Residence Information, (1960 data)," (Richmond, VA: Division of State Planning and Community Affairs, May, 1972), p. 14.

DATA SUMMARY: Pulaski "Work Residence Information, (1970 data)," (Richmond, VA: Division of State Planning and Community Affairs, June, 1974), p. 14.

DATA SUMMARY: Montgomery and Radford "Work Residence Information, (1960 data)," (Richmond, VA: Division of State Planning and Community Affairs, September, 1972), pp. 12,13.

## Appendix C

## ENERGY PROGRAM DESCRIPTICNS

### C.1 SOLAR HOT WATER SYSTEMS

The first step in determining the benefits of solar hot water heaters was to determine the installation cost of each component in 1972 dollars and assign them to their appropriate input-output model sector. Using the current, total cost of solar hot water heaters from a contractor in the NRV area and the cost breakdown of components of a solar hot water heater from an older, Los Angeles study,[44] the 1983, NRV cost for each component of the system was derived. To convert the cost figures to 1972 dollars, price deflators were selected according to the appropriate sector of the economy and applied to the 1983 figures.

These results were then multiplied by the number of new housing starts recorded in the NRV from 1972 through 1976, including apartments but excluding mobile homes, plus 3000 units assumed to be retrofitted.[45] Tables 6 and 7 show these

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[44] Adam Rose et al., The Employment Impact of Energy Options on the Los Angeles City Economy, A research report submitted to the Los Angeles Mayor's Energy Office by the Regional Economics Group, (December 4, 1980), p. 12.

[45] Tayloe Murphy Institute, Housing Units Authorized: Virginia Data for Planning Districts, Counties, and Cities: 1970-1974, (Charlottesville: University of Virginia, August, 1976).

calculations. The final 1972 figures are used in the final demand disturbance vector of the input-output model and are treated as a demand disturbance rather than an output disturbance. By being treated as a demand disturbance, the RPC's are applied to each respective sector of final demand so that the initial round of direct impacts is less than final demand.

## C.2 ENERGY EFFICIENCY STANDARDS

The efficiency standards programs were assumed to generate additional demand for weatherization, which includes insulation, caulking, storm windows and labor. A number of assumptions were made about the standard new home construction practice at the time, the existing housing efficiency, and the requirements of the stricter code. The two program's effects can be expressed as three weatherization packages with the following assumptions. Table 8 displays the assumptions made.

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Tayloe Murphy Institute, Housing Units Authorized: Virginia Data for Planning Districts, Counties, and Cities: 1975, (Charlottesville: University of Virginia, December, 1976).
Tayloe Murphy Institute, Housing Units Authorized: Virginia Data for Planning Districts, Counties, and Cities: 4th Quarter and Entire Year 1976, (Charlottesville: University of Virginia, August, 1977).

TABLE 6

Solar Hot Water Systems - Components & Cost

| I-O# | SIC# | Components | SERI Cost[1] | % | 1983 Cost[3] | Price Index[4] | 1972 Cost |
|---|---|---|---|---|---|---|---|
| 160 | 2810 | Antifreeze | $ 7 | .62 | $ 15 | 3.44 | $ 4 |
| 170 | 2821 | Urethane | 168 | 14.91 | 358 | 3.08 | 116 |
| 198 | 3211 | Glass | 194 | 17.21 | 413 | 1.81 | 228 |
| 249 | 3432 | Copper Tubing | 60 | 5.32 | 128 | 2.34 | 55 |
| 250 | 3433 | Heat Exchanger | 108 | 9.58 | 230 | 2.04 | 113 |
| 251 | 3441 | Steel Supports | 11 | 0.98 | 24 | 2.50 | 10 |
| 251 | 3441 | Tank | 330 | 29.28 | 703 | 2.50 | 281 |
| 257 | 3449 | Collector Frame | 108 | 9.58 | 230 | 2.33 | 99 |
| 296 | 3561 | Pump | 89 | 7.90 | 190 | 2.10 | 90 |
| 391 | 4200 | Transportation | 52 | 4.61 | 111 | 2.39[5] | 46 |
| | | Total | $1127 | 99.99 | $2400[2] | - | $1042 |

| I-O# | SIC# | Installation | SERI Cost[1] | % | 1983 Cost[3] | Price Index[6] | 1972 Cost |
|---|---|---|---|---|---|---|---|
| 16 | 1600 | Labor | $473 | 62.57 | $438 | 1.69 | $259 |
| 16 | 1600 | Overhead Labor | 95 | 12.57 | 88 | 1.69 | 52 |
| 16 | 1600 | Overhead Labor | 47 | 6.22 | 44 | 1.69 | 26 |
| 16 | 1600 | Profit | 141 | 18.65 | 131 | 1.69 | 78 |
| | | Total | $756 | 100.01 | $700[2] | - | $415 |

[1]Breakdown is from the LA study which cites the Solar Energy Research Institute, 1980.
[2]Control totals from Southwest Solar, May, 1983.
[3]Derived from the % of each component times control total.
Price Indexes from US Statistical Abstract: 1982-83.
[4]Table #751 (pp. 456-457).
[5]Table #759 (p. 462).
[6]Table #1330 (p. 742).

TABLE 7

Solar Hot Water Systems - Final Demand

| I-O# | SIC# | Components | 1972 Cost | * | Housing Units | = | Final Demand |
|---|---|---|---|---|---|---|---|
| 160 | 2810 | Antifreeze | $ 4 | | 6920 | | $ 27680 |
| 170 | 2821 | Urethane | 116 | | 6920 | | 802720 |
| 198 | 3211 | Glass | 228 | | 6920 | | 1577760 |
| 249 | 3432 | Copper Tubing | 55 | | 6920 | | 380600 |
| 250 | 3433 | Heat Exchanger | 113 | | 6920 | | 781960 |
| 251 | 3441 | Steel Supports | 10 | | 6920 | | 69200 |
| 251 | 3441 | Tank | 281 | | 6920 | | 1944520 |
| 257 | 3449 | Collector Frame | 99 | | 6920 | | 685080 |
| 296 | 3561 | Pump | 90 | | 6920 | | 622800 |
| 391 | 4200 | Transportation | 46 | | 6920 | | 318320 |
| | | Total | $1042 | | 6920 | | $7210640 |

| I-O# | SIC# | Installation | 1972 Cost | * | Housing Units | = | Final Demand |
|---|---|---|---|---|---|---|---|
| 16 | 1600 | Labor | $259 | | 6920 | | $1792280 |
| 16 | 1600 | Overhead Labor | 52 | | 6920 | | 359840 |
| 16 | 1600 | Overhead Labor | 26 | | 6920 | | 179920 |
| 16 | 1600 | Profit | 78 | | 6920 | | 539760 |
| | | Total | $415 | | 6920 | | $2871800 |

TABLE 8

Energy Efficiency Standards and Assumptions

New Construction (Slab - 1500 sq. ft.)

| Component | Standard Practice | New Standards | Cost |
|---|---|---|---|
| Ceiling | R-19 (6") | R-30 (9") | $.12/sq. ft.[1] |
| | | | $ 0 labor |
| Walls | R-11 (3") | R-11 (3") | - |
| Floor | slab | slab | - |
| Windows | storm | storm | - |
| Doors | storm | storm | - |
| Caulking | moderate | complete | $ 16 material[2] |
| | | | $ 84 labor |
| Total | | | $280 per unit |

New Construction (Crawl Space - 1500 sq. ft.)

| Component | Standard Practice | New Standards | Cost |
|---|---|---|---|
| Ceiling | R-19 (6") | R-30 (9") | $.12/sq. ft.[1] |
| | | | $ 0 labor |
| Walls | R-11 (3") | R-11 (3") | - |
| Floor | crawl space | R-19 (6") | $.30/sq. ft.[1] |
| | | | $300 labor |
| Windows | storm | storm | - |
| Doors | storm | storm | - |
| Caulking | moderate | complete | $ 16 material[2] |
| | | | $ 84 labor |
| Total | | | $1030 per unit |

Existing Construction (950 sq. ft.)

| Component | Standard Practice | New Standards | Cost |
|---|---|---|---|
| Ceiling | R-11 (3") | R-30 (9") | $.25/sq. ft.[1] |
| | | | $200 labor |
| Walls | R-11 (3") | R-11 (3") | - |
| Floor | crawl space | crawl space | - |
| Windows | no storm | storm | $ 40 each[1] |
| | | | $ 50 labor |
| Doors | storm | storm | - |
| Caulking | none | complete | $ 32 material[2] |
| | | | $168 labor |
| Total | | | $928 per unit |

[1]NRV dealer prices, May 1983.
[2]Eugene, Oregon study by Greg Page, 1980 prices.

The first package for new housing assumes that 70% or 3683 of all new housing units were built on slab. The second package assumes that the remaining 30% or 1544 of new housing was built with a crawl space. The housing with a crawl space was required to add six inches of floor insulation at a cost of $450 plus $300 for labor. Both packages assumed an increase of ceiling insulation from R-19 to R-30, covering 1500 square feet at $.12 per square foot for materials. No additional labor cost was added for the ceiling insulation, since some would have been installed anyway. Finally additional caulking and weatherstripping was assumed to cost half of what would be required to weatherstrip an entire house from scratch and amounted to $16 for materials and $84 for labor.

The third package was for existing housing and assumed a 950 square foot house with an increase in ceiling insulation from R-11 to R-30 at a cost of $.25 per square foot. Labor costs were added in this package and were assumed to be $200. No floor or wall insulation was added, but complete caulking and weatherstripping was assumed at a cost of $32 for materials and $168 for labor. Finally six storm windows were assumed as a part of the average package, costing $40 each plus $50 for complete installation.

After establishing the assumptions about the components of the weatherization packages for new and existing housing, each component was adjusted with an appropriate price index and then multiplied by the number of units assigned to that package. These calculations were used to develop the final demand disturbance vector for the energy efficiency programs. Table 9 shows the calculations that were made.

TABLE 9

Energy Efficiency - Components, Costs & Final Demand

New Construction (Slab - 1500 sq. ft.)

| I-O# | SIC# | Components | 1983 Cost | Price Index | 1972 Cost | Housing Units | Final Demand |
|---|---|---|---|---|---|---|---|
| 16 | 1600 | Labor | $ 84 | 1.69[2] | $ 50 | 3683 | $184150 |
| 165 | 2891 | Caulking | 16 | 3.44[1] | 5 | 3683 | 18415 |
| 172 | 2823 | Insulation | 180 | 2.19[3] | 82 | 3683 | 302006 |
| | | Total | $280 | - | $137 | 3683 | $504571 |

New Construction (Crawl Space - 1500 sq. ft.)

| I-O# | SIC# | Components | 1983 Cost | Price Index | 1972 Cost | Housing Units | Final Demand |
|---|---|---|---|---|---|---|---|
| 16 | 1600 | Labor | $384 | 1.69[2] | $227 | 1544 | $350488 |
| 165 | 2891 | Caulking | 16 | 3.44[1] | 5 | 1544 | 7720 |
| 172 | 2823 | Insulation | 630 | 2.19[3] | 288 | 1544 | 444672 |
| | | Total | $1030 | - | $520 | 1544 | $802880 |

Existing Construction (950 sq. ft.)

| I-O# | SIC# | Components | 1983 Cost | Price Index | 1972 Cost | Housing Units | Final Demand |
|---|---|---|---|---|---|---|---|
| 16 | 1600 | Labor | $418 | 1.69[2] | $247 | 3000 | $741000 |
| 165 | 2891 | Caulking | 32 | 3.44[1] | 9 | 3000 | 27000 |
| 172 | 2823 | Insulation | 238 | 2.19[3] | 109 | 3000 | 327000 |
| 198 | 3210 | Storm Windows | 240 | 1.81[1] | 133 | 3000 | 399000 |
| | | Total | $928 | - | $498 | 3000 | $1494000 |

Price Indexes from US Statistical Abstract: 1982-83.

[1]Table #751 (pp. 456-457).

[2]Table #1330 (p. 742).

[3]Table #1331 (p. 742).

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# VITA

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