Chapter IV

APPROACHES USED TO ASSESS IMPACTS OF ECONOMIC STOCKPILING

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The approaches used to assess the impacts of implementing five selected economic stockpile policies encompass both economic and noneconomic considerations. While a distinction has been drawn between economic and noneconomic impacts in order to simplify the analysis, it should be understood that such a precise distinction is not possible. Most of the impacts discussed in this assessment cannot in fact readily be expressed in dollar costs and require a type of analysis other than economic. Therefore, the noneconomic impacts include political, social, and market operation considerations as separate and distinct from the economic impacts analysis.

The possible impacts identified and analyzed with these approaches are presented in detail in chapter V as (1) impacts general to all five stockpile policies, and (2) as particular impacts associated with individual policies. In this chapter the methods used in the impacts analysis are presented for two categories:

- Methods of analyzing noneconomic impacts.
- Methods of analyzing economic impacts,

A. METHODS OF ANALYZING ECONOMIC IMPACTS

Economic impacts have been analyzed in two ways: (1) using a model developing and based on welfare economical to determine the gains or losses in domestic economic welfare, and (2) using an existing input-output model to determine the economic sector impacts created during the acquisition phase of stockpiling.

In the welfare model, economic impacts are estimated by developing generalized cost functions applicable to all five stockpiling policies and separate benefit functions particular to each of the five policies. Once the benefits and costs are ascertained with these two functions, the overall net benefits of an economic stockpile—which may be either positive or negative--can be determined. The estimates of economic impacts provided by input-output calculations were not entirely successful, primarily because there was no method to restrain supply in the selected model; however, the calculations did point the way to more extensive use of input-output modeling in the assessment of economic stockpile policy.

[1]Here "welfare economics' is used in the strict sense of economic theory and should not be confused with the popular use of the term "welfare,"

1. General Description of Economic Welfare Model

The Economic Welfare Model developed in this study proposes that a country such as the

United States should stockpile or continue to stockpile (i. e., continue to increase the size of the stockpile of any particular material) as long as the additional benefits derived by the country from adding one more unit of the material to the stockpile exceed the costs. These benefits and costs which accrue to the public should be differentiated from the private benefits and costs which accrue to firms or individuals which might motivate them, rather than the Government, to hold stocks. This distinction implies that the level of stocks which should be held is that quantity which maximizes the total net benefits to the country, as explained in chapter 111. It also follows that the Government need hold only sufficient stocks in excess of the private buffer stocks (if any) to make up the optimum quantity, provided coordination of actions can be arranged.

The Economic Welfare Model does not explicitly incorporate the change in economic welfare which may result from a distribution of income within the economy. The optimal stockpile size is that which maximizes the total net benefits to the country, even though this may involve a substantial redistribution of income among groups within the country. In theory, the effects of such a redistribution could either be alleviated or eliminated altogether by countervailing fiscal policies. In practice, however, history indicates this rarely happens. An estimate has been made of the benefits and costs to two general interest groups, materials producers and materials consumers, as well as to the stockpile investor; however, no attempt has been made to estimate the private stockpile as it would affect the public stockpile.

The economic net benefits of stockpiling do not change linearly with the amount of material stockpiled. In principle, the Economic Welfare Model allows calculation of the optimal size of an economic stockpile. In the study, however, economic net benefits—which are a function of stockpile size—were calculated for only three quantities so that the optimal size for the conditions used was not precisely determined. The Economic Welfare Model specifies a period of time for which calculations are made and requires estimates for various quantities such as prices, elasticities, and probabilities of actions affecting supply during this time interval. Estimation of economic net benefits over an assumed lifetime of the stockpile would require repetition of this calculation for a sufficient number of time intervals to cover the assumed lifetime. In the present report, however, attention is focused on calculations for a single time interval to illustrate the decision process and give typical results.

It should be clearly recognized (1) that these results are only estimates based on an approximation, (2) that the illustrative process here is necessarily simpler than the complex combination of real events, and (3) that this approximation requires input data which are based partly on judgment. Nevertheless, the results are believed to be valuable in indicating the nature (benefits and costs) and magnitude of the economic impacts for the circumstances assumed.

Other models for estimating economic impacts could probably be developed to give somewhat different numerical results. And while other calculations might differ in detail from those performed here, they must build upon the same basic requirements to consider the impacts of stockpiling on various parties, as well as estimate probabilities and price elasticities. Their general conclusions should therefore be similar. In any case, the Economic Welfare Model is one tool which the stockpile operator could use in making decisions regarding whether or not to increase, hold, or decrease the stock of each material.

The Economic Welfare Model estimates the economic benefits and costs of stockpiling which may be either positive or negative. It is important that not only the overall economic benefits and cost be estimated, but also that the degree to which different parties are impacted be identified. The terms making up the Economic Welfare Model have accordingly been structured into two categories to provide separate estimates of benefits and costs to materials producers and materials consumers. Two additional categories of benefits and costs borne ultimately by producers and consumers but not to either alone are also separately estimated. These are the direct benefits and costs to the stockpile operator and the external costs borne by the economy in general. It is also important to recognize that impacts on various. parties vary depending on whether the stockpile is acquiring. holding, or disposing of materials. The terms in the Economic Welfare Model have thus been structured to provide separate estimates of economic impacts associated with acquisition, holding, and disposal for each of the four categories of benefits and costs discussed above. These estimates are called partial benefits and costs.

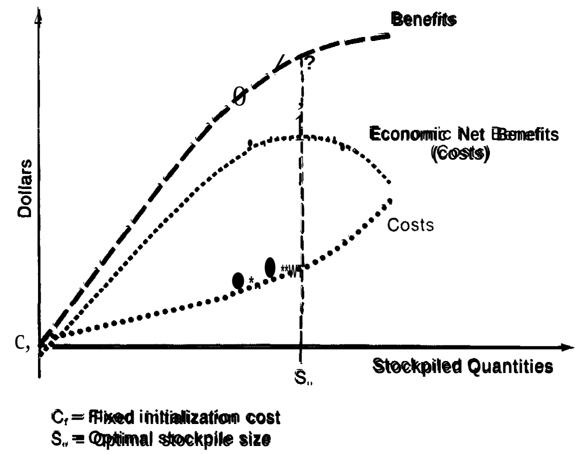
In order to determine the optimal quantity of a material to be stockpiled, two functions within the Economic Welfare Model should be determined for a specified period of time:

- The benefit function, which shows how public benefits increase with the quantity of material stockpiled; and
- The cost function, which shows how public costs increase with the quantity of material stockpiled.

Figure IV–1 conceptually illustrates how to determine the optimal stockpile size using the benefit and cost functions. The optimal quantity of stocks occurs at the point where the difference between the benefit and cost functions is maximum, i.e., the economic net benefit curve is at the maximum positive value. Economic net benefits are only positive, of course, when the benefit function is above (or greater than) the cost function. If this is not the case, then the particular material in question should not be stockpiled unless other, overriding noneconomic reasons exist.

In certain cases, it is readily apparent that the public benefits of stockpiling are zero or close to zero. For example, if an economic stockpile were established by the United States for the sole purpose of counteracting possible cartel actions, the benefits to the country of stockpiling materials which the

Figure IV-1.
Economic Net Benefits



United States does not import (such as molybdenum or coal) or which are highly unlikely to be cartelized (such as iron ore) are obviously nil. This is the theoretical justification for the set of Materials Selection Criteria outlined in chapter III which were used to determine the Problem-Related Materials which should be acquired to achieve the stockpiling policy objective.

In figure IV–1 the benefit function is shown passing through the origin, since the benefits associated with a stockpile of zero size are zero. It then rises with the quantity of material stockpiled but at a decreasing rate, on the assumption that those needs which generate the largest public benefits would have priority in the allocation of stockpiled material, Those needs which contribute little in the way of public benefits would receive stockpiled material only if stocks were still available after other, higher priority needs were met.

The cost function is assumed to intersect the vertical axis above the origin since there are certain fixed costs (equal to C_f in figure IV–1) associated with stockpiling which do not vary with the size of the stockpile. As the cost function is drawn in figure IV–1, the variable costs increase with the size of the stockpile. The rate of this increase is greater as the quantity becomes larger due to the effects of stockpile acquisition, a point discussed in the following section concerning the generalized cost function.

The Economic Welfare Model has two time dimensions. The first concerns the time period over which the economic net benefits of stockpiling action should be estimated. If, for example, the benefits and costs associated with a particular stockpiling program are reassessed once a year and changes in the desired level of stocks made, the coming time period is 1 year. It could, of course, be a month, 6 months, or 5 years. The review period is dependent upon the leadtime to establish a stockpile, the frequency with which an event is expected to occur, and the perishability of the material to be stockpiled.

The other time dimension concerns the period over which costs and benefits are estimated. It may be, for example, that the analysis of a prospective stockpiling action indicates that no action should be taken next year, but that a stockpile of a certain size should be established in 5 years. In such cases, both costs and benefits should be discounted to their present value. Also, with a longer time horizon, alternative rates of stock acquisition can be considered. The costs of acquiring all of this material in the year just before it is needed may be higher than if the stocks were accumulated more slowly over a longer period of time. Associated with each time path of accumulation is a stream of costs. The optimal timing of accumulation is that which has the stream of costs with the lowest present value.

The disposal of stocks can also be timed using the Economic Welfare Model. A stockpile will be accumulated to solve a specific problem such as an import disruption. When such an interruption occurs, the Economic Welfare Model can be calculated to determine, based on the probability of continued or more severe disruptions, the amount ,of stocks to be released to counteract the disruption. Likewise, after an interruption the level of the stockpile can be reevaluated and its effectiveness reexamined. The continual review of costs and benefits accrued through stockpiling can further refine the timing factors influencing accumulation and disposal of optimal quantities of materials.

2. Three Steps in Using the Economic Welfare Model

The Economic Welfare Model is a tool developed for use in quantitatively analyzing the economic impacts of stockpiling. The Economic Welfare Model provides a guide for determining actions to be taken by an economic stockpile: first, by estimating the net benefits to the country of stockpiling a particular material which is or should be stockpiled; second, by providing guidance on the timing of acquisition and disposal of that material; and third, by identifying the benefits and costs to particular impacted sectors of the country,

There are three steps involved in using the Economic Welfare Model, each of which is discussed immediately following the general description of the model:

- Step I—Estimate the costs of stockpiling;
- Step 2—Estimate the benefits of stockpiling as a function of the quantity for material stockpiled; and
- Step 3—Determine the net benefits as a result of stockpiling, net benefits being benefits minus costs.

Development of the Economic Welfare Model in terms of cost/benefit relationships has required the use of parameters for which, in some cases, materials information is not available, This, in turn, has required using a panel of experts to provide subjective estimates for these parameters. While estimates provided by experts are sufficient to ascertain the feasibility of stockpiling, implementation of one or more of the stockpiling options by an agency of the Federal Government would require establishing, a materials information system to supply inputs for use in calculating the economic welfare parameters. z

a. Step 1: Estimate the Costs of Economic Stockpiling. —In order to apply the Economic Welfare Model, the benefits and costs of stockpiling a particular material as a function of the quantity put into the stockpile must be estimated, It should be emphasized that there are two distinct types of costs associated with economic stockpiling: (1) the costs to various impacted interest groups and to the economy in general which accrue as a result of implementing a stockpile and which are derived using the Economic Welfare Model (impact costs); and (2) the direct costs, including acquisition, for a stockpile operator to run the stockpile (operating costs). Since the derivation of the impact costs in the first category will not change significantly with the different stockpiling policies, a general discussion of the cost function as it applies to all five stockpiling policies is presented here. Analysis of the operating cost function is presented in chapter VI.

The costs of an economic stockpile occur during the entire operation of the economic stockpile: the acquisition phase, the holding phase, and the disposal phase. During acquisition, the costs of a stockpile are incurred through initialization of the stockpile and through acquisition of the commodity. The holding phase of the economic stockpile's operation generates storage, administrative, and interest costs for stockpiling operations, while costs for releasing stockpiled materials accrue in the disposal phase. These costs are discussed as follows in three categories.

(1) Acquisition phase costs.—The capital required to acquire stocks—as opposed to the interest on that capital—should not be counted as a cost of economic stockpiling, since the purchase of materials merely involves exchanging one type of asset for another. It does not generate real costs for society in the sense that resources are consumed or lost.

While acquisition costs are not considered economic costs, they are nevertheless real costs to those who must consider outlays from the U.. budget. The Semiannual Stockpile Reports of the General Services Administration (GSA) to the Congress, covering all types of stockpiles of strategic and critical materials, show accumulated acquisition costs upward of $6 billion through 1962,f which more than $2.5 billion at acquisition costs (valued at about $6 billion at market prices) remained in these stockpiles at the end of 1974 after a long period of accumulation. The costs of acquiring and keeping materials for an economic stockpile are therefore of some importance in deciding whether or not such a stockpile should be established. Even if the calculations of economic benefits and costs indicate positive economic net benefits for a stockpile of a certain quantity of material, and even if the stockpile may be otherwise considered desirable from a policy standpoint, the overall costs of implementing such a stockpile may be so large as to be judged prohibitive in terms of the U.S. budget. The financing of acquisition costs and other budget costs to the stockpile operator are discussed in chapter VII. Acquisition costs are considered here to the extent of determining interest costs in the economic net benefits.

Acquisition costs are dependent upon the size of the stockpile and the unit costs of commodity purchase, so that:

$$AC = C_u Q \qquad (1)$$

where

AC = acquisition cost
C_u = unit cost of stocks
Q = stockpile size

Initialization of an econmic stockpile requires the development or acquisition of storage facilities, the establishment or augmentation of a cognizant stockpiling authority, and the implementation of systems for monitoring the stockpile activities. Initialization costs may vary with stockpile size and in-

[2] "Critical Materials: Commodity Action Analysis," [J, S, Department of Interior, May 1975. See also a recently completed OTA assessment, "Materials Information Systems" for a more definitive treatment of this point,

elude the fixed costs incurred in establishing the stockpile, so that:

$$IC = c_f + c_i Q \qquad (2)$$

where

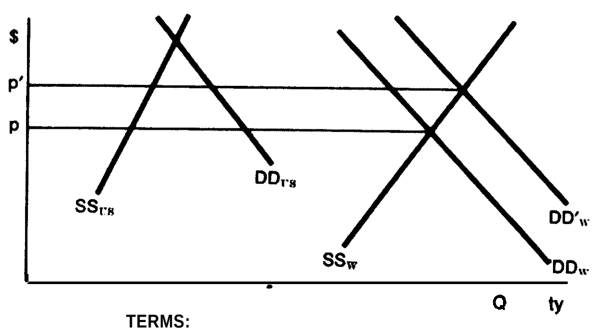
IC = initialization cost
c_f = fixed cost of initialization
c_i = variable unit cost of initialization
Q = stockpile size

The act of accumulating stocks increases the relevant demand for a commodity, and the increased demand will tend to raise the equilibrium price for the commodity. When the acquisition of stocks shifts the relevant (world) demand curve for a material rightward and the relevant (world) supply curve is not infinitely elastic, a rise in price on the world market will occur, as illustrated in figure IV–Z which also shows the effect this price increase has on the U.S. market. This price increase will generate two costs: (1) a net loss in domestic consumer surplus, and (2) external or second-order costs. Each of these costs is discussed in the following paragraphs.

The loss in domestic economic welfare resulting from the acquisition of materials for a stockpile introduces a net cost in that the loss in domestic consumer surplus is not offset by the increase in domestic producer surplus.[3] This net cost is indicated in figure IV-3 by the trapezoid abcf and is composed of the following three elements:

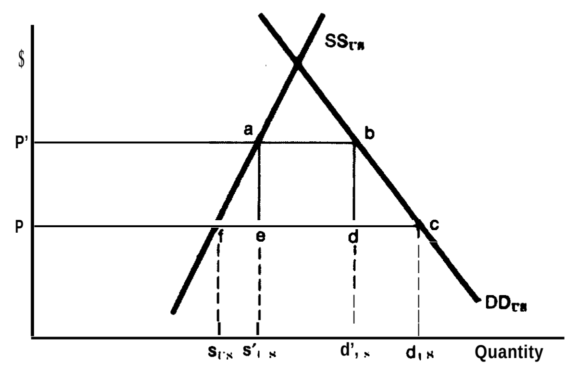
- The loss in consumer surplus which arises because the higher price drives some consumers out of the market—represented by the triangle bed;
- The loss caused by the incremental increase in real resources required to expand domestic production from s_{us} to s'_{us}—represented by the triangle aef; and
- The loss of real income by domestic consumers because they must pay higher prices for imported materials—represented by the rectangle abde. Some of this latter loss merely represents a transfer payment reflecting an increase in foreign producer surplus. From the U.S. point of view, however,

Figure IV-2.



TERMS:
DD_W = World Demand Curve
DD'_W = New World Demand Curve
SS_W World Supply Curve
DD_{US} = U.S. Demand Curve
SS_{US} = U.S. Supply Curve
p = Equilibrium Price (World)
p' = New Equilibrium Price (World)

Figure IV-3.



TERMS:
s_{US} = U.S. supply at price p
s'_{US} = U.S. supply at price p'
d_{US} = U.S. demand at price p
d'_{US} = U.S. demand at price p'

[3]There is a loss of domestic consumer surplus accompanied by the increase in domestic producer surplus—represented by the trapezoid p'afp, Since this is merely a transfer payment from one group within the United States to another, it does not represent a loss to the country as a whole. It is, however, a good illustration of how stockpiling can effect a redistribution of income.

it is a loss in control over real resources and should be considered a cost of stockpiling.

Figure IV–3 demonstrates that the net loss in domestic economic welfare can be estimated from the loss in domestic consumer surplus and the gain in domestic producer surplus, so that:

$$LEW = CL - PG \qquad (3)$$

where
LEW= net loss in economic welfare
CL = loss in domestic consumer surplus
PG = gain in domestic producer surplus

The terms in equation (3) are derived from—

$$CL = (d'_{US})(p'-p) + 1/2(d_{US} - d'_{US})(p'-p) \qquad (4a)$$
$$PG = (s'_{US})(p'-p) - 1/2(s'_{US} - s_{US})(p'-p) \qquad (4b)$$

yielding:

$$LEW = 1/2(s'_{US} - s_{US})(p'-p) + 1/2(d_{US} - d'_{US})(p'-p) + (d'_{US} - s'_{US})(p'-p) \qquad (4C)$$

where
s_{US} = U.S. supply at price p
s'_{US} = U.S. supply at price p'
d_{US} = U.S. demand at price p
d'_{US} = U.S. demand at price p'
p = Equilibrium price (world)
p'= New equilibrium price (world)

Equation (4) assumes that the U.S. supply and demand curves are approximately linear in the price range p to p', thus the coefficient of I/2 is used.

External or second-order costs to society may be generated by the net loss in domestic consumer surplus which occurs because some consumers are driven out of the market by the higher price. Firms may find it unprofitable to continue producing certain products and lay off workers. If alternative employment is not readily available for such workers and if other factors of production are idled, there are external costs (EC) imposed on society which must be added to the net loss in domestic consumer surplus.

It is important to note that these costs—the net loss in domestic economic welfare and the associated external costs-arise only when stockpiles are being accumulated, since the mere maintenance of an existing stockpile does not shift the demand curve and raise prices, Thus, the cost function will be steeper during acquisition periods than during holding periods. The rise in prices will be a function of the size of the stocks acquired during a given time period. That is, the greater the shift in the demand curve due to stockpiling, the larger the impact on market prices and the greater the loss in domestic consumer surplus and the external costs.

(2) Holding phase costs.—The budget for stockpiling operations will have to cover storage and administrative cost. According to the GSA, storage of the materials in the strategic stockpile fell overall from about 27 to 18 cents per ton per year between 1960 and 1964, and has remained in the range of 14 to 16 cents since then.

Reports from GSA to Congress indicate that annual administrative costs for the strategic stockpile are currently equivalent to under 3 percent of the acquisition cost of materials in the stockpile during the year; however, administrative costs will vary widely according to the materials and the kinds of activities (buying, selling, holding) required to administer the stockpile. An important cost component during the holding phase is the interest cost associated with the value of stocks originally acquired. For the cost function, this interest rate should be equivalent to the opportunity cost of capital.

In addition to storage and administrative costs and the interest costs on the capital required to acquire and hold stocks, a third holding cost of a materials stockpile is the loss arising from damage and spoilage of stocks in storage.

The costs of holding a material are a function of the size of the stockpile and the unit value of the material stored. For the present development of the cost function, it has been

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assumed that these holding costs vary linearly with the stockpile size, so that:

(5)

where

s = storage and administrative cost in \$/unit
d = quantity of stock loss
i = interest rate
C_u = unit cost of stocks
Q = stockpile size

(3) Disposal phase costs. -costs will be incurred for disposing of materials from an economic stockpile. For example, the use of a petroleum stockpile to counteract an OPEC cartel action will require the lifting of oil from storage (e.g., salt domes or capped wells) and into bulk terminals or refineries. The disposal costs will be dependent upon the quantity of material disposed and the expense of the disposal operation, so that:

$$DC = d_d Q_d \qquad (6)$$

where

DC = disposal cost
C_d = unit cost of disposal
Q_d = stockpile disposal

In sum, the cost function of the Economic Welfare Model for stockpiling developed above can be expressed as—

$$C = IC + LEW + EC + HC + DC \qquad (7)$$

where

IC = calculated from equation (2)
LEW = calculated from equation (3)
EC = the external cost
HC = calculated from equation (5)
DC = calculated from equation (6)

This basic cost function is applicable to all five stockpile policies studied in this assessment, though minor modifications have been made in subsequent descriptions of three of the policies.

b. Step 2: Estimate the Benefits of Economic Stockpiling.—The form of the cost function does not depend on the objective for which stockpiling is undertaken, and so is similar for each stockpiling policy. However, the benefit functions do vary with the objective of each stockpiling policy and are developed based solely on the purpose (or policy objective) of the five stockpiling policies in chapter V.

(1) Definition of benefits of economic stockpiling.—The benefits of an economic stockpile are equal to the expected damages which are either averted or counteracted through the operation of the stockpile. The benefits thus consist of the possible damage which could result from a disruption (change) in the normal materials supply or price, times the probability that such a disruption will occur.

The benefits of economic stockpiling will not be realized only through the utilization of the stockpile. On the one hand, holding materials will produce benefits for the U.S. economy by discouraging cartel or unilateral actions, On the other hand, the benefits of either counteracting a cartel or unilateral action or cushioning an import disruption will be realized only through the disposal of materials from the stockpile.

Calculation of the benefits of economic stockpiling thus assumes that a given quantity of materials will either be held or disposed at a particular point in time. Knowledge of the disposal price enables the determination of capital gains or losses resulting from stockpile disposal. The expected capital gains or losses, which are included in the benefits of the stockpile, serve to decrease or increase the cost of the stockpile to the operator.

(2) Interest groups.—Disposal from a stockpile directly influences two general interest groups: materials producers and materials consumers. The difference between the loss in domestic producer surplus and the gain in domestic consumer surplus yields the net gain in domestic consumer surplus, a benefit of economic stockpiling. There are also benefits and costs to third parties in the form of external costs which are offset or avoided through stockpiling holding and disposal.

c. Step 3: Determine the Economic Net Benefits of Stockpiling.—The difference between the benefits and costs yields the economic net benefits (ENB) derived from a stockpile, so that:

$$ENB = B - C \tag{8}$$

where

B = the benefits calculated from the benefit function

C = the costs calculated from the cost function

The Economic Welfare Model, thus used, can provide the tool by which the optimal stockpile size is calculated and the timing of stockpile acquisition and disposal are determined, Specific estimates of the economic impacts are presented in chapter V,

3. Discussion of Computer Program Developed To Estimate Economic Impacts of Stockpiling

The Economic Welfare Model has been developed specifically to estimate the economic net benefits of implementing SP-1, –2, –3, -4, and –5. To facilitate calculations, the model has been developed into a computer program.

Inputs to the program include stockpile sizes, unit costs, fixed initialization costs, interest rates, etc. Output from the program consists of the economic costs, benefits, and net benefits for various stockpile sizes.

The advantage of the program is that it permits the rapid calculation and analysis of a large number of stockpiling policies and the perturbation of variables with their resultant impacts on the costs and benefits. A range of optimal stockpile sizes can be estimated, then the sensitivity to parametric variations can be assessed.

The Operating Cost Model, which can be used to estimate the direct operating costs of an economic stockpile, has also been included in the computer program. For a discussion of the operating cost model, see the appropriate section of chapter VI.

The calculated results using the equations in the Economic Welfare Model and the Operating Cost Model are dependent on the magnitude and the relationship (relative magnitude) of all the input (independent) variables chosen for the calculations. These input variables are chosen from a variety of sources (e.g., graphs, tables, subjective reasoning, projections, etc.) by persons possessing the knowledge and training to allow this process to be accomplished with an acceptable probability of success.

The Economic Welfare Model and the Operating Cost Model have been used to calculate a “baseline” case, where the set of input variables have been carefully chosen as the most accurate and probable values. For each stockpiling policy (SP–1, –2, –3, –4, –5), one baseline case has been calculated for one material, The results are presented in chapter V under the sections dealing with each policy,

Whenever an analysis like that described above is performed, certain questions related to the validity of the calculated results always arise. Two primary questions can be listed: (1) what input variables are the most sensitive? (e.g., for small changes in input, the output changes are large); and (2) what input variables are the least sensitive? (e.g., for small changes in input, the output changes are small or zero).

It is important that an analysis be performed which seeks to answer these questions to permit validation of the models and to gain insight into the validity of the results. In doing this, it is important for the stockpile analyst to attempt answering certain corollary questions such as the ones listed below:

- For the sensitive input variables, what is the degree of certainty in the data which have been used?
- If these input data have an unacceptable degree of uncertainty, what additional data or analysis is required to narrow this range of uncertainty?

- What is the cost of obtaining the additional information required?
- What is the tradeoff (break even) between the increased cost to improve the certainty and the cost of the impact of the uncertain y remaining?
- Conversely, are we spending too much time and money to determine the values of the least sensitive input variables?

The scope of this assessment did not allow for exhaustive analysis of the type discussed above, as the primary intent was the development of the methodology and not the analysis of all specific cases. The development of the computer program did, however, allow for some first-order sensitivity analyses to be performed using the digital computer to save time and money over manual analyses.

The sensitivity analysis chosen for this study consisted of determining the relative importance of each input variable in the benefit, cost, and net benefit functions. The sensitivity of the cost and benefit functions to changes in the formulation parameters was computed. The sensitivity of the net benefits and optimal stockpile size to changes in the cost function and the benefit function was also computed. These sensitivity y computations were made for each stockpile policy.

To effect this sensitivity analysis, the computer program automatically modifies an input parameter by a specified percentage (+10 percent in this study) and recalculates the output parameters. Each input parameter is individually modified and the program repeats the output calculations for all parameters. Each stockpiling policy is then recalculated using this automatic feature.

4. Economic Damage Not Averted

The establishment and use of an economic stockpile is intended to ameliorate the economic damage which particular events—import interruptions, price fluctuations, etc,—would cause, However, the optimal stockpile as estimated with the Economic Welfare Model will seldom, if ever, be large enough to completely offset the damage inflicted on the economy. The difference between the total economic damage and that portion offset by the stockpile is defined as damage not averted. Estimation of damage not averted becomes important when policy makers assess the tradeoffs between incurring some damage which the optimal stockpile cannot offset and the additional costs incurred for a larger stockpile size. The Economic Welfare Model incorporates equations to estimate the economic damage not averted,

5. Economic Impact of Not Establishing a Stockpile

Even under conditions when the economic net benefits for a particular stockpile are positive, policy makers may not want to establish the stockpile, or at minimum may want to know what the costs and benefits of not establishing a stockpile would be. The economic costs of no stockpile are obviously zero, but at the same time the economy will incur the expected damage which the optimal stockpile would offset if it were established. Or put differently, the economy will forgo benefits which it otherwise would have. Hence, the adverse economic impact of not establishing a stockpile is equivalent to the benefits calculated with the benefit function,

B. METHODS OF ANALYZING NONECONOMIC IMPACTS

The range of possible political and social impacts was derived through the use of relevance trees. These impacts were then examined to identify those which promised to be the most important and therefore worthy of further analysis, A discussion of the relevance tree and impact relevance matrix are presented as follows, and specific political and social impacts are discussed in chapter V.

1. Discussion of Relevance Tree

In concept, a relevance tree is a hierarchic structure in which the entries at each successive level, in the aggregate, describe completely the next immediate level above. A relevance tree describes a domain and, theoretically at least, describes it completely. In this study, four relevance trees were constructed in order to synthesize material collected during the interviews and literature search tasks. The relevance trees were then used to subdivide particular stockpiling subjects into their constituent building blocks in order to identify important areas which would later be included in analyses of stockpiling impacts and alternatives to stockpiling.

There are two advantages in using a relevance tree to examine the fine-grained structure of a problem. First, it provides a means of systematically searching for omissions. For example, insights about possible impacts of the stockpiling policies were discussed during the interviews and foreshadowed by experiences described in the case studies. However, even after tabulating the impacts derived from these sources, the question remained: What other impacts might occur in the future? While there is no absolute assurance that a relevance-tree analysis will provide the entire universe of impacts, the systematic approach required provides a higher degree of assurance that important impacts are indeed discovered. Second, since the organization of a relevance tree is hierarchic, the researcher must ask at each level whether or not his description is complete. This induces a process of self-learning and discovery, which further insures that the field under study will be effectively described,

As might be expected, the relevance trees themselves underwent an evolution during the study. The content of the four trees is illustrated below, and the complete trees are included as appendix D.

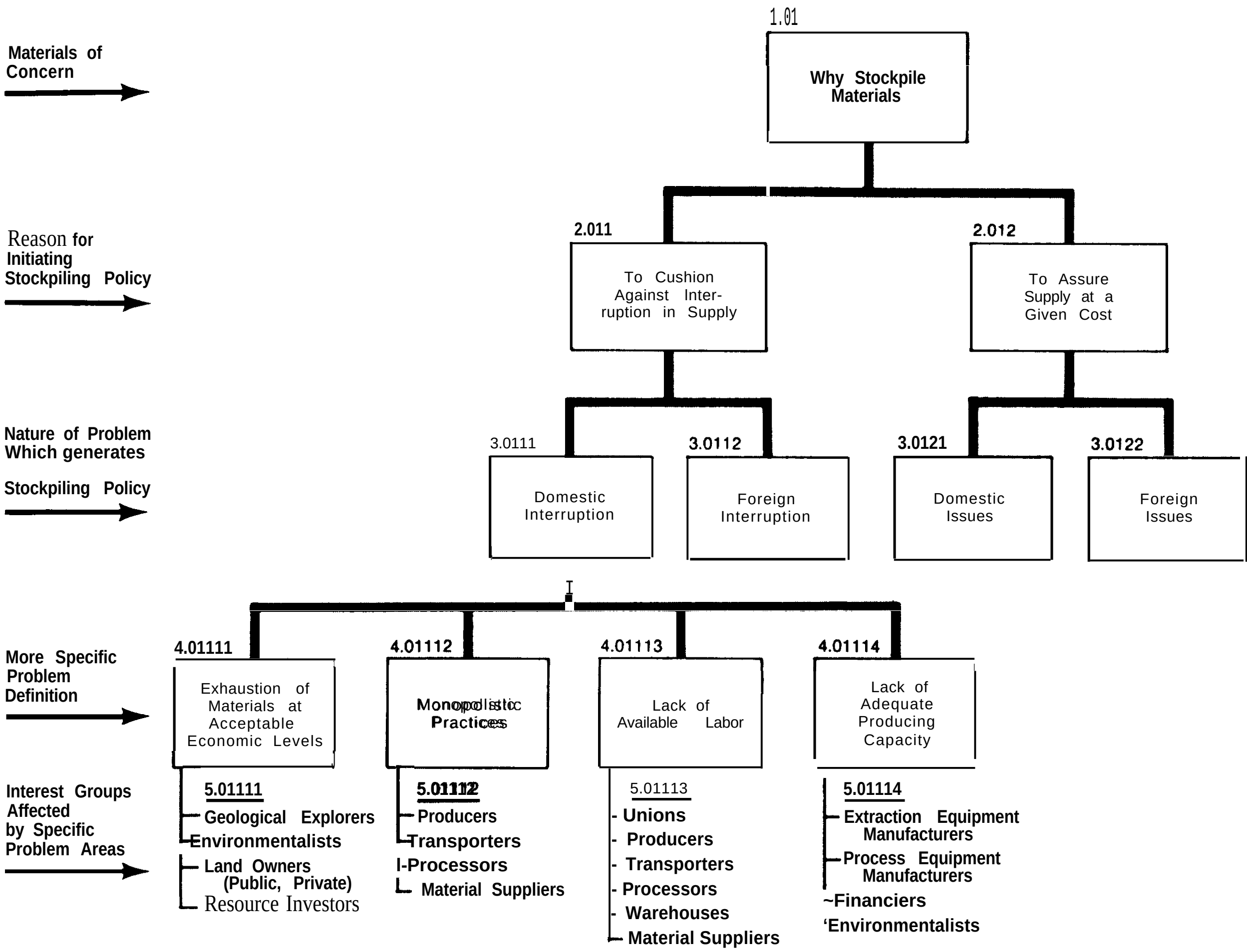
a. Stockpiling Policy Tree.—The stockpiling policy tree (Level 1) begins with the question: Why stockpile? Level 2 shows two general reasons for initiating stockpiling: to maintain a supply in case of cutoff from primary sources, and to provide protection against economic pressures. Level 3 identifies that material resource problem area as being either domestic or foreign. The problems which may be alleviated by stockpiling are detailed in Level 4 (e.g., increasing labor and production costs in producer countries, sociopolitical disruptions, etc.). The lowest level (Level 5) shows the interest groups which are likely to be affected by the problems. An illustrative segment of this relevance tree is shown in figure IV-4,

b. Stockpiling Procedure Tree.—The stockpiling procedure tree (Level 1) deals with the question: “How can stockpiling be accomplished?” Level 2 shows the two areas of concern: domestic and foreign. On Level 3, general stockpiling approaches are identified (e.g., stockpile in proven reserves, stockpile as raw ore, etc.). Specific storage procedures are shown on Level **4 (e.g.,** purchases of land and mineral rights, etc.). Level 5 (the lowest level) again identifies the interest groups which may be affected by the stockpiling procedures.

c. Alternatives to Stockpiling Tree.—The alternative to stockpiling tree (Level 1) derives from the question: “What alternatives to stockpiling exist?” The general policies which may be identified as a result of stockpiling are given on Level **2 (e.g.,** influence consumption, encourage recycling, etc.), Level 3 specifies policies sufficiently (e.g., limit production, materials R&D, etc.) so that the programs derived from these policies can be identified on Level 4 (e.g., taxation, incentives, etc.), The lowest level (Level 5) shows interest groups which would be directly affected by those programs.

d. Stockpiling Impact Tree.—The stockpiling impact tree (Level 1) begins asking where, throughout the world, the impacts might be felt. The major divisions recognized

Figure IV-4.
Illustrative Segment of Relevance Tree



are the United States, other countries which import the material, countries which export the material, countries which could export the material or substitutes, and countries which have secondary dependence on the material (e.g., countries which import products manufactured from the material). At Level 2, the relevance tree centers on the question: "How might the impact be felt?" Here, the divisions are social, economic, political, legal, and other. The domain of the impact is next addressed at Level 3: the impacts can be felt internally, or in relations between the country and others. Level 4 consists of a further subdivision of the domain, and Level 5 addressed the impacts themselves (e.g., institutional feasibility, political stability between nations, and trade alliances).

2. Impacts Relevance Matrix

After the five stockpiling policies were designated, the most important social, political, and legal impacts for each policy were identified. A matrix was constructed to accomplish this task. The five policies were deployed on one axis; the potential impact areas (derived from the fourth relevance tree) were deployed on the other. Figure IV–5 is a sample of the political impacts portion of this matrix.

The numbers entered into the matrix depict judgments as to the relevance and weight (importance) of a particular impact of a stated policy, Judgments about weight were made first. Here, the task was to identify those impacts which, in and of themselves, appeared to be most important to the future of the United States. Looking at figure IV–5, for example, one sees impact area No. 66 (Political Stability Between Nations) was given a weight of 5—much higher than the weight of 2 given impact No. 62 (Cultural Alliances and Agreements). Second, judgments were made about how relevant each impact was within the context of the assumed stockpiling policies, i.e., whether the stated impacts were relevant to the stated policies. These judgments are depicted in figure IV–5 as the numbers entered in the matrix cells. Finally, the data contained in the matrix were used to rank-order the impacts in terms of their importance for each stockpiling policy. The rank order was determined by taking the product of the weight and the relevance number contained in the matrix cell. Thus, for SP–1, impact No. 53 (Internal Political Stability) rated a "score" of 25.

Using the above technique, it was possible to rank-order the impacts for each of the policies, and to designate a subset of impact area for further study. The impacts designated by this weighting matrix operation served as the basis for the detailed discussion of political and social impacts in chapter V. A further discussion of impacts evaluation matrices can be found in appendix D.

Figure IV-5.

Political Impacts Portion of Impacts Relevance Matrix

Impact Areas	1	2	3	4	5	Weight
52 Levels of Satisfaction with Government	5	3	5	3	4	4
53 Internal Political Stability	5	2	4	2	2	5
54 Laws and Regulations	4	i	4(4		4	4
55 Regulatory Structure	5	4	5	4	4	3
56 Institutional Viability	5	4	5	4	4	3
57 Int'l Relations Trade Agreements & Alliances	5	5	5	4	4	4
58 Buyers' and Sellers' Consortia	5	2	5	2	2	5
59 Aspirations of Other Potential Consortia Members	5	2	5	2	2	4
60 Aspirations of Consortia in Other–Materials	5	2	4	2	2	5
61 perception About U.S. Intent	5	3	5	3	3	4
62 *Cultural* Alliances and Agreements	3	0	3	0	0	2
63 U.N. Effects	4	0	4	0	0	3
64 impacts on Other International institutions	4	0	4	o	0	3
65 Military Alliances and Agreements	5	O	4	t"	o 0	4
68 Political Stability Between Nations	5	1	4	2	1	5
67 Political Aspirations of Others	5	1	4	1	1	4
68 National Boundaries	1	0	1	0	0	5
69 Political Pressures on Third Parties	3	2	3	2	2	4

Relevance Key

5 = Great Relevance
3 = Moderate Relevance
1 = Little Relevance
O = No Relevance

Weight Key

5 = Extremely Important Impact Area
3 = Important Impact Area
1 = Of Little Importance
O = No Importance