MAXIMIZING BENEFITS FROM PUBLICLY OWNED DEPLETABLE RESOURCE RENTS

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Introduction

When a valuable depletable resource is held as a public asset and sold at a considerable profit, the question arises as to the proper division of those revenues between current public consumption and savings. Because the revenues are temporary, it is generally accepted that some of them should be set aside for use when the resource is depleted.[1]

For example, a state may be the owner of petroleum-rich lands from which it derives rents in the form of severance taxes, royalties, and other taxes when the petroleum is produced. The timing of the receipt of these revenues is dictated by the economics of the market and the geology of the particular site, as they affect the leaseholder, who may be a private company. The pattern of revenue flow will likely follow the depletion curve of the reservoir and not correspond in any meaningful way to the best time pattern for the public expenditure of those revenues. Consequently, a public decision must be made as to the proportion of revenues received which should be spent immediately, and the proportion which should be saved, or invested, for consumption at some future date.[2]

This is a simple problem of finding the optimal allocation of current income between consumption and investment. A planner with perfect information on future prices and perfect knowledge of the social welfare function of the community could easily determine the rate at which the public wealth, in the form of the resource rents plus the financial and other assets into which it can be transformed, should be consumed. In the world outside of textbooks, however, the specification of a social welfare function for even one time period is beyond our present capabilities; uncertainty abounds about future prices of natural resources such as petroleum; and most policy makers have never studied optimal control theory. If a model incorporating economic principles of optimal investment behavior is to be operationalized in a way that is accessible to policy makers, a simple approximation is required.

This paper describes a model for investigating the question of the proper savings rate for revenues received in the form of rents from a depletable resource. Its strengths are its simplicity and flexibility. Its simplicity maximizes its accessibility to policy analysts and decision makers. Its flexibility allows one to investigate the implications of a variety of different savings strategies as well as assumptions about important parameters.

The most important policy lesson of the model is that, in general, the best amount of saving does not have a simple relationship to the rate at which revenues are received. For example, a policy of constant consumption over time does not correspond to a policy of saving a fixed percentage of revenues received. The rate of savings, or transformation of depletable into nondepletable assets, is a function of the sum of all publicly held assets--not only those held as depletable resource rents.

Theory

Assume a depletable natural resource in the public domain for which the production rights are leased to a private firm in return for a royalty payment on production. There may also be various other taxes which are levied against the producer of the resource such as property and income taxes. The leaseholder chooses when to produce the resource, based upon the cost of production including royalty payments, market price, physical parameters of the resource, and the tax environment.

The royalties and taxes paid to the government will consist partly of economic rents and partly of levies on factors of production. The mix is relevant for the producer as it affects his production costs. For the owner of the resource, the government, the mix is also relevant for the determination of the total amount of the resource produced and thus the total payment to the government. For simplicity, we assume that all revenues are pure economic rents and that the government appropriates all the economic rents. Thus we can make the rate of production exogenous to our model. The government simply collects whatever economic rents are produced while the leaseholder earns a normal return on his investment.

The government passively receives the rent as the resource is produced and faces the choice of how much to spend immediately on public goods and services and how much to save for future consumption. A reasonable criterion to guide the decision is that the present value of the benefits from the consumption of the rents should be maximized. If the total amount and timing of the rental payments, the interest rate (g), the social discount rate (r), and the social welfare function ($U(C_t)$) are all known, then consumption at time t, C_t, can be found by solving for its time path in the following functional:

$$MAX \int_0^\infty U(C_t)\, e^{-rt}\, dt$$

$$ST. \quad S_t = S_o\, e^{gt} - \int_0^t C_t\, e^{gt}\, dt$$

$$S_t \geq 0$$

where S_o is the present discounted value of the vector of economic rents to be received in the future, and S_t is the value of assets held at time t, which must be greater or equal to zero. For a given initial stock of the resource, social welfare will be maximized by a choice of consumption from asset holdings in each period, t, which equates the present value of the marginal unit of consumption in each period.

There are several problems with operationalizing this model. The first is the obvious difficulty in identifying the form of the social welfare function, $U(C_t)$. At a minimum, it will be some function of current and future population and income level of the community. For example, a political jurisdiction within a federal system, such as a state in the United States or a province in Canada, has open borders allowing migration of population so that some weighting scheme must be applied not only to current but also to future residents in constructing a function.[3]

The second problem is that the rate of saving of current revenues cannot be calculated because the stock rather than the flow of the rents is modeled. In fact, there is no explicit comparison of the flow of rents and the stock of assets. Therefore, it is difficult to relate the consumption rate or level to the more obvious variables observed in a real life situation--revenue flow and level of savings. Typically, the policy maker wants to know what percentage of current revenues from the resource should be saved. An answer to that question is not explicit in this form of the problem.

As the depletable resource is produced, the rents not immediately consumed are saved or transformed into alternative assets. Although optimal consumption from the depletable resource depends on the value of these assets as well as revenues from rents, the two do not appear separately in the model. If we explicitly recognize both, the formulation of the problem is as follows:

$$\text{MAX} \int_0^\infty U(C_t)\, e^{-rt}\, dt$$

$$\text{ST.} \quad S_t = S_o\, e^{gt} + \int_0^t R_t\, e^{gt}\, dt - \int_0^t C_t\, e^{gt}\, dt$$

$$S_t \geq 0$$

$$R_t = \bar{R}_t$$

where R_t is the exogenously determined rental revenues collected at time t.[4]

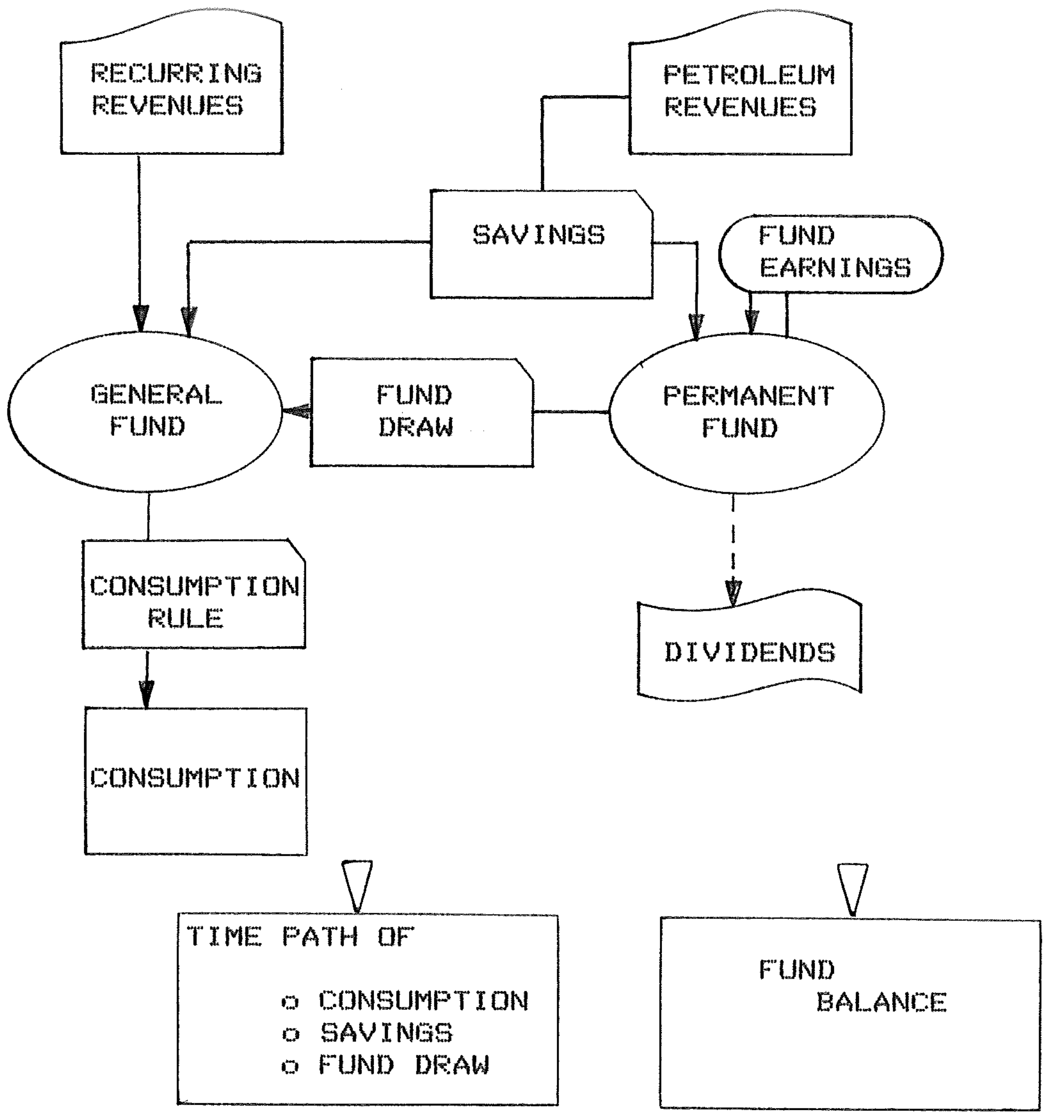
This formulation allows one to compare savings and consumption in any period both to the value of financial assets and to the flow of revenues. These rates are of interest to policy makers. Unfortunately, these rates are not, in general, constant. The rates and factors which determine their variation can be demonstrated using a simple non-optimization framework which shows the implications of different savings strategies for consumption possibilities based on different assumptions about parameters describing resource value and investment return.

The Model

The primary objective of the model is to demonstrate the consumption levels which can be obtained from different savings strategies for depletable resource rents collected by a government. The model does not optimize on a particular social welfare function. Different savings strategies result in different consumption paths. The optimal one for any policy maker depends upon his own social welfare function. A secondary objective of the model is to demonstrate the sensitivity of the consumption path to the many assumptions which are inherent in this type of intertemporal decision-making process.

The structure of the model is shown in Figure 1. Inputs consist of (1) a vector of depletable resource rents to be collected in future years, (2) vectors of other tax revenues expected in future years under the current tax regime (recurring revenues), and

FIGURE 1. MODEL STRUCTURE



(3) potential revenues from sources not currently utilized. Any revenues not immediately spent on consumption are invested in a fund of financial assets, which initial value must be specified. The rate of return on publicly held assets must be specified. The user chooses a rule which is a vector of public spending for each year limited by the constraint that consumption in any year must not exceed the sum of the level of current revenues from depletable resource rents; tax revenues from other sources, including financial asset earnings; and available financial asset balances.

In addition, the model may be "customized" to represent a particular institutional structure for the collection of resource rents and the distribution of asset earnings. This makes it easier to illustrate the effects of changing specific policies designed for the collection and distribution of rents and earnings. For example, in Alaska a portion of financial asset earnings based on a formula involving inflation and prior portfolio performance is automatically distributed to citizens annually as a Dividend.

The model output includes the time pattern of attainable spending based upon the rule, the time pattern of the flows of saving and consumption out of resource revenues consistent with that spending, and the associated values of the financial assets and rents yet to be received. It identifies critical watershed years for the chosen spending rule. These are (1) the year when savings out of current resource revenues end and withdrawals from accumulated assets begin and (2) the year when all assets have been used up and spending cannot exceed current recurring revenues. The model can be run iteratively to identify spending rules which achieve different targeted spending patterns.

This model has been used for a number of years in Alaska to identify the level of public spending which could be sustained over various time horizons. Expected revenues from petroleum production in Alaska are shown in Table 1 along with a projection of present and potential recurring revenues from that portion of the tax base which is not dependent upon a depletable resource. It is clear that an unsatisfactory time pattern of public consumption results if all revenues are consumed when received.[5] Revenues fall over time because the depletion of currently producing fields dominates additions to reserves.[6]

In recognition of this, the state has established the Alaska Permanent Fund, which is a savings account for a portion of these revenues. By law, a fixed percentage of current-year petroleum revenues--approximately 25 percent of petroleum royalties or about 10 percent of all revenues from petroleum--are deposited into the Fund. The choice of 25 percent of royalties as the savings rate was a political rather than an economic decision. The Fund is invested outside the state. The earnings of the Fund are currently allocated among a distribution program, maintenance of principal through "inflation proofing," and other retained earnings. The existence of

TABLE 1. PROJECTED REVENUES TO STATE OF ALASKA[a]

Fiscal Year	General Fund Petroleum Revenues	Permanent Fund Petroleum Revenues	Recurring Revenues	New Revenues from Basic Industry
1987	1,110	122	239	0
1988	1,164	152	232	250
1989	1,184	163	226	300
1990	1,205	175	225	25
1991	1,095	168	225	25
1992	1,023	160	224	25
1993	1,037	164	220	25
1994	927	151	224	25
1995	847	141	229	50
1996	832	142	231	50
1997	805	130	234	50
1998	707	119	232	50
1999	612	109	236	50
2000	531	99	236	75
2001	464	89	239	75
2002	415	78	238	75
2003	340	68	237	75
2004	284	59	236	75
2005	233	53	237	100
2006	190	43	238	100
2007	151	34	240	100
2008	144	33	241	100
2009	137	31	243	100
2010	130	30	245	100

[a]Does not include earnings on Fund balances.

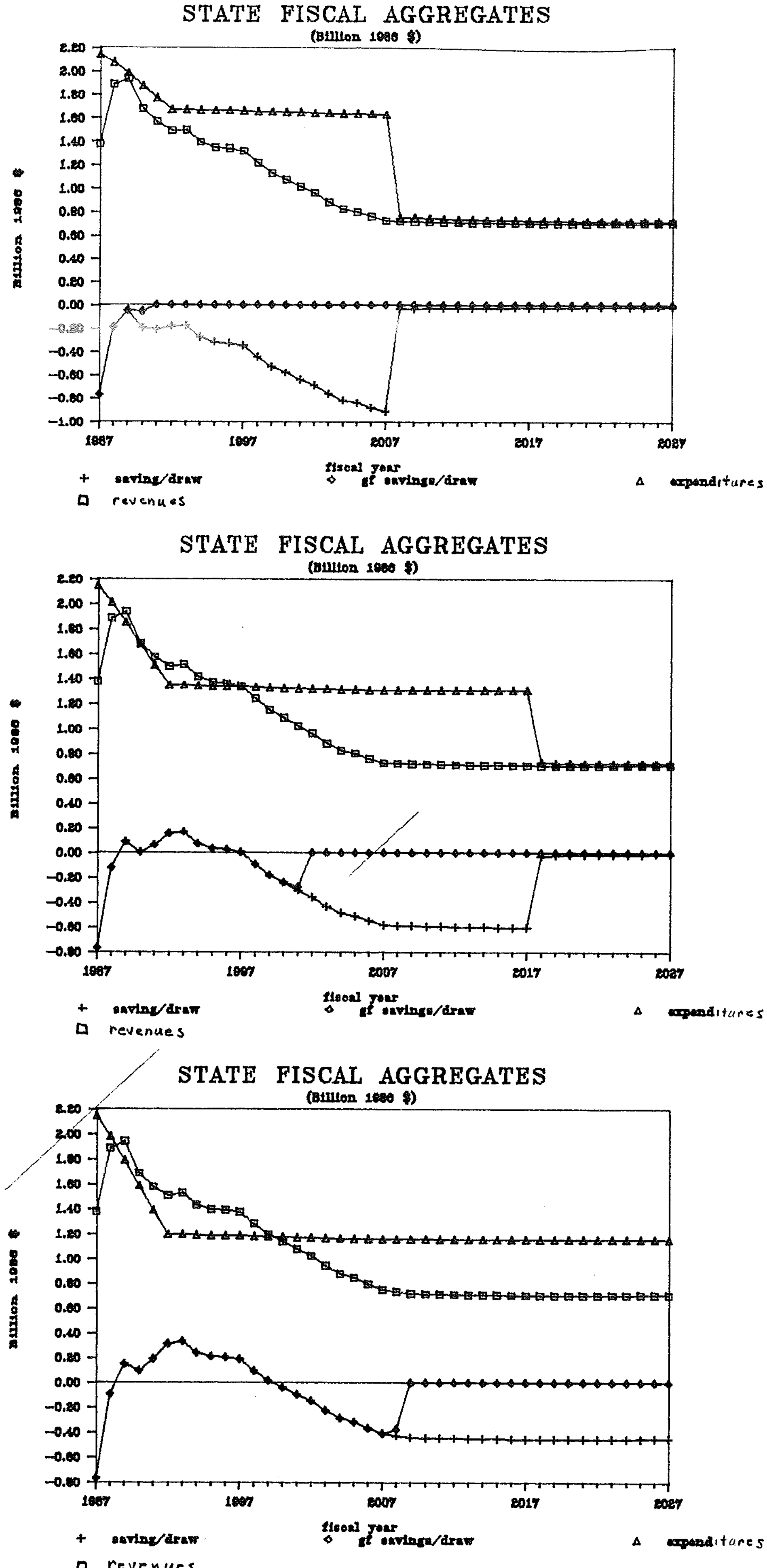
SOURCE: State of Alaska, Department of Revenue, October 1986, and author's estimate. West Coast oil price assumed to be $12,40 in FY 87, $14.60 in FY 88, and $15.90 in FY 89.

the Permanent Fund Distribution Program makes calculation of the net rate of savings from resource rents complicated, because revenues flow into the Fund at the rate of 25 percent of royalties and simultaneously flow out at a rate based upon the earnings of the Fund. This model allows calculation of the net savings rate out of current revenues.

The rule most often used for consumption is to choose the highest constant real level sustainable for a given number of years. One can argue whether a rising, falling, or constant real level of public expenditures is preferable.[7] The rationale for a constant level in real terms, or sustainable spending pattern, is that the expectation of public needs at the current level is easy to conceptualize and consistent with the popular notion of a cap on the level of public spending at the current level.[8]

The results of a set of calculations investigating levels of public spending which can be sustained based upon the revenues in Table 1, combined with assumptions about rates of return and initial nonpetroleum assets, is shown graphically in Figure 2. For a given set of policies regarding new taxes and distributions from the Fund,[9] the maximum level of annual sustainable consumption is a declining function of the time horizon chosen--in this case 20, 30, or 40 years. Consistent with each level of sustained consumption is a time pattern of savings out of current rents and of withdrawals out of accumulated savings in future years--also depicted in Figure 2.

Figure 2

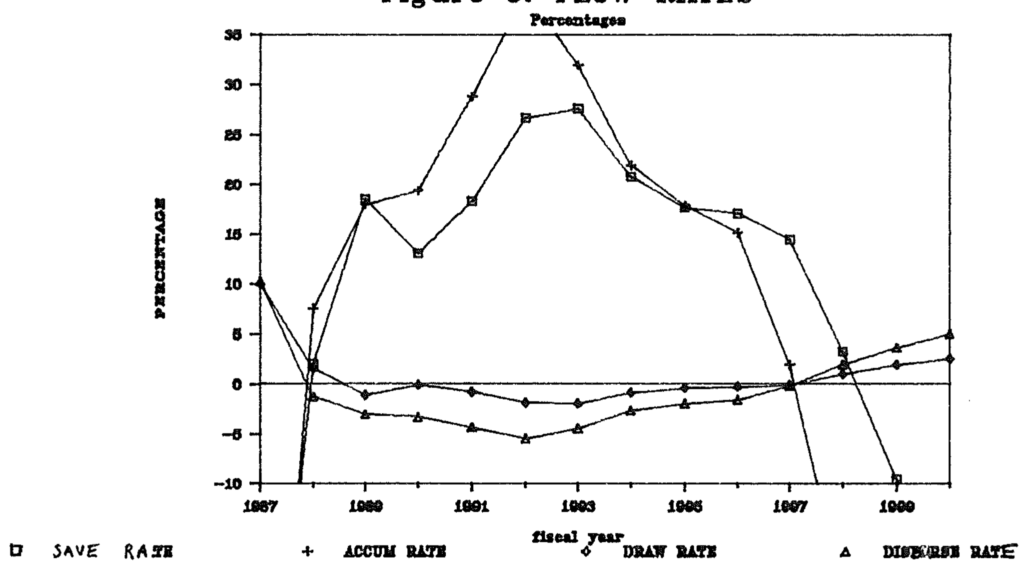

STATE FISCAL AGGREGATES
(Billion 1986 $)
Billion 1986 $
fiscal year
1987
1997
2007
2017
2027
+ saving/draw
◇ gf savings/draw
△ expenditures
□ revenues
STATE FISCAL AGGREGATES
(Billion 1986 $)
Billion 1986 $
fiscal year
+ saving/draw
◇ gf savings/draw
△ expenditures
□ revenues
STATE FISCAL AGGREGATES
(Billion 1986 $)
Billion 1986 $
fiscal year
+ saving/draw
◇ gf savings/draw
△ expenditures
□ revenues

The savings rate out of current rents not only is different for each time horizon but also for each year for a particular time horizon. In Figure 3, four different rates of flow are depicted for the early years of a 40-year time horizon.[10] The savings rate--the annual savings out of currently received resource rents--is different in each year. If asset earnings are added, the rate still varies (accumulation rate). Neither are flows out of the fund a constant percentage of the fund balance. The withdrawal rate--the rate funds are used for consumption and dividends--is variable. Including contributions (disbursal rate) also results in an uneven rate.[11]

Although it comes as no great surprise that the rates of savings and withdrawals calculated as a percentage of either the flow of revenues or the stock of assets is not a constant, it is a politically complex concept to sell. The idea of setting aside a certain proportion of current revenues or using a certain portion of accumulated assets seems to make a lot of sense as a simple rule of fiscal behavior. It generates less suspicion than a variable rate developed by some economist using a set of uncertain assumptions.

This suspicion is enhanced by the large degree of uncertainty underlying the assumptions. It is important for the policy maker to have an understanding of how sensitive the conclusions are to the important assumptions. Over time both assumptions and inputs will need to be modified as price fluctuations change the value of the

Figure 3. FLOW RATES



depletable resource in the ground or as the rate of return on investments changes. Furthermore, because this is an intertemporal problem, the sensitivity of assumptions is a function of time.[12]

Two types of sensitivity analyses are depicted in Table 2 and Figure 4. The effect on the level of spending that can be sustained for 40 years from variations in the rate of return on the principal of the Fund are shown in Table 2. Figure 4 shows the vector of savings rates for three different spending levels.

Another model use is to compare actual spending levels with levels based upon some long-term rule of sustainability. Differences between actual and sustainable spending may serve as a measure of current excess spending at the expense of the future. For example, the 1987 Fiscal Year Budget of the State of Alaska is approximately $2.1 billion--which is about $.7 billion above a level which is sustainable for 40 years. The current rate of spending is sustainable for about 15 years before all accumulated public assets are dissipated. The consumption tradeoff implicit between current spending policy and a 40-year sustainable policy is shown in Figure 5.

TABLE 2. MAXIMUM SUSTAINABLE SPENDING LEVEL FOR DIFFERENT RATES OF RETURN ON INVESTED FUNDS

(million 1986 $)

Return on Funds	20-Year Sustainability	40-Year Sustainability
2%	$1,550	$1,050
3%	$1,600	$1,125
4%	$1,725	$1,300

Figure 4

SAVING RATES FOR THREE SPENDING TARGETS

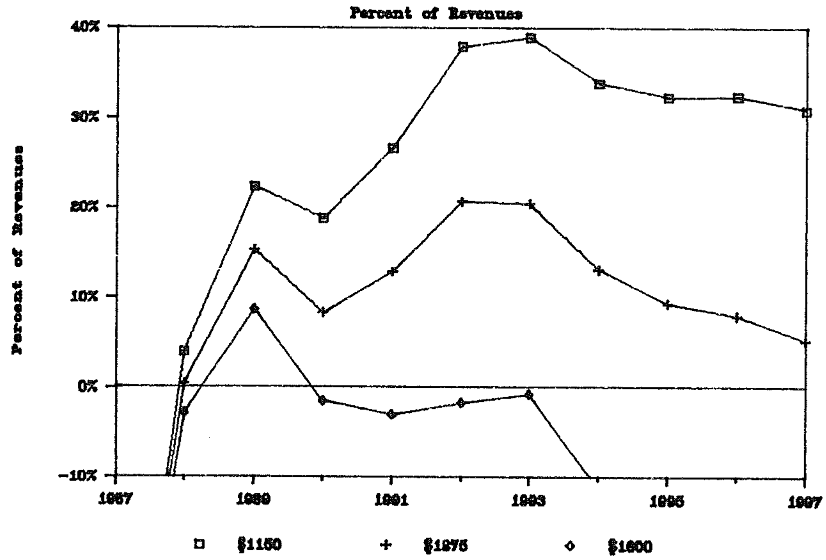
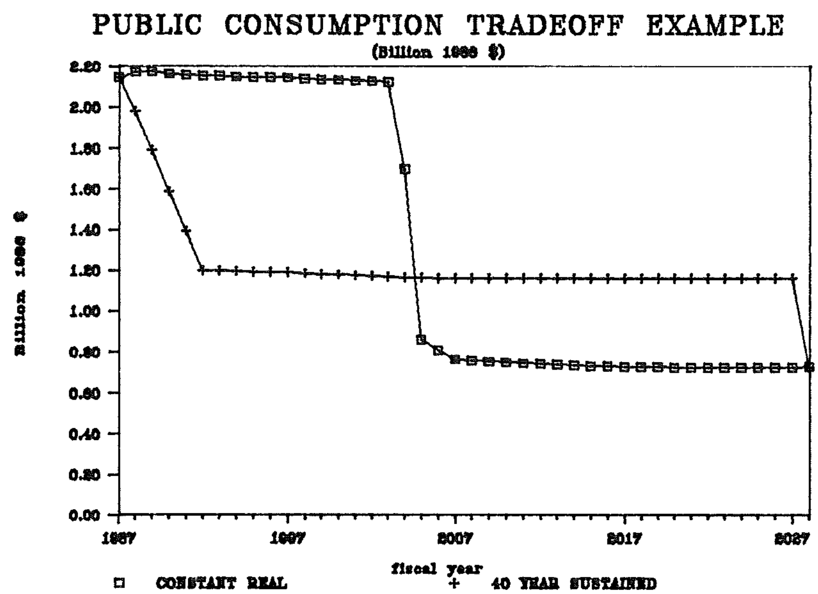


Figure 5


PUBLIC CONSUMPTION TRADEOFF EXAMPLE
(Billion 1988 $)
Billion 1988 $
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1987
1997
2007
2017
2027
fiscal year
CONSTANT REAL
40 YEAR SUSTAINED

Conclusions

An iterative model for analyzing various spending policies for governments with economic rents from depleting resources is presented. It is based upon the theoretical model of optimizing the present value of the consumption stream from a resource stock. It operationalizes the model in a way which makes the structure simple to understand and flexible to use. It shows the annual amount which should be saved from current depletable resource revenues in order to meet any long-run total spending target. This allows the policy maker to see the relationship between the desired level of future spending and current saving since for a constant spending stream the rate of savings out of resource revenues must change over time. Although the "optimal" savings rate is a function of the social welfare function, the social discount rate, the rate of return on investment, and the initial stock of the resource, the implications of different savings rates are easier to see with simple examples using a simple model.

ENDNOTES

1. This paper does not address the separate issues of whether the public sector should own depletable natural resources or should retain the revenues from their sale.

2. The question of how the wealth should be invested is not addressed in this paper.

3. An attempt has been made to define a social welfare function in this context. See B. L. Scarfe and T. L. Pownie, "The Optimal Savings Question: An Alberta Perspective," Canadian Public Policy Special Issue (1980), pp 166-176.

4. A similar type of problem is posed in Raymond Mikesell, "Rate of Exploitation of Exhaustible Resources: The Case of an Export Economy," Natural Resources Forum (1976), pp. 39-46.

5. The demand for public goods would not be expected to fall with petroleum production because production has very little direct impact on population. Indirectly, of course, the demand for public goods seems to be a strong function of the availability of public money to pay for them.

6. There is general agreement that the probability of maintaining the current level of petroleum revenues in the future is essentially zero since the supply curve for new production in Alaska is too steep to suggest the possibility of unitary price elasticity of revenues.

7. This analysis does not attempt to determine the optimal mix between the public and the private sectors. The mix can be altered within the context of whichever consumption path is chosen by adjusting the levels of the personal taxes levied on the population.

8. A rising level of public expenditures would reflect the rising needs associated with an increasing population, increasing incomes, and the associated increase in private consumption (complements to public goods), or both. A declining level would be consistent with the notion of growing wealth not adequately reflected in projected revenues from the recurring tax base, or a smaller weight to future generations because of their mobility, or both.

9. In this case, reimposition of an income tax and continuation of the Dividend program.

10. Saving rate is the sum of statutory contributions and special contributions to the fund net of dividends paid as a percentage of revenues collected.

Accumulation rate is the sum of statutory contributions, special contributions, and fund earnings net of dividends paid as a percentage of revenues collected.

Draw rate is the sum of withdrawals for consumption and dividend payments as a percentage of the fund balance.

Disbursal rate is the sum of fund contributions net of dividends and withdrawals as a percentage of the fund balance.

11. Except in the case of an infinite time horizon, in which case the investment becomes a consul, the principal of which is never spent, only the earnings.

12. The results are more sensitive to the rate of return on investment late in the period of resource decline because a larger share of income is then generated by financial assets. Early in the exploitation of the resource, its own price is more important.