Discount Rate for State Participation in the Alaska Natural Gas Pipeline Project

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Washington, DC

November 3, 2004

Briefing report summarizing presentation made in Anchorage, AK on August 26, 2004

Introduction and overview

The State of Alaska is in the process of negotiating with potential builders of a natural gas pipeline from the North Slope of Alaska to markets in the lower 48 United States and Canada. The purpose of the proposed project is to commercialize 35+ trillion cubic feet of stranded gas on Alaska's North Slope, to be sold throughout North American markets through hubs in Alberta and/or Chicago. The proposed design would produce about 4.5 billion cubic feet of gas per day with expansion potential to about 5.6 bcfd. The pipeline would consist of a 2,100 mile segment from Alaska to Alberta and a 1,500 mile segment from Alberta to market. The buried, chilled pipe would be constructed of 5-6 million tons of X-80 carbon steel, with a diameter of 48 to52 inches, and an operating pressure of 2,000 to 2,500 psi.

The estimated construction cost of the project is approximately $20 billion, including a $2.6 billion gas treatment plant primarily for carbon dioxide extraction (and re-injection into gas wells). The project thus represents the largest ever oil and gas project in the world; about three times the size of the next largest. To reduce risk to potential participants in the project and thereby move the project forward, the State is contemplating taking an equity position in the project and a significant level of project risk.

There are differing perceptions about the need for the State to play such a role in order for the project to move forward. Oil and gas producers with whom the State is in negotiations argue that under the status quo the gas is truly commercially stranded and that the pipeline project will not move forward without major State and Federal fiscal incentives. Federal incentives for the pipeline have in fact recently been signed into law, including loan guarantees, a depreciation tax credit, and an enhanced oil recovery tax credit. Nonetheless, the producers continue to insist that further State incentives are necessary.

Conversely, another view is that the pipeline project is likely to occur irrespective of State involvement, and that at most State participation might only accelerate the project by a few years, rather than being pivotal to the project ever moving forward. From the perspective of analysis, one way to view this difference in perceptions is through the lens of probability. That is, there is a chance that the project will not take place without State participation, and thus "the project" from the State's perspective is to increase the likelihood that the project will happen, or will happen sooner. The benefits and costs of the project, from the State's perspective, are therefore not simply the State's portion of construction costs and gas revenues. Rather project effects depend on a careful definition of the base case "counterfactual" (i.e., what is assumed to happen in the absence of State participation), what exactly the State's role is in the project, and what the effects of this role are relative to the base case.

In order to evaluate the financial and economic impacts of such State participation in the pipeline project, it also becomes necessary for the State to choose an appropriate discount

rate for analyzing the present value of the costs and benefits of project participation. This report summarizes a presentation made to officials of the Alaska Department of Natural Resources and the Alaska Department of Revenue regarding the appropriate discount rate for the State to use in evaluating participation in the Alaska natural gas pipeline project. Among other things, the presentation responded to three questions:

- Do major oil/gas companies use a different discount rate than the government?
- Should the state adopt a corporate discount rate when assessing its participation in pipeline project alternatives?
- What rate should the state use, and how should it account for project risk and uncertainty?

In summary, the succinct answer to these questions is as follows. First, there are good reasons for the State to use a different discount rate than oil and gas companies. Second, the State should not adopt a corporate discount rate when assessing its participation in pipeline project alternatives. Third, a reasonable benchmark rate for the state to use is 5% nominal, or 3% real (assuming 2% inflation), with additional sensitivity analysis of this rate and separate accounting for project risks and uncertainties. This rate could differ if the market interest rate on funds used for project purposes was to change significantly from present levels.

The paper is organized around the following five topics:

- Discounting in financial analysis;
- Accounting for risk;
- Discounting in economic cost-benefit analysis;
- Discount rate policies; and
- Concluding remarks.

There is a large literature on discounting, and there have also been numerous syntheses of this literature, including studies by Lind (1982, 1990), Lyon (1990), Portney and Weyant (1999), U.S. EPA (2000), Newell and Pizer (2001, 2004) and Moore et al. (2004). This briefing paper does not attempt to replicate that literature, but rather provides a brief summary of the elements that are most relevant for guiding the state's analysis of particular energy project alternatives.

Discounting in financial analysis

The rationale for discounting is to weight costs and benefits occurring at different points in time so they are comparable in economic terms. The discount rate is a price that accounts for the opportunity costs of resources over time. The concept of "opportunity cost" is the value of something when used in its next best alternative use. This may or may not equal the market price on something, as discussed further below, depending on existing distortions in the economy. Opportunity costs over time arises because cost and

benefit flows may displace or augment consumption or investment. Investment has a time opportunity cost because over time investment generates returns, thereby allowing for higher future consumption.

On the other hand, consumption has a time opportunity cost due to impatience and income growth. Impatience, known in economic circles as the "pure rate of time preference" implies that consumers prefer consumption today to consumption tomorrow, giving rise to an opportunity cost if consumption is delayed in favor of investment. Income growth also gives rise to positive time discounting because individuals typically value incremental income less highly as their consumption levels rise. That is, additional consumption has a positive value, but each additional dollar is not quite as valuable in terms of individual welfare as the last. Because incomes are generally growing in real terms over time, this gives rise to another reason for discounting future consumption.

Discounting is typically carried out using a constant discount rate applied in an exponential manner, so that the standard mechanics of discounting are as follows:

$$\text{Net present value} = \sum_{t=0}^{T} \frac{B_t - C_t}{(1+r)^t}$$

where

B_t = benefits at time t

C_t = costs at time t ; and

r = discount rate .

Financial versus economic analysis. An important distinction that needs to be made in determining the most appropriate discount rate for a particular analysis is whether that analysis is best described as "financial cash-flow analysis" or "economic cost-benefit analysis" (see European Commission (2002), for example). Financial cash-flow analysis is done from the relatively narrow perspective of project net revenues and it primarily concerned with whether the project will be profitable on the basis of project net revenues. In this case it is cash flows to and from project that are relevant. The appropriate discount rate in this case is the financial opportunity cost of project funds over time, which we discuss further below.

Economic cost-benefit analysis, on the other hand, is conducted from a relatively broad societal perspective, and asks the question of whether the project will have positive net benefits to society. This requires several additional complications and adjustments relative to financial cash-flow analysis. One such complication is defining the scope of "society": is it Alaska, the United States, the world? This question is critical for properly assessing impacts. A second adjustment that must be made is that market prices may not reflect social opportunity cost, due to existing taxes, subsidies, or externalities.

In addition, while taxes to the government would be treated as a positive cash flow in financial analysis, taxes and subsidies are "transfers" from the perspective of economic cost-benefit analysis because the are positive cash flows to the government, but negative cash flows to the private sector. They must therefore be netted out in moving from financial cash-flow to economic cost-benefit analysis.

Finally, and more to the specific topic at hand, the appropriate discount rate for economic cost-benefit analysis is not necessarily the financial opportunity cost of funds, but is rather the societal opportunity cost over those funds time. Societal opportunity costs represent the benefits to society foregone by using investment funds for the project, rather than their next best alternative use in society. As with other market prices, the financial interest rate will not generally reflect the social opportunity cost due to existing distortions from taxes on corporate and personal income. As explained further below in the section on discounting in economic cost-benefit analysis, these distortions arise because taxes on corporate and personal income create a wedge between the returns that firms earn on investments, and the portion of these returns that corporations, and in turn individuals, get to keep after taxes.

Financial discount rate. The discount rate for use in financial analysis depends on the financial opportunity cost of funds. The financial opportunity cost of funds over time represents the rate of return of those funds if used in the most valuable alternative use. In practice, this opportunity cost depends on whether it is assumed that there is an overall constraint on project funds and a comparison among the project of interest and all other projects. If that is the case, then when choosing between projects with limited funds, the appropriate discount rate is the financial rate of return on the next best alternative investment, as this is the relevant opportunity cost. In that case the discount rate becomes a device for rationing scarce project funds.

Without this type of inter-project evaluation in the face of limited investment funds, the appropriate financial discount rate is simply the rate of return on the source of project funds. For example, the cost to the State for funds raised through debt is simply the market interest rate that must be paid on that debt.

Scenarios for state participation in the pipeline tend to assume some level of debt financing through general obligation (G.O.) bonds, so that the relevant financial discount rate becomes the expected rate on Alaskan G.O. bonds. This implicitly answers the question: "Can the project pay the interest on whatever debt is necessary to undertake the project and still make a profit?" The nominal rate on Alaskan G.O. bonds was about 4% in a recent issue, and recent analysis by Merrill Lynch, suggests that a 5% nominal rate for a future project-related G.O. bond issue (or 3% real assuming 2% inflation) is conservative. This is the simple answer to the question of what discount rate the State should use. We come back to this question and embellish on it further throughout the paper.

Due to the sensitivity of project net present values to discount rate assumptions, it is also valuable to compute the internal rate of return of each alternative and to conduct

sensitivity analysis using a range of discount rates. Importantly, as we discuss next, it is also critical to assess project risks and uncertainties, but this is best done through explicit risk analysis rather than through incorporation of risk premia through ad hoc adjustment of the discount rate.

Regarding the discussion in the introduction to this paper regarding the definition of the project, one might ask whether that project definition has any bearing on the discount rate that should be used in analysis. For financial analysis, the answer is that these issues are independent, with the exception that the source of investment funds, which is part of the project definition, could of course affect the interest rate on those funds. As discussed in the next sections, because the issues of discounting and risk are best addressed separately, issues of risk that enter into the definition of and impacts of the project would not generally affect the discount rate. An exception to this separation between risk and discounting is that if alternative ways of defining the project actually raised the risks to those investors providing construction funds (e.g., bond holders) and thereby raised the interest rate that they would charge, then this would affect the level of the discount rate. But conceptually the appropriate discount rate would still be the market cost of those investment funds, with no adjustment to the discount rate for risk, other than that which the market itself imposes.

Returning to the questions posed in the introduction of the paper, major oil companies use a different discount rate than the State should use for financial analysis because these entities face different financial opportunity costs of investment funds. The weighted average cost of capital for major oil and gas companies is around 15% (see, for example, Texas Comptroller of Public Accounts 2002), while the interest rate on bonds for the State is likely to be more like 4-5%. As discussed further below, these differences arise due to both the tax treatment of the State versus private corporations, as well as investor's perceptions of the riskiness of investments in large oil and gas companies versus State bonds. The existence of this higher cost of investment funds for large oil and gas companies should not, however, cause the State to use a similar discount rate, even when undertaking similar investments. Rather, each institution should use a discount rate for financial analysis of project costs and benefits that is appropriate for that institution.

Accounting for risk

In addressing project risks, it is useful to first distinguish between uncertainty and economic risk. Uncertainty represents a lack of information on what the actual values of project costs and benefits will be, giving rise rather to variation and a range of possible outcomes. Economic risk specifically depends on whether variability in project costs and benefits raise the overall variability of income, not simply the variability in project income alone. This depends on the correlation of project returns with all other income. If there is positive correlation between project net revenues and other income, then the project increases risk because the project tends to do poorly at the same time ads other sources of income are down. If there is negative correlation between project net revenues and other income, then the project actually decreases risk because the project tends to do

well when other sources of income are doing poorly, thereby providing a form of insurance.

From this perspective, it seems likely that the pipeline project does add aggregate risk to state finances because volatility in its returns is likely to be positively correlated with other state income from oil and gas. The main uncertainty in pipeline project returns is the price of natural gas, which will tend to be high when other sources of state income, which are highly dependent on oil and gas revenues, are also high. Interestingly, and in contrast to the State of Alaska perspective, the project likely has insurance value from national perspective because energy prices tend to be negatively correlated with aggregate gross national product. Thus, while there is a cost of risk due to project uncertainties at a state level, these same uncertainties are likely to give rise to insurance value from a national perspective. The project has insurance value from a national perspective because, as with automobile or house insurance, the project pays off when other things go badly.

For public projects it is often or even typically assumed that it is acceptable to use expected (average) values in analysis, so that no further adjustment to the magnitude and timing of project cash flows is necessary to adjust for risk. The rationale is two-fold: risk spreading and risk pooling. First if risks are spread over many individuals, as they typically are with public projects, and the project is not too large, then any uncertainty will be small as a percent of individual income. Second, because the government is typically engaged in many different types of projects with different characteristics at the same time, risks from different project will tend to offset one another through risk pooling, or diversification. (See Lind (1982), for example.)

However, these typical assumptions probably do not hold for the envisioned pipeline project, which is large in magnitude and as discussed above is likely to have returns that are highly positively correlated with other state income. This suggests that explicit risk analysis is warranted and would provide an important additional dimension along which the state can measure the desirability of state participation. The tools of risk analysis are appropriately the domain of another paper, but two broad approaches warrant mentioning. Both approaches require first conducting risk analysis by treating certain key variables that affect benefits and costs as having a distribution of values, rather than as if they had single values that were known with certainty.

One approach to accounting for risk that is often mentioned in the literature on discounting is to convert uncertain benefits and costs to "certainty equivalents", which makes them "as if" they are certain. Briefly, a certainty equivalent is the amount of certain money you would need to give (or take) from someone to leave them equally as well off as they would be if they faced a particular situation with uncertain outcomes. For example, the certainty equivalent value of a lottery to win something is the amount of money someone would have to pay you, for certain, to forego the potential but uncertain gain from the lottery. For individuals that are risk averse, that certainty equivalent value will be less than the average value of the lottery. Thus risk adjustment involves weighting uncertain benefits downward and weighting uncertain costs upward, relative to

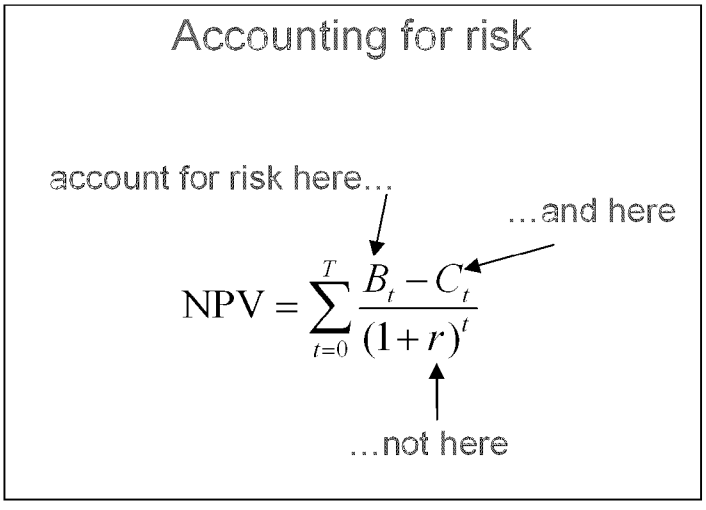
their average or expected values. Determining certainty equivalent values requires either using stated preference techniques whereby individuals are asked about these tradeoffs and necessary payments, or by employing a functional assumption about the risk aversion function that should be used to convert uncertain to certain values.

An alternative to specifying a welfare function for risk adjustment is to subjectively assess the distributions of net present value that result from the risk analysis. This requires better communication techniques on the part of analysts, and a willingness on the part of decision makers to confront probability distributions of outcomes. But it provides a more explicit treatment of risk that allows the decision maker rather than the analyst to apply his own subjective assessment of risk.

Nonetheless, as a protection against individual decision makers who may have risk preferences that are not reflective of the broader public, it may also be worthwhile (and reasonably straightforward) to employ the certainty equivalent approach as well for comparison purposes, using standard assumptions about risk preferences. One could also imagine a type of break-even analysis whereby one posed the question "How risk averse would one have to be for the project to not make sense, and how does that degree of risk aversion compare to how we treat other risky decisions?"

In any event, there is a consensus among economists and in guidelines to the conduct of project evaluation that it is generally incorrect to try to account for uncertainty in project costs and benefits through adjustment of the discount rate, for example through the addition of private sector risk premia. This is not surprising, as accounting for the time opportunity cost of resources, and accounting for project uncertainties are two different things. This point is illustrated in Exhibit 1, which suggests that it is best to account for risk through the incorporation of uncertainty in the flows of project benefits and costs, rather than through the adjustment of the discount rate.

Exhibit 1: Accounting for risk



There are several reasons underpinning the separation of risk from discounting. The first is that uncertainty in public project benefits and costs does not generally take same exponential form as discounting, so that it is mathematically incorrect to use an exponential form to try to capture uncertainty that is fundamentally not exponential with respect to time. For example, the Capital Asset Pricing Model upon which much estimation of risk premia to financial assets (i.e., stocks) is based, assumes a very particular underlying structure to uncertainty (i.e., a random walk or Wiener process).

One example that makes this perfectly clear is that any attempt to account for risk by adjusting the discount rate upward has exactly the wrong effect with uncertain future costs. Increasing the discount rate would lower the present value of uncertain future costs, whereas a correct account for risk should raise such costs. This example is somewhat extreme, however, as most investment projects, including the one at hand, involve primarily front-loaded costs and future benefits. In that case, risk-adjustment has the correct directional effect on present values, but the example illustrates that the magnitude of the effect is not generally correct, and can a times even have the wrong sign.

Finally, risk from public projects is not the same as private investment risks. The types of risks and the value that the public sector might place on those risks could be quite different than the equity risk premium implied by private stock market investments. Thus, even if one wanted to adjust for risk by adjusting the discount rate, it would not be appropriate to use private sector risk premia to reflect the risk preferences of the public sector in assessing public sector projects.

Discounting in economic cost-benefit analysis

Although it seems clear that the type of analysis intended by the state with respect to its participation in the natural gas pipeline is financial cash-flow in nature, it is nonetheless useful to discuss differences that arise in the context of economic cost-benefit analysis. However, the issues covered in this section are not critical for understanding the financial discount rate that the State should use, which was discussed earlier.

A described above, when moving from financial cash-flow analysis to economic cost-benefit analysis, one must take account of the fact that financial cost to a project does not necessarily equal the opportunity cost to society. These issues do not arise in the context of financial analysis, however, where what matters is the cash flows to and from the project, not the broader effects on society.

Producer versus consumer discount rates. One major reason for such divergence between private and social costs is the presence of taxes. Particularly with regard to the discount rate, corporate and personal income taxes on investment returns cause a divergence in the incremental costs and benefits of investment. This is analogous to how a sales tax creates a wedge between what a good costs to produce and what a consumer is willing to pay for it. Therefore, in cost-benefit analysis economics has evolved to

thinking about the interest rate distortion in the same way it treats other distortions to market prices, that is, through so-called "shadow prices". The concept of shadow prices in this context represents the idea that market prices do not represent the true social cost of using a particular resource, due to distortions such as taxes, other policies, and externalities. Thus, shadow prices must be constructed by adjusting market prices to account for these distortions. This is routinely done in cost-benefit analysis to reflect the divergence between wage rates and the opportunity cost of labor, caused by social security and income taxes on wages.

Before moving on to discuss the implications further, it is useful to first introduce some terminology often used in the discount rate literature. The "producer return on investment", also sometimes called the return on capital, the opportunity cost of capital, or the producer discount rate, represents the before-tax marginal rate of return producers gain on investment. The "consumption discount rate", or consumer rate of time preference, on the other hand, is the rate a consumer uses to weigh present versus future consumption when making investment decisions.

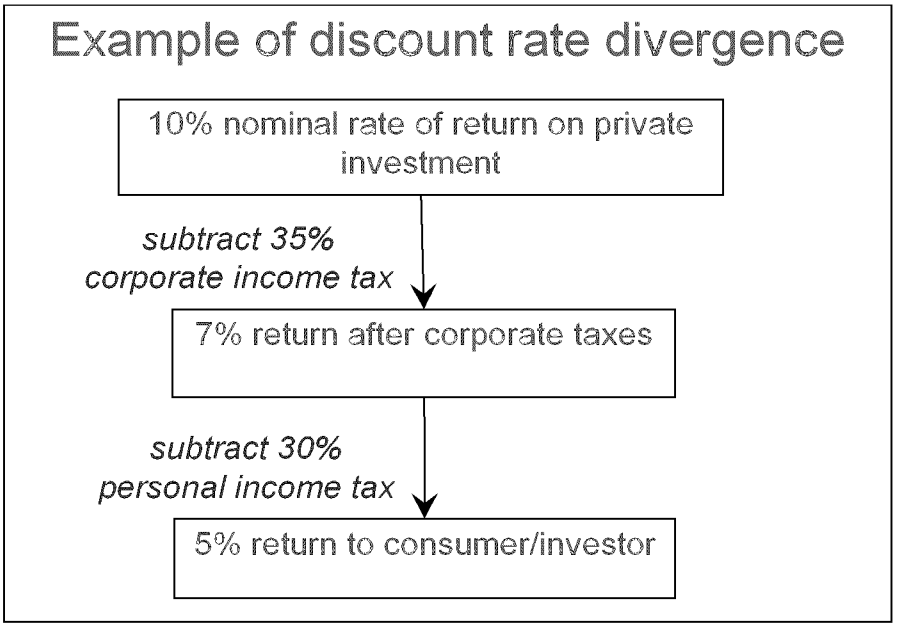
A third concept, called the "social rate of time preference" or social discount rate is sometimes used, representing the rate society uses to weigh present versus future consumption. The social discount rate is typically set equal to consumer rate of time preference in the spirit of individual preference-based analysis that underlies much economic analysis. Some argue, however, that individual rates of time preference are not necessarily appropriate for decisions faced by society as a whole, which may be different in type and may be subject to different preferences. A note as an appendix to the paper briefly discusses this form of the social discount rate.

As mentioned above, the producer discount rate does not equal the consumer discount rate because taxes cause a wedge between the before-tax rate of return on productive capital and the after-tax return received by the consumer/investor. (See example in Exhibit 2.) The resulting divergence in the producer return on investment versus the consumption discount rate implies a divergence in the opportunity cost of project flows that come from or displace investment versus consumption. This in turn implies that project flows increasing or decreasing consumption need to be treated differently than those increasing or decreasing investment. Specifically, because the return on every $1 of consumption is less than the return on every $1 of investment, in cost-benefit analysis every $1 of project flows that displaces investment should be valued more highly than every $1 that displaces consumption. There is a consensus in the literature on this issue that the ideal method of adjusting for the differing rates of return to consumption versus investment is the "shadow price of capital" approach, analogous to shadow prices that are used in project appraisal for other market prices that suffer from tax or other distortions.

For example, project investment funds that would come at the expense of a private investment opportunity should be thought of as displacing investment. Likewise, profits from the project that are invested should be thought of as augmenting investment. In the current context, this might be the case for profits that are invested in the Permanent Fund. On the other hand, project costs covered through a sales tax that reduces consumer

purchases would displace consumption, not investment. Or project profits that are rebated to residents would go mainly to augmenting consumption, because the vast majority of income is consumed (the savings rate is low).

Exhibit 2: Divergence between the rate of return on investment and the returns to consumers/investors



Market measures of producer and consumer discount rates. When looking to market interest rates and rates of return to get some empirical measure of producer and consumer discount rates, and to understand the wedge between them, one is confronted by a mass of data on different types of assets with different risk and tax characteristics. Regarding the producer return on investment, there is the 15-16% nominal weighted average cost of capital that is typical for large companies, including large oil and gas companies. Consistent with this before-tax measure, studies find a 10-11% average return on large company stocks, after an approximately 35% corporate income tax. Studies typically find a lower 10-11% nominal average return on all private capital (including real estate and private companies). The lower-risk corporate bond rate, on the other hand, has averaged about 7-8% in nominal terms. Taking all this together, a 7% real rate, or 9-10% nominal rate is a reasonable default for the producer discount rate looking forward. The U.S. Office of Management and Budget (OMB) has, for example, argued in favor of a 7% real rate for the producer discount rate.

Assuming an approximately 30% personal income tax rate, these rates of return would translate into an after-tax 7-8% nominal return to individuals on large company stocks, and a 3-4% nominal after-tax return on government bonds (5-6% on U.S. bonds before tax). Consumers differ, however, in their rates of borrowing and saving, their tax rates, and their expectations regarding future returns, and have been demonstrated to exhibit

behavior that is not fully consistent with a simple model of exponential discounting. Notwithstanding the difficult issues related to different savings behavior, tax rates, and seemingly "irrational" behavior, which have been explored at length elsewhere, a 3% real rate, or 5-6% nominal rate is a reasonable default for the consumer discount rate looking forward. This is again consistent with OMB guidelines regarding the consumer discount rate.

Accounting for displaced investment. Because the opportunity cost of displacing investment is higher than the opportunity cost of displacing consumption, properly accounting for this requires careful scrutiny of the sources of funding up-front capital costs. Likewise, it also requires scrutiny of the incidence of project benefits, as benefits that augment investment have a greater value than benefits that augment consumption. This requires knowledge or at least assumptions about how government will fund project investment costs and how it will distribute project benefits. This can become quite complex.

For example, if debt is used, the incidence on investment versus consumption depends on how fixed the pool of investment funds is assumed to be. If it is assumed that the pool of investment funds is fixed (the so-called "closed economy" assumption") then any funds raised through debt for a project will come at the expense of or "crowd out" other investment through a rise in interest rates. On the other hand, if it is assumed that there is an effectively limitless pool of investment funds (the so-called "open economy" assumption"), then debt financing can be expected to have a negligible effect on interest rates, implying little or no crowding out of investment. This would seem to be increasingly true over the last few decades.

If project costs are covered through increased taxes, however, the incidence depends on the type of tax and on savings behavior. The traditional thinking based on a federal financing perspective is that taxes are primarily imposed on personal income (income and social security taxes), and most income is consumed, not saved. Thus tax financing for federal projects displaces primarily consumption, not investment. The case for the State of Alaska is likely to be different, however, because Alaska relies heavily on taxes on the oil and gas industry, does not now have a personal income tax, and also has large investments in the Permanent Fund which are regularly rebated to taxpayers. This is discussed further below.

The shadow price of capital (SPC) approach. As mentioned above, the consensus among economists is that the ideal method of accounting for the higher opportunity cost of displaced investment is through the "shadow price of capital" (SPC) approach (see Lind (1982, 1990), Lyon (1990), and Moore et al. (2004)). While implementing the SPC approach can become very difficult, the idea is straightforward. The approach is based on the fundamental idea that investment is valuable insofar as it allows greater future consumption, since it is consumption that is valuable to people. Investment is just a means to an end. Once again, however, adjustments using the SPC approach are only potentially necessary when undertaking economic cost-benefit analysis, and are not relevant for financial analysis.

The steps in the SPC approach are as follows. First separate project cost and benefit flows that displace or augment private investment from those flows that affect consumption. As suggested above, this is potentially a difficult task depending on the particulars of the project. Next, convert all cost and benefit flows that reduce or augment investment to so-called "consumption equivalents" by multiplying them by the SPC. The SPC will be greater than 1 so long as the rate of return on investment is greater than the consumption discount rate. The SPC represents the present value of the future consumption stream resulting from an investment, discounted at the consumption discount rate.[1]

For example, if construction funds for the project are raised through issuing bonds, and a portion of those bonds are assumed to crowd out an alternative private investment, then that portion of the construction funds should be multiplied by the SPC. The remaining portion, which is assumed to come out of consumption would not be multiplied by the SPC. The same goes for the future profits from the project. If these profits are anticipated to be returned directly to residents, then most of it can be assumed to be consumed, requiring no adjustment (because savings rates are typically low). But that portion that is anticipated to be invested, either directly by the government or by residents through savings, would again be multiplied by the SPC

The final step in the SPC approach is to discount all resulting flows, which are now all measured in terms of consumption effects, using the consumption discount rate.

In the interest of full disclosure, it is important to note that while the SPC approach has been recognized by both economists and by government cost-benefit analysis guidelines as the technically correct approach, substantial inquiry uncovers no example where it has been used in practice for an actual government project appraisal or cost-benefit analysis.

Investment effects, the pipeline project and the SPC. Application of the SPC approach to a cost-benefit analysis of the pipeline project, if that was undertaken, would require careful specification of project details. For example, should it be assumed that public investment funds would come from G.O. bonds? If so, if the assumed geographic scope of the analysis is the state of Alaska, or even U.S., it may be the case that little private investment is displaced.

In fact, unlike many government cost-benefit analyses, such as those on environmental regulations, the pipeline project may have positive private investment effects, depending on how any profits from the project are distributed. For example, unlike most jurisdictions Alaska has a Permanent Fund to which it could deposit a portion of any profits from the project. Thus, if the debt used for construction funds were assumed to not displace investment, and the profits from the project were assumed to augment investment, then adjusting for these effects would seem likely to only make the project

[1] Calculation of the SPC itself requires some complex assumptions for which there is not a clear consensus and that depend on individual cases. The SPC may also be quite sensitive to these assumptions, including assumptions about the consumer discount rate, the rate of return on investment, the rate of saving, and the treatment of future depreciation in investments.

look better. In that case, not adjusting for the "SPC effect" could actually be a conservative assumption.

However, ascertaining where the future profits of the project would go, and whether they would augment consumption or investment, may be even more difficult than doing so for the construction costs. For example, what percent of royalties would go into the Permanent Fund, which has at least in the past tended to reinvest most of its returns? Other things equal, from the SPC perspective deposits into the Permanent Fund that are invested would in effect have greater value than direct rebates back to residents that are largely consumed. If project profits were instead used to offset taxes on oil and gas that would otherwise be necessary, this would have different consequences for investment. These consequences would depend on whether the oil and gas taxes come out of producer profits or are passed on to consumers, and in turn whether those producer profits would have been reinvested or distributed as dividends. Or if any project profits were used to obviate the need for a personal income tax that might otherwise be necessary, the investment effects would depend on whether those personal income taxes would have come out of investment or consumption. As most income is consumed, it is typically assumed that personal income taxes mostly displace consumption, not investment. But this would depend on the structure of the particular tax that was envisioned.

In any event, it should be kept in mind that these concerns do not affect the answers to the main questions posed at the beginning of the paper. As long as the type of analysis being conducted is financial rather than economic cost-benefit analysis, the issues surrounding the shadow price of capital are not relevant.

Discount rate policies

In assessing the appropriateness of a discount rate for state use in evaluating project participation, it is useful to understand the discount rate policies and assumptions used by Alaska for other purposes and by other jurisdictions. The most frequently referenced guidance is that given by the U.S. OMB (US OMB 1992, 2003, 2004) for cost-benefit analysis, cost-effectiveness analysis, and other government investment decisions. That guidance acknowledges the SPC approach as the analytically preferred approach to discounting, but opts for a simpler approach as general practice. The OMB guidance acknowledges that the relevant discounting approach depends on whether investment or consumption is displaced. The OMB guidance then establishes 3% and 7% as estimates of the relevant consumer and producer discount rates, and directs all federal executive agencies to discount at *both* a 3% and a 7% rate for cost-benefit analyses.

The guidance also suggests that agencies calculate the internal rate of return and conduct other sensitivity analysis of the discount rate. For cost-effectiveness analyses, lease-purchase decisions, and internal government investments, the OMB guidance directs agencies to use the U.S. Treasury borrowing rate, which was recently given at about 3% real or 5% nominal for a 20 year project. It is useful to note that the OMB guidance also points out that the analysis of uncertainty is important, but that "variations in the discount

rate are not the appropriate method of adjusting net present value for the special risks of particular projects."

The U.S. Environmental Protection Agency (2000), in its general guidelines for the conduct of cost-benefit analysis, also referenced the SPC approach as the analytically preferred method, and suggested 2-3% real as an appropriate consumption discount rate. The U.S. Government Accountability office (GAO) and the Congressional Budget Office both typically use the federal bond rate of about 3% real for discounting (Bazerlon and Smetters 1999). The National Oceanic and Atmospheric Administration (NOAA) uses 3% real for discounting in the context of Natural Resource Damage Assessments (US NOAA 1999). The United Kingdom, in its Greenbook that guides government investment analysis, recommends ministries use a 3.5% discount rate (U.K. Treasury 2003). The European Commission (2002) in recent guidance on project appraisal recommends a default 5% discount rate for cost-benefit analysis, but suggests that this choice could vary from situation to situation and country to country.

Research revealed no existing general policy in the State of Alaska regarding discounting procedures. Specific examples of analyses and policies from State agencies revealed discount rate assumptions ranging from 3% to 7% real, with reference to the OMB guidance. The Alaska Department of Transportation has used a range of rates from 3% to 7% in different project appraisals, with reference to the OMB guidance on discounting (Parsons Brinkerhoff 1999; HLB Decision Economics 2004). The Alaska Department of Education and Early Development (ADEED) uses 3% real for life-cycle cost analyses, again based on the OMB guidance (ADEED 1999).

Concluding remarks

One can draw several conclusions about the appropriate discount rate for analysis of state pipeline project participation from this discussion.

- Due to tax distortions, differences in financing opportunities, and differing risk preferences, the public and private sectors generally do not and should not employ the same discount rates.
- There is an important distinction between financial cash-flow analysis and economic cost-benefit analysis that can influence the discounting approach and discount rate that is used in these analyses.
- Given likely project funding sources and current market interest rates, 5% nominal or 3% real (assuming 2% inflation) is a reasonable discount rate for the state to use for financial analysis.
- Use of this benchmark rate should be coupled with sensitivity analysis using a range of discount rates, as well as calculation of the internal rate of return of project alternatives.
- It is generally not appropriate to try to account for risk by adjusting the discount rate. Risk assessment is best accomplished through direct incorporation of

uncertain variables effecting project costs and benefits and through computation of distribution of net present values and use of other risk analysis tools.

- If the state were to undertake a more thorough economic cost-benefit analysis, it would be important to consider the effects of project costs and benefits on the displacement or augmentation of investment.
- For cost-benefit analysis, a 3% real (5% nominal) discount rate is also a reasonable estimate of the consumption discount rate and social discount rate. This is consistent with guidance on discounting issued by several state, federal, and international government institutions.

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Note on the optimal growth model approach to the social discount rate

As mentioned briefly earlier, if one uses individual preferences as an indication of the social opportunity cost of resources over time, then the social discount rate equals the consumption discount rate. Some argue that this is inappropriate and instead derive the social discount rate from a social utility function and a model of optimal economic growth (see Arrow et al. (1996), for example). This leads to a simple relationship between the social discount rate and several economic variables:

$s = p + (g \times e)$

where,

s = social discount rate;
p = pure rate of time preference, a measure of the pure impatience part of discounting;
g = growth rate of consumption; and
e = % change in utility from a 1% change in income.

Determining a value for the social discount rate then becomes a matter of assuming values for p, g, and e. Plausible assumptions are $p = 1\%$, $g = 2\%$, and $e = 1$, leading to a real social discount rate of $s = 3\%$, which is consistent with the consumption discount rate suggested above. Of course one could justify different social discount rates based on this model using different assumptions, but 3% real is certainly well within the range of plausible resulting values.