Managing Oil Price Risk in Developing Countries

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This article presents a simple framework for understanding the impact of oil dependence on growth in terms of an optimal savings and investment strategy. Among the more important factors underlying this strategy is the extent to which oil price changes are temporary or permanent. This in turn determines whether a country should rely on stabilization and savings funds or the use of financial instruments to manage oil revenues—or both. Country experiences with stabilization and savings funds are surveyed, and the case is presented for using financial instrument to manage oil price risk. Policy implications for enhancing the use of financial instruments are explored, including an expanded role for international financial institutions.

Beginning with Hotelling's seminal paper in 1931, a large body of literature in economics has focused on exhaustible resources and the special problems they pose for development. Between 1960 and 1990, resource-rich countries grew three to four times more slowly than resource-poor countries, and this gap in growth rates has widened considerably since the 1970s (Ranis 1991; Sachs and Warner 1995). Among the factors underlying this phenomenon is the impact of commodity price volatility on macroeconomic aggregates, particularly investment spending and the adjustment costs associated with rapid changes in expenditure (Ramey and Ramey 1995).

The problems of oil dependence are no less severe for oil importers, but they are dealt with less explicitly in this article. Among African oil-importing countries, in particular, unexpected increases in oil prices adversely affect government budgets and domestic currency and contribute to a deterioration in rural-urban terms of trade, particularly in countries that export primary agricultural commodities (Rutten 2001).

This article surveys country strategies in managing oil dependence, particularly the strategies of oil-exporting developing countries, rather than analyzing the problems associated with oil dependence, on which there is already a large body of literature.

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The article presents a simple framework for understanding the impact of oil dependence on growth and surveys countries' use of stabilization and savings funds, fiscal rules, and hedging programs to respond to the problems of the volatility and exhaustibility of oil revenues. Although the country examples look at issues of managing oil price risk, many of the lessons apply to other minerals.

The first section briefly discusses an optimal savings and investment strategy for oil-exporting countries and the rationale for implementing savings and stabilization funds. The second section surveys country experiences with stabilization and savings funds. The third section explores the potential benefits of using financial instruments to manage oil price risk. The fourth section examines why so few developing economies use financial instruments to manage price risk and looks at some problems and mechanisms to mitigate the shortcomings of this approach. The final section presents some policy implications.

The Optimal Savings and Investment Policy

The main problems of oil dependence are associated with volatility in oil prices and exhaustibility of oil wealth. For a country where oil represents roughly 20 percent of gross domestic product (GDP), a one-standard-deviation shock to the price of oil represents an income shock equivalent to 6 percent of GDP (Hausmann and Rigobon 2003). Both volatility and exhaustibility can be incorporated into a simple framework for dealing with oil dependence in a developing country context.

Consider a hypothetical economy with substantial oil resources but lacking basic infrastructure, such as roads, schools, and telecommunications equipment. Suppose that the country has relatively benevolent leaders who would like to embark on a sustainable level of infrastructure investment funded by commodity revenues. In this context, sustainability implies that the expected present value of investment expenditures cannot exceed the expected present value of oil revenues. Because of borrowing constraints, investment must be funded from current oil revenues or from past oil revenues that have accumulated in a savings or stabilization fund. A savings fund is designed to create a store of wealth for future generations by converting a depletable revenue stream into a perpetual income flow. A stabilization fund is designed to stabilize revenue flows and, implicitly, expenditure.

An important component of this argument is that fluctuations in the rate of infrastructure investment reduce the efficiency of the investment program for several reasons. Building roads, schools, and hospitals requires a reasonably skilled workforce, and it is costly to train new workers when investment levels unexpectedly increase and to lay off workers when investment levels are unexpectedly cut. These training and lay-off costs are considered investment adjustment costs.

If commodity prices were certain and there were no political constraints, determining a country's optimal level of infrastructure investment would be straightforward. Infrastructure investment should increase smoothly over time in a way that minimizes investment adjustment costs. In this case, savings and stabilization funds serve simply as a place to bank excess commodity revenues until they can be efficiently invested.

If a country's revenues are generated from a commodity with a very volatile price, implementing an investment plan that increases slowly and smoothly over time becomes much more challenging. One of the roles of savings and stabilization funds is to allow the country to smooth out investment expenditures and thus increase the efficiency of investment by minimizing adjustment costs. As will be discussed, the extent to which savings and stabilization funds can smooth out investment depends on the random process generating the commodity prices.

An Example

Consider an economy that has a substantial amount of oil that can be extracted relatively quickly, say, over 10 years. Because of the costs associated with quickly increasing the level of investment, the economy should optimally invest its oil revenues over a time horizon that is substantially longer than the time it takes to extract the oil. Thus, the economy will need some sort of savings plan that allows it to bank the excess oil revenues, enabling it to continue to invest after the oil is depleted.

When oil prices are certain, the optimal investment and savings choice can be solved using dynamic programming. The optimal investment and savings levels at each date depend on current and future oil prices, current investment levels, marginal productivity of capital, and costs associated with increasing and decreasing the rate of investment. In general, the optimal solution involves an investment level that increases slowly until it reaches a steady-state level and then tapers off as oil revenues are exhausted.

Now consider the case of uncertain oil prices. Assuming that the oil price risk is not hedged, the optimal level of investment in each period will fluctuate as oil prices fluctuate. Intuitively, when the price of oil increases, the economy becomes richer, allowing a higher investment level. However, because investment fluctuations due to oil price fluctuations diminish the average efficiency of the investment program (because of the adjustment costs), the optimal rate of investment should fluctuate substantially less than the price of oil.

To understand this, consider an economy that is investing US$2 billion a year on infrastructure. Now suppose that because of an increase in oil prices, the country has $3 billion a year in revenues that can be invested. It would not make economic sense to immediately increase investment to this higher level because this would require that the country quickly hire and train a large number of construction workers

and find supplies of building materials, a process that is not likely to result in the use of the best workers and suppliers. Moreover, if the price of oil subsequently falls to its previous level, infrastructure investments would need to be cut, forcing the country to lay off the new construction workers and perhaps bankrupt its new suppliers.

These arguments suggest that savings and stabilization funds can contribute substantially to economic development by dampening the effect of oil price volatility on investment volatility. The next subsection looks deeper into the economics of oil price uncertainty to provide insights about conditions in which savings and stabilization funds provide the greatest benefits and conditions in which they can only partially reduce investment volatility. Under these second conditions, hedging offers substantial benefits.

The Random Process Generating Oil Prices

The choice of a country's stabilization or savings plan depends on the temporary and permanent factors that influence the random process that determines oil prices (Deaton and Laroque 1992; Arrau and Claessens 2001; Cashin and McDermott 2002). Oil prices fluctuate from month to month because of temporary changes in global economic and political conditions that affect the supply and demand for oil. For example, political problems in Venezuela may temporarily disrupt oil supplies, causing prices to rise. Prices subsequently fall again as the problem is resolved or as other producers step up their production to offset the shortfall. Similarly, a recession may lead to a temporary oversupply that generates temporary price declines. Long-term or permanent factors can also affect oil prices. Permanent changes can arise because of longer-lasting changes in demand arising from the emergence of substitute fuels or stronger incentives for conservation as well as technological changes and new discoveries that increase the supply of oil.

The distinction between the temporary and permanent components of price changes is important for understanding the optimal investment and savings strategy in an economy with a savings or stabilization fund. When prices are strongly mean-reverting, as when price changes are largely temporary, the present value of future revenues is not very sensitive to changes in spot prices. This implies that the long-term sustainable level of investment is not likely to be substantially affected by a change in spot prices. Savings and stabilization funds serve a useful purpose in this case, because they allow a country to maintain an investment strategy with very little variation in an environment where revenues vary substantially.

When price changes are mainly permanent (less mean-reverting and resembling a random walk), the present value of future revenues is strongly affected by changes in spot prices. Savings and stabilization funds cannot be used to smooth out investment expenditures, and oil price volatility will significantly affect the efficiency of the country's infrastructure investment program.

A savings or stabilization fund can serve a useful purpose when commodity prices are strongly mean-reverting, but it cannot substantially smooth the effect of price changes over time when prices follow a random walk. In this second case, substantial gains are associated with reducing the variance of revenues by using financial instruments to deal with price risk.

The evidence on the statistical properties of oil prices tends to show more support for mean-reversion (Pindyck 1999; Barnett and Vivanco 2003) than for persistence (Cashin, Liang, and McDermott 2000; Engel and Valdes 2000), using unit root tests, although much depends on the time interval under scrutiny. This is underscored by the behavior of futures markets, which suggests that markets expect price shocks to be largely temporary. One way to evaluate the relative importance of the temporary and permanent components is to compare the fluctuations in futures and forward prices of various maturities with spot price changes. If price changes are largely temporary, long-term futures prices will have substantially less volatility than either short-term futures prices or spot prices. Evidence indicates that the long-term futures prices of oil are about half as volatile as the short-term futures prices (Barnett and Vivanco 2003; Schwartz and Smith 2000).

How Effective Are Savings and Stabilization Funds in Theory?

The effectiveness of a stabilization or savings fund depends on the relation between a country's initial oil revenues and its investment needs and whether oil price changes are temporary or permanent.

Consider the case of an oil-exporting developing country that expects to generate enough revenue on average to fund its investment plans but may have a surplus or a shortfall in some years because of price volatility. This is a fairly typical scenario for small-population, high oil-resource countries, such as East Timor, Kuwait, and São Tomé and Principe. Suppose the country plans to invest $2 billion a year in health care and education and expects oil revenues to be sufficient to fund this investment. However, in years when oil prices are high, revenues greatly exceed $2 billion, and in years when oil prices are low, there is a shortfall.

When oil revenues greatly exceed the planned investment allocation and most of the price volatility is temporary, a savings or stabilization fund can eliminate most of the negative effects of fluctuating oil prices. Because most of the volatility in this case represents temporary changes, the present value of future oil revenues is not substantially affected by month-to-month changes in oil prices. Moreover, when oil revenues exceed investment plans, the surplus can be used to offset future shortfalls resulting from temporary price declines. However, when either of these conditions is violated, a savings or stabilization fund will not be sufficient to offset the potential negative effect on investment of fluctuations in oil prices. In this case, there will be gains to using market-based financial instruments.

Now consider the case in which planned investment is close to expected oil revenues and there is a smaller expected surplus from oil revenues. This is more typical in countries with large populations and moderate to declining oil revenues, such as Iran, Russia, and Venezuela. If prices are volatile and if the country saves very little, the savings fund may be fully drained before the first decline in prices.

Issues relating to the importance of temporary and permanent components of oil price volatility are more subtle and require additional explanation but can be easily understood through examination of the polar cases of those that are 100 percent temporary and those that are 100 percent permanent. When price changes are mean-reverting, the present value of all future oil revenues is not very sensitive to changing current oil prices, implying that the country's long-term ability to meet its investment plans is not likely to be impaired as long as the savings or stabilization fund is sufficiently funded to meet the temporary shortfall. Changes in current oil prices should have little influence on the level of investment. In contrast, when oil prices follow a random walk, changes in spot prices are permanent, implying large changes in the present value of future oil revenues. The sustainable level of future investment will also change when oil prices change, so volatile prices are likely to result in substantial year-to-year changes in the level of investment, even with a savings or stabilization fund.

Optimal Investment and Savings Plans When Oil Prices Are Uncertain

The optimal funding of investment and savings funds thus depends on the following factors:

- The rate at which oil reserves can be extracted. If oil reserves are extracted quickly, the country should amass a substantial fund that allows it to continue to build up infrastructure when oil revenues start to decline.
- The costs associated with increasing and decreasing the level of investment. When there are substantial costs associated with altering the level of infrastructure investment, the benefits from smoothing investment are greater, implying a greater need for a fund that acts as a buffer when oil prices decline.
- The productivity of the investment. If the investment contributes substantially to productivity, the country should invest more initially and take the risks associated with subsequently having less of a buffer in the event of a decline in oil revenues.
- The random process that determines oil price changes. When oil prices are strongly mean-reverting, a relatively modest fund will be an adequate buffer against oil price declines. However, as the tendency to mean-revert declines, savings and stabilization funds will become less effective.

How Effective Are Stabilization and Savings Funds in Practice?

During the 1990s, the number of stabilization and savings funds proliferated, with the addition of Algeria, Azerbaijan, Ecuador, Iran, Kazakhstan, Mexico, Nigeria, Norway, Venezuela, and others based on the successes and failures of such pioneers as Alaska, Alberta, Kiribati, and Papua New Guinea in the 1960s and 1970s. Empirically, the effectiveness of funds appears to be limited, although data limitations have prevented rigorous analysis in this regard. Time-series analysis suggests that in countries with such funds, fiscal spending is less correlated with changes in the price of the resource, although it is difficult to separate the effects of the fund from the impact of prudent expenditure policies (Davis and others 2001).

More recent analysis using pooled cross-section and time-series data for 71 countries for 1970–2000 suggests that although funds appear to have a dampening effect on government spending as a percentage of GDP, this effect is offset by a deterioration in the fiscal balance as the size of the fund increases. However, implementing a fund appears to raise fixed capital investments as a share of GDP by nearly 3 percentage points, and there is a positive relationship between the balances held in the fund and fixed capital investment, suggesting that funds may have some impact on adjustment costs related to investment. In some countries, however—Chile, Norway, and Oman, for example[1]—funds appear to deliver a number of favorable outcomes: less volatility in government spending, lower government spending, and higher shares of gross fixed capital investment. This suggests that country-specific circumstances matter a lot, in particular the use of fiscal rules and targets to guide spending decisions over a longer time horizon.

Funds and Fiscal Rules

Funds are clearly not a guarantor of fiscal stability. Many countries have erred by assuming that expenditures will automatically be stabilized and fiscal restraint encouraged by using a stringent accumulation rule to stabilize revenue flows. Accumulation rules have been price contingent (accumulation of revenues greater than a target price), as in the case of the Chile Copper Stabilization Fund; revenue contingent (a set percentage of oil revenues), as in the case of the Alaska Permanent Fund; and both (a set percentage of oil revenue above a reference price, as in the case of the Venezuela Stabilization Fund). The crucial link is the one between oil prices and fiscal expenditure (Devlin and Lewin 2002).

In countries where funds work well, there tend to be strong mechanisms that break the link between oil price behavior and fiscal expenditure, generally in the form of a fiscal rule. For example, Norway's Norges Fund income is treated as central government net cash flow and transferred to the treasury to finance the nonoil deficit. Linking fund accumulation to fiscal surpluses avoids the problem of an overall

deterioration in the government's net asset position as a result of fund accumulation. In the case of Chile, withdrawals from the fund are subject to the fiscal rule, with the structural balance calculated by factoring out the cyclical component of the copper price and other cyclical factors (Perry 2002; Fiess 2002).

A related issue is how to determine a benchmark price for forecasting fiscal needs. Many countries (such as Chile and Russia) have engaged in prolonged discussion and dispute over forecasting methods, a process that is vulnerable to political pressure. In Chile, the copper benchmark price was traditionally determined annually by a group of experts in a largely nontransparent fashion. An alternative is to use widely available and generally unbiased estimates provided by futures markets, such as the price of a five-year swap, for longer term fiscal planning.

There are two important caveats about the effectiveness of fiscal rules and operational guidelines in developing economies. First, in a perfect Barro world, private borrowing by domestic firms could potentially offset government savings with a fiscal rule. However, the empirical evidence is not conclusive, and most oil-exporting countries tend to be more affected by private capital flight than by private borrowing abroad. This suggests that expectations are more likely influenced by fundamental issues of institutional weaknesses characteristic of oil-exporting economies, particularly with respect to property rights and the functioning of the judicial system.

A second caveat is that informal norms and practices tend to have a greater effect on fiscal behavior in developing economies than formal rules and medium-term expenditure frameworks (Schick 1998), especially in oil-exporting countries where the "rentier" nature of oil revenues tends to weaken formal mechanisms of revenue accountability (Eifert, Gelb, and Tallroth 2003). Thus, in weak fiscal environments, the effectiveness of funds may also be influenced by the level of financial and income incentives in the government overall.

Funds and Managing Windfalls

Prudent use of windfalls requires appropriate governance structures based on transparency and accountability, and funds can provide an opportunity for developing economies to import better governance mechanisms to deal with windfalls. In Botswana during the 1970s and 1980s, for example, recurrent and investment spending were based on estimates of long-run diamond revenues and during windfalls reserves were accumulated in the Central Bank. This provided leeway for using windfall revenues to target investments in areas of major bottlenecks to economic development by the second half of the 1980s (Hill 1991).

Although there are no guarantees against the possibility that by allowing better saving of windfalls, funds will transfer resources from good governments to bad (Collier 2002), the experience of relatively effective funds suggests that a system of checks

and balances both internal and external to the fund can provide a mechanism for "padlocking" the fund's resources. Ideally, funds should have vertical accountability to an oversight board of representatives of the central bank or ministry of finance and horizontal accountability to agencies in the state and outside observers, such as the media and civil society, particularly environmental groups and traditional exporters (Karl 2000; Bates 1997). Specifically, there must be built-in mechanisms for control, reporting, and evaluation of fund resources and operations (Heilbrunn 2002). In addition, funds should be professionally managed, with oversight by the ministry of finance or central bank. In Norway, the Ministry of Finance supervises the activities of the fund and sets guidelines for investments and reporting requirements. Transfers to and from the fund require parliamentary approval.

Transparent Design of Funds

The institutional design of the funds can also make the earnings and use of resource revenues more visible (Bjerkholt 2002). In the case of the Alaska Permanent Fund, for example, which uses invested oil revenues to distribute annual dividends to all Alaskan citizens, the population can check the monthly earnings and expenditures of the fund to determine the exact amount of dividend checks (table 1). One proposal along these lines is to deposit surplus commodity revenues into pension accounts to encourage more public scrutiny of fund resources (Hannesson 2001).

Information on the fund's activities should be publicly available and widely disseminated. Where private oil companies produce most of the oil and natural gas, public disclosure of tax records and revenue transfers to the government is another alternative for improving the transparency of commodity revenues. Electronic tracking of oil market sales worldwide may help increase the transparency of these revenue flows.

Optimal Size of Funds

Another lesson is that the size of the fund matters. For economic and political reasons, larger funds tend to be more inefficient and to create more distortions. The optimal size of a fund tends to be much smaller than expected, with the determining factor being the statistical properties of oil prices rather than rules for accumulation and withdrawal of funds (Arrau and Claessens 2001; Crain and Devlin 2002). Larger funds (or fiscal surpluses) are also more vulnerable to political economy pressures—as evidenced by the Indonesian government's decision during the 1970s to hide fiscal surpluses.

Table 1. Features of Selected Savings and Stabilization Funds

Fund and date founded	*Rules*	*Governance*	*Asset management*
Alaska Permanent Fund	• Accumulates 50 percent of mineral revenues.	• Principal protected by constitution.	• Alaska Permanent Fund Corporation, independent from state.
1976	• Uses earnings for dividends, inflation proofing, adding to principal.	• Governed by board of six trustees—members of public, commissioner of revenue, and one governor's appointee.	• Investments largely out of state.
	• Calculates dividends as net income of fund for last five years, times 21 percent, divided by 50 percent.	• Executive director employed to manage the fund.	
	• Pays dividends to each Alaskan resident.	• Expenditures limited to 1.2 percent of net income.	
	• Links oil income and spending through the dividend program, since there is no state income tax.	• Regular reporting and auditing, with all information publicly available.	
Norway	• Fully integrated into budget process under the control of the treasury.	• Parliamentary approval for transfers to and from the fund.	• Ministry of Finance sets guidelines for asset strategy.
1990, activated 1995	• Finances nonoil deficit.	• Regular reporting to Parliament on fund status.	• Managed by Norges Bank.
	• Receives fund earnings, nonoil surplus.	• Supervision by Ministry of Finance.	• Parliamentary approval for changes in guidelines.
	• Higher government spending or lower taxes result in smaller allocations to the fund.	• Quarterly and annual reporting.	• Investment in overseas assets.
	• Operations incorporated into fiscal accounts.	• Regular, public audits.	
		• Legal requirement to provide information on fund management to public.	
Oman	• Accumulating when price is above State General Reserve Fund reference price ($15 a barrel).	• Supervised by the Financial Affairs and Energy Research Council.	• Managed by Ministry of Finance

(Continued)

Table 1. (Continued)

Fund and date founded	*Rules*	*Governance*	*Asset management*
1980	• Accumulation of privatization proceeds.	• Executive Committee supervises fund investments.	• Guidelines from Financial Affairs and Energy Research Council.
	• Discretionary transfers to budget.	• Monthly internal audit and review.	• Short-term account manages cash flow over two-year horizon.
	• Withdrawal to fund budget gap when oil price below reference price ($15 a barrel).	• Monthly reporting to Executive Committee.	• Long-term fund invests in higher return assets.
		• Quarterly external audit.	
		• Biannual portfolio performance review.	

Source: Davis, Ossowski, and Fedelino 2003.

The Case for Using Market-Based Instruments to Manage Oil Price Risk

When oil revenues lag behind initial investment expenditures and prices are mean-reverting, there may be strong efficiency gains from using financial instruments to manage oil price risk. The use of market-based financial instruments has long been proposed as the first-best solution for dealing with oil price volatility, but risk management programs are rarely implemented (Engel and Mellor 1993; Larson and Varangis 1996; Claessens and Duncan 1993; World Bank 1999).

Benefits of Using Financial Market Instruments

Instruments such as swaps, futures, and options make it possible to lock in a known price for a given period, thus eliminating price uncertainty, and they allow a country to transfer commodity price risk to the market, rather than self-insuring. A risk management strategy can also make credible the promise not to spend windfall income (Hausmann 1999). To mitigate the effects of permanent price components, small savings or stabilization funds can be combined with financial instruments to avoid paying risk premiums or depleting the fund (Larson and Varangis 1996; Shimko 1995; Humphreys 2000).

Instruments for managing commodity price risk are becoming more sophisticated with the development of derivatives and are being traded on capital markets.

For example, futures and options for crude oil and natural gas are traded on the New York Mercantile Exchange, whereas forward and swap contracts are traded on over-the-counter markets.

Exchange-traded instruments are usually more transparent, easier to monitor, and more liquid than over-the-counter instruments, such as swaps and forwards. Options are one way to protect against volatility in oil prices. With a put option, a government buys the right to sell a certain quantity of oil at a specific price for a specific period, effectively establishing a price floor. If prices fall below this floor, the value of the strike price increases and the option can be exercised or sold for a profit. To help offset the cost of the premium on a put option, the government can sell call options or the right to buy oil at a specific price over a given period, effectively establishing a price ceiling. Various combinations of puts and calls enable a government to benefit from the upside potential as well—for example, with a "costless collar," a government can sell a call option and use the premiums to purchase a put option. The state of Texas is using this strategy to hedge the 25–30 percent of state revenues tied to oil revenues.

An adequate assessment of basis risk—the difference between the benchmark price used to hedge and the realized price in the exporting country—is important for using futures and options. Although in practice the basis risk for oil tends to be much smaller than the overall price risk, the benefits and costs of using risk management instruments are clearly affected by basis risk. For Alaskan oil, for example, prices have ranged from $9 to $41, whereas the basis difference has ranged from $0.80 to $4.20 (Lindahl 1996).

Over-the-counter instruments, such as swaps and forward contracts, are more flexible than exchange-traded instruments because they are customized transactions between the government and the financial intermediary. They can mitigate basis risk, are available in large volumes for single transactions, and frequently cover longer periods. Initial deposits and margin calls are also avoided. In a swap transaction, the oil-producing government contracts with a private bank to lock in a price (say, $20 a barrel) for a long period, say, two to three years. The government then sells the oil on the open market, and both parties calculate an average sales price every six months. If the average price that the country receives is less than $20 a barrel, the bank pays the difference. If oil prices rise, the payment flows in the reverse direction. There are several variations on this approach. A country could also use a swap to establish a price floor and could sell a cap (say, $25 a barrel) to help cover the cost of the floor. The country would pay the bank any oil revenues received over the $25-a-barrel cap.

A forward contract is like a futures contract except that it is an agreement between a buyer and a seller directly (not on an exchange), and forward contracts generally give rise to physical deliveries.

Using both exchange-traded commodities and over-the-counter instruments, oil-producing governments can sell their production forward or buy insurance against

large price declines. A good time to start risk management is when prices are high relative to trend. During a high price period, a producing country can lock in revenues at the high price through swaps and protect against low price scenarios with put options.

Global Externalities from Using Financial Markets to Manage Oil Price Risk

There are likely to be favorable externalities for the global economy from greater use of financial markets to manage oil price risk. When prices fall, a constrained producer may want to increase (rather than reduce, as microeconomic theory would predict) its production to generate sufficient revenues to meet its investment needs. Thus, because of the tendency of some producers to increase production and contribute to an oil glut, what would otherwise be a temporary price decline can be both amplified and extended.

Although consumers benefit from the decline in oil prices, the increased volatility created by this perverse incentive to increase production as prices fall creates substantial inefficiencies in consuming countries as well as in producing countries. When oil prices are very volatile, consuming countries are likely to find it difficult to sustain fuel efficiency and conservation efforts, whereas producing countries are likely to experience greater political instability.

When a country is able to hedge a large portion of its oil revenues, it no longer tends to increase production as prices decline. Indeed, the country will be able to benefit by timing its oil production to coincide with higher oil prices. Oil producers will generate higher revenues on average, and oil prices will be less volatile.

Why Few Developing Country Governments Use Financial Instruments to Manage Oil Price Risk

Despite the expansion of markets to absorb commodity risk, there is little evidence that developing economies are using market-based instruments to manage oil price risk. This appears to result mainly from two causes: the status quo problem and the lack of coordination in international financial markets.

The Status Quo Problem and the State of Texas Hedging Program

Although the use of financial instruments reduces risk and increases efficiency, there may be some risk for government officials who implement such a policy. Policymakers are likely to be evaluated by how well market-based instruments work relative to the status quo with no use of hedging.

Officials must be concerned not only with the volatility of prices but also with the possibility that the country will end up worse off as a result of the risk management

decisions. Although policymakers will benefit politically from the use of risk management instruments if commodity prices decline, the political costs may outweigh the benefits if prices rise. Because there is close to a 50 percent chance that any given risk management decision will lose money relative to the status quo of no risk management, it is not surprising that government officials do not generally consider risk management a viable alternative.

Finally, the effectiveness of risk management strategies needs to be evaluated from the vantage point of fiscal stability, an important area for further research. Recent evidence suggestions that when market-based instruments are not used, government will realize the highest portion of expected revenue but also will experience the highest level of revenue volatility and more frequent budget deficits. Exchange-based risk management can effectively manage extreme downside risk and stop large budget deficits from occurring (Buttimer, Shaw, and Swidler 1999).

Many of these issues came into play in the oil price risk management program of the state of Texas, one of the few examples of using market-based instruments to hedge a state budget.[2] Texas collects about half a billion dollars from a 4.6 percent production tax on crude oil, and in 1991 the Texas Senate introduced a bill authorizing a two-year pilot risk management program, with expanded legislation passed in 1993. To avoid opposition, the program was initiated in a quiet, unobtrusive way as part of existing treasury operations with program support financed by unclaimed royalties. Political support for the risk management program was created and maintained through continuing efforts to educate legislators and their staffs and to address fears about risk management operations. In addition, the program had well-defined safety mechanisms, including board oversight, use of exchange-traded options, monthly and quarterly reporting, and a system of internal and external checks and balances. The State Depository Board, which had a strong reputation for technical competence, was selected to supervise the program. Guidelines and operating procedures, drawn up in consultation with an advisory committee, covered authorization to trade, decision-making responsibilities, position limitations, broker constraints, daily monitoring, separation of responsibilities, and internal reporting to both fiscal authorities and the oversight board.

In addition, a system of checks and balances was established to monitor the activities of the risk management program, incorporating treasury supervision, oversight board supervision, Risk Management Group trading, banking functions, accounting functions, broker and clearing agents, and external audit. Treasury staff familiar with exchange and fiscal spending transactions were included in the auditing of the risk management program—staff checked the daily activities of the program and wired the money to be used in purchasing options on behalf of the Risk Management Group. Other controls included stop-loss limits on the amount of money that could be placed at risk in one day ($500,000) and a total amount that could be lost throughout the program ($2.5 million—the program would stop immediately if that

limit was reached). Limiting risk management instruments to exchange-traded options (no futures or swaps) offered additional security because no open-ended losses could be incurred (as they could be with futures), options are more liquid and easier to understand, and trades would be subject to greater scrutiny in a well-regulated market. At the end of two years, the program would be assessed and either closed down or continued.

This experience shows that to implement an effective risk management program, governments need to identify a clear objective (such as risk management) to deal with fears of speculation. Ideally, risk management programs would be the responsibility of existing treasury operations, not a new unit, and would rely on existing staff with high levels of technical expertise in commodity markets. Clear operational guidelines should be developed, including authorization to trade, decision-making responsibilities, position (stop-loss) limitations, broker constraints, daily monitoring, separation of responsibilities, and internal reporting. Alternative risk management strategies (options, swaps, futures) should be evaluated on paper first, and the selected strategy should be introduced as a pilot program with a sunset provision if the program loses too much money. The program should have clear opportunities for upside potential.

Coordination Failures in International Financial Markets

Low use of financial instruments by developing country governments also stems from a coordination failure in international financial markets. Suppose that major oil corporations and major sovereign producers simultaneously decide to hedge their oil price exposure. This would of course solve the status quo problem. But there is a second problem that would need to be overcome before these risk management strategies can be implemented. Selling the equivalent of billions of barrels of oil in financial markets requires buyers who are willing to purchase these amounts.

Who are such potential counter-parties? In general, they come from two groups. The first group consists of institutions and individuals with an incentive to take the other side of these transactions to hedge their own risks. For example, power producers with gas-fired generators have an incentive to lock in gas prices to hedge the costs of generating power. Similarly, large purchasers of oil, such as airlines, plastics, and chemical companies, can serve as natural counter-parties for oil producers. The amount of oil such companies consume is likely to be relatively small, however. Most oil is consumed by individuals, in the form of gasoline and heating oil. But few individuals find it practical to buy oil futures and forward contracts to hedge future expenses.

The second major counter-party group is made up of large pension funds, individual investors, and hedge funds. Because individuals in developed economies, who are the largest oil consumers, are unlikely to hedge, there is likely to be a substantial

gap between the amount of oil that producers should in theory sell forward and the amount of oil that consumers can be expected to buy forward. That means that there should be a positive risk premium associated with holding oil price risk that should make such investments attractive to institutional investors. But most pension funds and other institutional investors lack the expertise to invest in these commodities, and learning that skill will likely take many years. Although there are hedge funds that can take the other side in these transactions, these funds tend to be thinly capitalized and can likely take on only a small part of the necessary exposure.

With the amount of capital that can plausibly be used to take the other side in risk management transactions so small relative to the aggregate oil price risk, prices on futures and forward markets would decline substantially if producers tried to hedge a significant amount of the oil price risk. Markets are liquid enough to absorb small trades by small producers but not yet deep enough to allow large producers to hedge as much as they would like. Anecdotal evidence suggests that large oil companies tend to hedge only the gap between current production levels and the minimum amounts needed to keep facilities going.

A Role For International Financial Institutions

There are likely to be substantial benefits associated with developing markets that allow oil-producing governments to hedge their oil price exposure. As a result, there is a role for international financial institutions to address the status quo and coordination problems just outlined.

With respect to the status quo problem, the key to developing deeper markets for managing oil price risk is to educate government officials on the use of market-based instruments to deal with oil price risk. International financial institutions can also encourage the involvement of investment banks to develop the counter-party side of the financial market for oil price exposure.

Ultimately, if oil producers hedge a significant amount of their oil price risk, the largest fraction of the risk will need to be held by international institutional investors, because relatively little oil price exposure will be taken by petroleum users. However, this will require the development of securities that are tailored to the needs of international institutional investors, in addition to the removal of various regulatory and legal impediments.

This points to a potential third role for international financial institutions in facilitating securitization of oil resources. One possibility would be to develop an international agency, resembling Fannie Mae or Freddie Mac, to act as a conduit for banks that initiate loans with interest payments tied to oil prices. These loans could then be packaged, securitized, and divided into tranches to appeal to various investor clienteles. For example, a senior AAA tranche could be sold to pension funds and insurance

companies. A BBB tranche could be sold to more adventurous institutions, like university endowments, that would like to have some oil exposure but are prohibited in their charters from holding derivatives. Hedge funds and other more specialized investors could hold the riskier junior tranches.

International financial institutions could play a role by helping originate the transaction and working to ensure that the developing country gets the best possible terms for financing. In addition, international financial institutions can provide guarantees and insurance against the risk of default, analogous to the role that Freddie Mac played in developing a market for mortgage-backed securities. In the initial development of the residential mortgage-backed securities market, Freddie Mac acted as a conduit between the savings and loan institutions that initiated the mortgages and the investment banks that offered the securities. As a conduit, an international financial institution might need a few billion dollars to initially hold some of the loans while they are being securitized and might want to set aside funds to insure the loans.[3]

Thus, international financial institutions may be able to facilitate the development of a market for securitized oil-linked loans by dealing with legal and regulatory issues related to the introduction of new securities, addressing concerns about political risk, and marketing these securities to countries that import a substantial amount of oil to help them hedge oil consumption risk.

There are likely to be favorable externalities for the global economy as a result of the greater use of financial markets for managing oil price risk. When prices decline, a constrained producer may want to increase its production (rather than reduce it, as microeconomic theory would predict) to generate sufficient revenues to meet its investment needs. As a result, what would otherwise be a temporary price decline can be both amplified and prolonged because of the tendency of some producers to increase production and contribute to an oil glut.

Although oil consumers benefit from the decline in oil prices in these situations, the excess volatility resulting from this perverse incentive to increase production as prices fall creates substantial inefficiencies in consuming countries as well as in producers. For example, it is likely to be more difficult to maintain fuel efficiency efforts and to increase conservation efforts when oil prices are very volatile. In addition, oil price volatility is likely to contribute to political instability in oil producing countries.

When a country hedges a significant portion of its oil revenues, its tendency to increase production as prices decline can be eliminated. Indeed, the country will be able to benefit by timing its oil production to coincide with higher oil prices. By doing this, the oil producers will generate higher revenues on average, and oil prices will be less volatile.

Finally, international financial institutions can work more closely with major international oil companies in sharing oil price risk with developing country governments. Major oil companies are already exposed to substantial amounts of oil price

risk. The largest international oil companies—British Petroleum, Exxon Mobil, Royal Dutch Shell, and Total Fina Elf—produce about eight to nine million barrels of oil a day. This amount exceeds the total production of non–OPEC South American and African producers—in other words, the production from developing economies that would benefit the most from hedging. What this means is that the major oil companies can take a significant amount of the oil price exposure of the smaller producers without substantially increasing their own exposure. The oil companies can do this either by buying the securities described or by structuring their contracts with the exporting countries in ways that shift the price risk to them.

Conclusion

To deal with oil price volatility and exhaustibility, countries have set up stabilization and savings funds. Although the funds have helped manage windfalls and turn depletable wealth into productive assets, their performance has been much weaker in reducing the effect of volatile oil prices on government revenues and spending. Especially important have been a sound fiscal framework and accountability and transparency in fund structure.

Two limiting influences on the effectiveness of oil funds are oil price processes, which are almost entirely beyond the control of policymakers, and political economy factors. Both tend to put downward pressure on the optimal size of funds and raise the efficiency gains from the use of market-based financial instruments.

In theory, the first-best strategy to deal with commodity price volatility is the use of market-based risk instruments. In practice, however, policymakers in developing areas are deterred by the status quo problem and by coordination failures in the development of international financial markets. On the status quo problem, Texas's experience suggests that government hedging of oil price risk is challenging but not impossible when the program has the clear objective of insurance and is introduced gradually, preferably as a pilot program by extending existing responsibilities for treasury operations rather than by creating a new, stand-alone program. Clear operational guidelines for the program, with appropriate layers of authorization for trades, automatic stop-loss provisions, separation of responsibilities, and internal reporting are critical to avoid speculation.

There is also a potential role for international financial institutions in promoting the use of market-based instruments to manage oil price risk, given coordination failures in international financial markets. Education, publicity, and technical assistance in working with oil-producing and -importing governments to manage oil price risk are possibilities. International financial institutions can also work to develop instruments to facilitate securitization of oil proceeds an can encourage oil companies to work with developing economies in sharing oil price risk. There are

likely to be significant externalities for the global economy associated with this role—namely, reduced volatility in oil prices.

Notes

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1. In Chile and Norway, commodity revenues as a percentage of overall government revenues are significantly lower than in most oil-exporting countries, implying that the impact of a volatile revenue stream is significantly lower. Copper prices are also less volatile than oil prices, lessening the degree of potential fiscal volatility. These effects were taken into account in Crain and Devlin (2002).

2. This discussion is based on Patterson (2001).

3. However, the proposed hedging strategy need not put very large amounts of much money at risk. First, it is assumed that the oil-producing country would put significant amounts of money on deposit at the banks to serve as partial collateral for the volumetric loans. Second, the loans would also be collateralized by oil, which presumably can be seized if the defaulting country tries to export the oil. It should be emphasized that the oil exporter will have an incentive to renege on the loan agreement only when oil prices are substantially higher than the contracted price. However, if the oil-importing countries agree to recognize these contracts, the exporting countries will not be able to renege and sell their oil at the higher market price. Of course, there is still political risk associated with political events that result in a disruption in the country's ability to produce oil.

References

Arrau, Patricio, and Stijn Claessens. 2001. "Commodity Stabilization Funds." World Bank, Washington, D.C.

Barnett, Steven, and Alvaro Vivanco. 2003. In J.M. Davis, R. Ossowoski, and Al Fedelino, eds., *Fiscal Policy Formation and Implementation in Oil-Producing Countries*. Washington, D.C.: International Monetary Fund.

Bates, Robert. 1997. *Open-Economy Politics. The Political Economy of the World Coffee Trade*. Princeton, N.J.: Princeton University Press.

Bjerkholt, Olav. 2002. "Fiscal Rule Suggestions for Economies with Non-Renewable Resources." Paper presented at the IMF/World Bank Conference on Rules-Based Fiscal Policy in Emerging Market Economies, 14–16 February, Oaxaca, Mexico.

Buttimer, Richard, Ron Shaw, and Steve Swidler. 1999. "Government Risk Management: Motivation, Implementation." *Public Budgeting & Finance* 19(4):75–90.

Cashin, Paul, and C. John McDermott. 2002. "The Long-Run Behavior of Commodity Prices: Small Trends and Big Variability." IMF *Staff Papers* 49(2):175–99.

Cashin, Paul, Hong Liang, and C. John McDermott, 2000. "How Persistent Are Shocks to World Commodity Prices?" IMF *Staff Papers* 47(2):177–217.

Claessens, Stijn, and Ronald C. Duncan, eds. 1993. *Managing Commodity Price Risk in Developing Countries*. Baltimore, Md.: Johns Hopkins University Press.

Collier, Paul. 2002. "Best Practice in Diversification Strategies for Mineral-Exporting Countries." Presentation for the Managing Volatility Thematic Group Workshop, 7 January, Washington, D.C.

Crain, Mark, and Julia Devlin. 2002. "Nonrenewable Resource Funds: A Red Herring for Fiscal Stability?" Draft working paper. World Bank, Washington, D.C.

Davis, Jeffrey, Rolando Ossowski, James Daniel, and Steven Barnett. 2001. "Stabilization and Savings Funds for Nonrenewable Resources: Experience and Fiscal Policy Implications." IMF Occasional Paper 205. International Monetary Fund, Washington, D.C.

Davis, Jeffrey, Rolando Ossowski, and A. Fedelino. 2003. *Fiscal Policy Formulation and Implementation in Oil-Producing Countries*. Washington, D.C.: International Monetary Fund.

Deaton, Angus, and Guy Laroque. 1992. "On the Behavior of Commodity Prices." *Review of Economic Studies* 59:1–23.

Devlin, Julia, and Michael Lewin. 2002. "Issues in Oil Revenue Management." Presentation for the World Bank ESMAP Workshop on Petroleum Revenue Management, 23–24 October, Washington, D.C.

Eifert, Ben, Alan Gelb, and Nils Borje Tallroth. 2003. "The Political Economy of Fiscal Policy and Economic Management in Mineral Exporting Countries." In Jeffery Davis, Rolando Ossowski, and A. Fedelino, eds., *Fiscal Policy Formulation and Implementation in Oil-Producing Countries*. Washington, D.C.: International Monetary Fund.

Engel, Eduardo, and Patricio Meller, eds. 1993. *External Shocks and Stabilization Mechanisms*. Baltimore, Md.: Johns Hopkins University Press.

Engel, Eduardo, and Rodrigo Valdés. 2000. "Optimal Fiscal Strategy for Mineral Exporting Countries." IMF Working Paper 00/118. International Monetary Fund, Washington, D.C.

Fiess, N. 2002. "Chile's New Fiscal Rule." Draft. World Bank, Washington, D.C.

Hannesson, Rögnvaldur. 2001. *Investing for Sustainability: The Management of Mineral Wealth*. Boston, Mass.: Kluwer.

Hausmann, Ricardo. 1999. "Managing Terms of Trade Volatility." *PREMnotes* 18. Poverty Reduction and Economic Policy Group, World Bank, Washington, D.C.

Hausmann, Ricardo, and Roberto Rigobon. 2003. "An Alternative Explanation of the Resource Curse." In Jeffery Davis, Rolando Ossowski, and A. Fedelino, eds., *Fiscal Policy Formulation and Implementation in Oil-Producing Countries*. Washington, D.C.: International Monetary Fund.

Heilbrunn, John R. 2002. "Governance and Mineral Funds." Working Paper, Colorado School of Mines, Golden, Colo.

Hill, Catherine. 1991 "Managing Commodity Booms in Botswana." *World Development* 19(9):1185–96.

Humphreys, Brett. 2001. "Commodity Stabilization Funds and Risk Management." Presentation for the World Bank Managing Volatility Thematic Group, 16 November, Washington, D.C.

Karl, Terry Lynn. 2000. Presentation at the Managing Volatility Thematic Group Workshop on Volatility and the Political Economy of Reform, 20 June, Washington, D.C.

Larsen, Don, and Panos Varangis. 1996, "Dealing with Commodity Price Uncertainty." Policy Research Working Paper 1667. World Bank, Washington, D.C.

Lindahl, Mary. 1996. "A Risk Management Strategy for Alaska: Learning from the Texas Experience?" *Journal of Energy, Finance & Development* 1(1):1–8.

Patterson, Linda. 2001. "The State of Texas Risk Management Program: A Long Position and Long Perspective." Presentation for the World Bank Managing Volatility Thematic Group, 25 June, Washington, D.C.

Perry, G. 2002. "Can Fiscal Rules Help Reduce Macroeconomic Volatility in LAC?" Paper presented at the IMF/World Bank Conference on Fiscal Rules and Institutions, Oaxaca, Mexico.

Pyndick R. 1999, "The Long-Run Evolution of Energy Prices." *Energy Journal* 20(2):127.

Ramey, Garey, and Valerie A. Ramey. 1995. "Cross-Country Evidence on the Link Between Volatility and Growth." *American Economic Review* 85:1138–52.

Ranis, G. 1991. "Towards a model of development." In L.B. Krause and K. Kihwan, eds., *Liberalization in the Process of Economic Development*. Berkeley, CA: University of California Press.

Rutten, Lamon. 2001. "Risk Management Strategies for Mineral Importers." Presentation for the World Bank Managing Volatility Thematic Group, 20 March, Washington, D.C.

Sachs, J., and A. Warner. 1995. "Economic Convergence and Economic Policy." NBER Working Paper 5039. National Bureau of Economic Research, Cambridge, Mass.

Schick, Allen 1998. "Why Most Developing Countries Should Not Try New Zealand Reforms." *World Bank Research Observer* 13(1):123–31.

Schwartz, Eduardo, and James Smith. 2000. "Short-Term Variations and Long-Term Dynamics in Commodity Prices." *Management Science* 46(7):893–911.

Shimko, David. 1995. "Long Term Energy Risk Management in the Alaskan Context." Paper prepared for the Risk Management Workshop, October, University of Alaska-Anchorage, Anchorage, Alaska.

World Bank 1999. "Commodity Price Risk Management in Developing Countries: Proposal for a Market Based Approach." International Task Force on Commodity Risk Management in Developing Countries, Washington DC.