How Should Donors Respond to Resource Windfalls in Poor Countries? From Aid to Insurance

Anton Dobronogov, Alan Gelb, and Fernando Brant Saldanha

Abstract

Natural resources are being discovered in more countries, both rich and poor. Many of the new and aspiring resource exporters are low-income countries that are still receiving substantial levels of foreign aid. Resource discoveries open up enormous opportunities, but also expose producing countries to huge trade and fiscal shocks from volatile commodity markets if their exports are highly concentrated. A large literature on the "resource curse" shows that these are damaging unless countries manage to cushion the effects through countercyclical policy. It also shows that the countries least likely to do so successfully are those with weaker institutions, and these are most likely to remain as clients of the aid system. This paper considers the question of how donors should respond to their clients' potential windfalls. It discusses several ways in which the focus and nature of foreign aid programs will need to change, including the level of financial assistance. The paper develops some ideas on how a donor like the International Development Association might structure its program of financial transfers to mitigate volatility. The paper outlines ways in which the International Development Association could use hedging instruments to vary disbursements while still working within a framework of country allocations that are not contingent on oil prices. Simulations suggest that the International Development Association could be structured to provide a larger degree of insurance if it is calibrated to hedge against large declines in resource prices. These suggestions are intended to complement other mechanisms, including self-insurance using Sovereign Wealth Funds (where possible) and the facilities of the International Monetary Fund.

JEL Codes: E63, F35, G23, Q33

Keywords: countercyclical, foreign aid, hedging markets, low-income countries, macroeconomic stabilization, natural resources, volatility

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I. Introduction

Oil, gas and minerals are being discovered in more countries, both rich and poor. Tanzania, Mozambique, Kenya and Uganda, traditionally regarded as energy-poor, are poised for resource booms and Ghana has already experienced the initial phases. Some agriculture-based countries like Zimbabwe are evolving into hard-mineral exporters with investments in diamond and platinum mining. Other established mineral exporters such as Zambia have begun to see a dramatic increase in mining tax revenues as investments are fully depreciated and new agreements negotiated and some, like Mongolia, have seen large increases in estimates of proven reserves. For hydrocarbons and most minerals, resource discoveries have outpaced depletion in recent years, leading to new approaches to model the difficult question of how to account for reserve exhaustion in national accounts (Gelb, Kaiser and Vinuela 2012, Hamilton and Atkinson 2013). Many of the new and aspiring resource exporters are low-income countries that are still receiving substantial levels of aid. In 1995 Sub-Saharan Africa had only four fuels exporters; depending on world market scenarios, the outlook is for as many as 19 (Ross 2012) and virtually all of the additional countries are currently IDA-eligible. Some, like Tanzania, are politically stable and well managed. Others, like South Sudan, are beset by severe political instability and civil conflict, and with a very problematic record on fiscal management.

This paper considers the question of how donors should respond to their clients' potential windfalls. Should they greet them with elation or with dismay? They could simply walk away, grateful for the relief given to their taxpayers. In cases like Equatorial Guinea, which combines large resource rents and very weak governance, walking away seems to be the obvious choice, at least in terms of continuing to provide large-scale financial assistance. Some countries are projected to cross the threshold to middle-income status in a few years and to be transition out of highly concessional windows like IDA (Moss and Leo 2011). Others, with lower starting points and more modest resource finds, might continue to be aid-dependent for longer. For all of these cases, donors need to think creatively and strategically about the most constructive roles that they can play, as funders or "beyond lending" to include a wider range of engagements. While the emergence of extractive industries opens up a number of potential "entry points" for development partners all along the natural resource value chain (Dietsche et al 2013), experience to date suggests that finding ways to stay productively engaged may not be easy in all cases.

One important challenge, and the main focus of this paper, is the potential role of donors in helping the new resource exporters to deal with increased risk. Resource discoveries open up enormous opportunities but also expose producing countries to huge trade and fiscal shocks from volatile commodity markets if their exports are highly concentrated. A large literature on the "resource curse" shows that these are very damaging unless countries manage to cushion the effects through countercyclical policy. It also shows that the countries least likely to be able to do this are those with weaker institutions, and these are most likely to remain as clients of the aid system. Developing countries have a wide array of potential instruments to help manage risk. They can implement fiscal rules to help stabilize spending, save and dis-save abroad using Sovereign Wealth Funds (SWFs) and can also use the IMF, in particular the Exogenous Shocks Facility (ESF) within the PRGF.[1] Donors, in particular, the Multilateral Development Banks, can play a role in several of the more market-based approaches (Perry 2009), but some mechanisms, such as developing local currency bond markets or index-linked bonds, may be more applicable to middle income countries, or at least to countries emerging from aid dependence towards market-based financing.

The specific topic considered here is how donors might reshape their flows of concessional development assistance to provide some insurance against resource booms and busts. Insurance could be provided to the country or facilitated at the macroeconomic level. Alternatively, insurance could be provided to the development program itself to reduce its vulnerability to fiscal shocks. While the arrangements for the latter might be more complex, in some situations it might be a more acceptable approach for a donor especially if there are concerns that providing macroeconomic or budget support will not necessarily insulate "good" development programs from changes in counterpart funding. Either way, the question is how best to design a program that is able to respond to shocks from volatile commodity markets and how to finance such a program within the often rigid funding constraints faced by the donor.

Volatility is of course not the only issue. Resource windfalls raise several difficult questions for donors. Even if they endorse "country ownership", as most do in principle, donors

[1] IDA 2006 notes that while the ESF is intended to provide counter-cyclical balance of payments support it is also intended to play a catalytic role, with the expectation that other donors would provide additional concessional financing to help countries mitigate shocks. Further, IDA 2013 identifies four special themes that warrant intensified and systematic focus for during the IDA17 Replenishment period which runs from July 1, 2014 to June 30, 2017. One of these themes is inclusive growth, and within this theme special attention will be devoted to three important channels for inclusive growth, including managing natural resource wealth.

sometimes become uneasy when they lose leverage over the policies and programs of their clients. How should they respond if governance weakens or the efficiency of the public investment program deteriorates? These are not simply theoretical possibilities -- oil exporters score far lower than other developing countries on the index of public investment management (PIMI) produced by the IMF (Dabla-Norris et al 2011). How should an issue-focused donor react when it becomes apparent that its mission is not a priority for the country's own spending? Many donors, such as the Global Fund, expect that recipient countries should shoulder an increasing share of program costs as they become richer, but they may have other priorities. This debate has surfaced, for example, over the question of who should fund the continuing commitment to provide HIV/AIDS treatment. Another question is how to respond if the booming regions of the country leave the poorest communities behind?

These examples suggest that donors can conceptualize their role in terms of three priorities. The first, as noted above, is to assist countries to cope with volatile and unpredictable trade and fiscal revenue shocks, and at the same time to also try to protect important development programs from disruption. The second is to help countries manage their own resources well -- what has been termed "investing in investing" (Collier 2007). This can involve a range of approaches and initiatives as discussed below, including co-financing specific investment projects. The third -- to the extent that donors are willing to do it -- is to continue to support activities and development goals that they see as a priority but which the country is reluctant to fund.

Donors can respond to these priorities by changing the focus and nature of their programs as well as the level of financial assistance. One option is to change the mix of financing instruments. With the stress on "country ownership", many have advocated the use of budget support as an essential component of assistance if the legitimacy and capacity of the government is not to be undermined by fragmented project aid. However, as resource taxes cause fiscal revenues to balloon programs for resource-rich countries might shift away from budget support towards projects, especially if they provide technical assistance or create incentives to help the country improve the management of its own funds.[2] One promising

2 Morrison 2012 notes that the shift from projects towards budget support has partly been driven by the view that project performance cannot be insulated from country conditions. While this view was validated by earlier studies on the relationship between project and country performance ratings, more recent studies suggest that extra management effort together with better project selection can result in well-performing projects even in difficult conditions. Denizer and Kraay 2011, for example, find that project performance in fragile states has

approach is the development of results-based assistance, such as the Program-for-Results (PforR) approach recently approved by the World Bank. Most of the PforR operations have been quite highly leveraged, with the World Bank providing less than half the total program, raising the hope that combining domestic and external funds can improve the use of at least part of the resource revenues.[3] In especially difficult cases donors might seek to channel much of their funding through non-government channels.

A second response is to increase the role of technical assistance. This can be provided to governments to strengthen management across the entire resource value chain, from improving geological information to structuring resource concessions and taxation through budget management and to the choice of expenditures and the quality of spending. It can also include support to civil society organizations and parliaments to improve their capacity to understand the size and implications of resource discoveries and to monitor government policies, programs and spending. Mongolia presents an example, with an innovative donor program engaging parliamentarians and specialized committees in response to the need to inform the policies of an unusually activist legislature.

A third approach is for donors to help develop and support global norms and standards to name and shame individual governments (in some cases including sanctions) and to provide a basis for countries to compare themselves against others. These efforts include the EITI/Resource Charter, the Kimberly Process, the Dodd-Frank legislation in the US, and comparative benchmarks such as the Open Budget Index, the PIMI Index and the Santiago Principles for sovereign wealth funds.

Even though some of these mechanisms mark a shift away from resource transfer towards broader strategies for engagement, there is still the question of how to cope with trade and fiscal volatility for those components of the program that do involve financial support. This is, of course, less necessary for countries that have the capacity to manage volatility, but even some of these will face political constraints to limiting spending and the risk that hard-won savings built up in a SWF could be raided by a future, less prudent, government.[4] Section II outlines the scope of the prospective challenge. It takes Uganda as a specific example, comparing estimates of aid and IDA flows with projections of oil income. There is every

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more or less caught up with performance in better-managed countries. The unit preparation and supervision costs of projects in the fragile states are far higher, however, than those for projects in well-managed countries.

[3] For a synthesis of the first PforR operations see Gelb and Hashmi, 2014, forthcoming.

[4] For a country capable of setting up and implementing fiscal rules it might also be useful to supplement revenue projections with expected aid receipts

prospect that resource taxes will far eclipse budgeted aid flows, but also great uncertainty over the level of resource exports and fiscal revenues. Amid the excited speculation on the future of the new resource exporters, it is important to recognize that some countries, like Uganda, might end up with little or nothing.

Section III considers how a donor like IDA might structure its program of financial transfers to mitigate volatility. One approach is to support efforts by the country to hedge its own risk. This could involve funding part of the cost of hedging (for example, through purchasing options as done by Mexico to hedge oil price risk) or by increasing the country's access to futures markets through reducing the level of risk perceived by counterparties. This could be done, for example, by committing part of the future aid envelope as a first-loss reserve in the event of a default. The attractive feature of this arrangement is that it is precisely at the time when oil prices are high – and aid less needed—that country risk is highest, since it is in this state that Uganda would have the most incentive to renege on a forward contract and would face margin calls on any futures contract.

Another approach would be to adjust the level of program disbursements in response to resource shocks so that countercyclical aid flows provide a degree of insurance to the development program. This could include a range of budget support, project support and results-based instruments. The approach would complicate project agreements but it could offer some advantages, especially in situations when the donor is not comfortable in providing the equivalent of budget support to the country or if project lending is preferred because of its associated technical and management benefits. With insurance provided to the program there is less risk from government cutting its counterpart contribution if oil prices and incomes fall as this would automatically be offset by an increase in donor funds. Variable support could be enabled in a number of ways and through a range of instruments.

The question then is how a donor like IDA can vary disbursements in response to resource shocks even though the country envelope, which covers all project commitments, is determined by other factors. One appealing possibility is to make the allocation formula sensitive to terms of trade shocks. However, this would not be a simple change to a formula reached through a lengthy process of political negotiation. The approach would also be subject to long data lags, including the time needed to scale the country program up or down in response to a changing allocation. Considering these difficulties, we outline some possible ways in which IDA could use futures contracts to vary disbursements while still working within a framework of country allocations that are not contingent on oil prices.

Using a typical futures price distribution Section IV offers some simulated examples of how an IDA program could help to cushion funding volatility while still keeping its own risk within manageable bounds. The arrangements could be set up to provide a graduated response to oil price changes or be tailored towards more "catastrophic" coverage in the event that oil prices collapse, as indeed they did during the global crisis in 2008. IDA cannot of course insure against all risks. It cannot cover output risk, since the level of production can be affected by country policy. Neither can it cover basis risk, the changing margin between the price received for Uganda's (low-quality) crude and a benchmark price such as that of Brent Light for which futures markets exist. Basis risk can be considerable for oil of different quality trading on widely separated markets but still leaves a larger component .of market price risk that can be cushioned. [5] There are also practical limits on the ability to hedge against medium-longer-run price cycles. Nevertheless, simulations suggest that it would be possible to hedge against sharp declines in oil prices over a horizon of a few years at little or no net cost if the government agrees to forego part of IDA's disbursements when oil prices are high. For this to work in an automatic and countercyclical way, it would be important not to subject the program to additional conditionality, but to see the upward and downward revisions in disbursements as simply scaling the agreed program.

Section V concludes. The Bank is already offering a variety of financial services to its clients through Treasury operations, so has a stronger basis than most other donors for providing hedging services of the kind discussed in the paper. However, building consensus among donors and political constituencies takes time, as does the elaboration of new modalities of aid delivery. It is not too early to begin planning, a few years before substantial resource revenues begin to flow into the budgets of new producers.

II. Aid and Resource Rents in Uganda

Uganda offers a typical example of a low-income aid-dependent country that is in the process of transition to becoming an oil exporter. In 2011 total net ODA amounted to $1,582 million, or 9.4 percent of GDP (OECD/DAC). Of this, $585 million was provided by multilateral agencies and $997 million by bilateral donor programs. According to the government's annual budget performance report, about one-quarter of the total was provided in the form of direct budget support while another quarter consisted of project

[5] Claessens and Varangis 1994 estimate basis risk on the order of 30% for a number of Latin American crudes. While this is substantial and will prevent perfect hedging, they note that the use of hedging instruments can still reduce variability by up to 70%.

support included in the budget. The remainder, or about half, was off-budget support delivered through a wide range of institutions and modalities. IDA was one of the largest donors, disbursing US$231 million or about 15% of the total.

Oil discoveries made in the Lake Albert Rift Basin in Western Uganda since 2006 are estimated at over 1.3 billion barrels, with total basin potential of over 2 billion barrels. Sizeable capital gains taxes were levied in 2012; but debate on the future shape of the oil industry, in particular whether it should include a refinery in addition to an export pipeline, have slowed development. In the end, a comprehensive agreement was not reached until 2013, so that substantial oil revenues are only expected to accrue after around 2018. Peak production is estimated at about 210,000 barrels per day, a rate that could be reached by 2021 and sustained for 10-25 years on the basis of current reserve estimates. Based on reported fiscal terms and a long-term oil price of $96 per barrel (in 2012 US dollars), government revenue at peak production will reach over $4.1 billion per year in 2012 prices (Table 1). If the Ugandan economy continues to grow at its recent long-term trend of about 5 percent per annum, revenue would be equivalent to about 8 percent of non-oil GDP in 2018. Prospective initial oil revenues are therefore comparable to aid flows, or about seven times IDA flows, but with the important difference that they all would flow through the budget. Since domestic revenue collection languishes at an anemic 13 percent of GDP, this would increase domestic resource mobilization by more than half relative to current levels.

However, Uganda's prospective oil rents are very uncertain. This partly reflects market conditions. Through the last two price cycles oil exports per head in OPEC countries have ranged from around $200 (in constant 2000-year prices) to over $1,200. For many specialized producers, the difference between an oil export price of $50 and $150, starting from a baseline of $100, can be on the order of 50% of GDP. Even though the new exporters might not be as specialized, over these grand super-cycles resource taxes could range from almost zero to twice the level of baseline projections. In Uganda's case this would mean a fiscal range of uncertainty equivalent to almost 20% of GDP, or almost twice the level of ODA and far larger than the shock thresholds suggested as triggers for compensatory arrangements.[6]

[6] Griffiths-Jones and te Velde consider the appropriate level of shock threshold. They suggest a high of 3% of GDP and a low of 1% of GDP.

Table 1. Estimates of Oil Revenue for Uganda, 2015-34

	2018-22	2023-27	2028-32	2033-37
	(US$ million, annual average)			
Oil revenue	1,663	3,666	4,113	3,451
Royalty	501	675	675	562
Profit	865	2,441	2,798	2,314
Corporate Income tax	267	373	464	425
Dividend and interest	30	177	176	149
	(% of GDP, annual average)			
Oil revenue	5.1	7.2	6.2	4.0
Royalty	1.5	1.3	1.0	0.6
Profit	2.7	4.8	4.2	2.7
Corporate Income tax	0.8	0.7	0.7	0.5
Dividend and interest	0.1	0.3	0.3	0.2
Oil revenue				
% of average revenue in 2011-12	63.4	139.7	156.7	131.5
% of total ODA disbursement in 2011	105.1	231.7	260.0	218.1
Memo items				
Government revenue, FY 2011-12, (% GDP)	13.1			
Total ODA disbursement, 2011 (US$m)	1,582			
IDA disbursement, FY 2011-12 (US$m)	250.5			

Sources: IMF, OECD/DAC; Loan kiosk, and World Bank staff estimates.

Moreover, efforts to predict price trends have an unsatisfactory record. Major turning points have not been generally identified, whether in an upward or downward direction. Influenced perhaps by the 1972 study "Limits to Growth", analysts failed to anticipate the collapse in oil prices after their peak in 1981, when the consensus forecast was for a sustained rise at 3% in real terms. More recently there has been less of a tendency to extrapolate trends and more to project current price levels. This is consistent with the statistical evidence that the path of prices is close to a random walk, but is not particularly helpful for economic planning.[7] While shorter-term uncertainty, as estimated from the

7 Oil prices have very high long-term volatility and hard mineral prices are not far behind. Hamilton 2008 estimates the likely price band for oil prices up to four years into the future, assuming that the logarithm of prices follows a Gaussian random walk. Starting from an initial price of $115 per barrel, the 95% confidence range for the four year distribution was between $34 and $391. At the time, in the middle of the super-boom with prices

distribution of one-year futures prices, is less than that of the long-run price swings it is still very large. The standard deviation of a typical one-year futures price distribution is around 20% of the expected value and sometimes higher.[8]

Uganda's revenue is even more uncertain than suggested by these calculations, especially if oil taxes follow good practice and are designed to be progressive. Lack of clarity on policies and tax disputes have delayed the onset of commercial oil production and disagreements may recur in the future. The decision to build a refinery exposes the treasury to an additional risk -- political pressure to reduce domestic fuel prices that are currently very high because of the need to import fuel from the coast. Both options – pipeline and refinery— will require large upfront investments and servicing these will cut into the cost-price margin for oil and so reduce rents. The lower quality of Uganda's crude further squeezes the potential rent margin, and makes it more sensitive to market conditions than the margin for a low-cost high-quality crude producer like Saudi Arabia.

The boom-bust cycles induced by large price swings can be very damaging. A large body of evidence summarized in van der Ploeg 2011 and other studies suggests that a major part of the so-called "resource curse" can be attributed to the failure of producing governments to implement counter-cyclical policy in the face of large trade and revenue shocks. The effect of volatility is not independent of country characteristics such as the levels of export concentration, financial development and the quality of political institutions.[9] Improved capacity to manage shocks, a more robust financial sector, and efforts to encourage a more diversified economy are some of the ways in which resource-rich countries can work to minimize the curse. A few, like Chile, have succeeded in sustaining counter-cyclical policies using fiscal rules and transparent and independent projections of long-run resource prices to guide policy (de Gregorio and Labbe 2011), but even for these it has not been easy to resist the pressures to increase spending at times of high resource prices. Many countries have

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spiking up to $140, no one could have imagined prices at the low end of the scale, but they collapsed to that level shortly after the publication of the study with the onset of the global crisis. In addition, many of the new producers face high base production costs, further increasing the sensitivity of rent flows to market prices.

[8] The IMF commodities outlook for December 17, 2013, puts the expected price for Brent Light Oil at $105 with a 95% confidence interval of [60, 150], corresponding to a coefficient of variation of about 25%. ehttp://www.imf.org/external/np/res/commod/pdf/cpor/2013/cpor1213.pdf

[9] Van de Ploeg and Poelhekke 2010 show that adverse growth effects of natural resources results mainly from the volatility of commodity prices, especially for point-based resources. Indeed, the indirect effects of resource exports on growth via the volatility channel outweigh a direct positive effect of resource endowments on growth. Arezki, Hamilton and Kazimov 2011 find that overall government spending in resource-exporting countries has been pro-cyclical relative to commodity prices and that in the long run resource windfalls have negative effects on the growth of non-resource GDP. Both the effects of windfalls on macroeconomic stability and on growth are moderated by the quality of political institutions.

promulgated fiscal rules and set up stabilization funds in vain. Sustaining counter-cyclical policies and protecting reserves and Sovereign Wealth Funds from looting will not be possible without improvements in political institutions. The net effect, as shown by several studies, can be to turn a large export windfall into a substantial output loss. Large spending shocks have a similarly destructive impact on development programs. Quality and cost controls fly out the window as spending is rapidly ramped up; financing cuts force large adjustment costs in the downswing with capital projects left incomplete and recurrent budgets too low to operate and maintain investments.

Against the scale of this problem, what can be said of the record of aid in providing countercyclical support? A considerable literature suggests a varied picture but not a reassuring one. Private capital flows are invariably pro-cyclical (Perry 2011) and although low-income countries may be less integrated into world capital markets resource exporters will also feel the impact through surges and slowdowns in mining investment. A considerable literature finds that aid flows have tended to be mildly pro-cyclical, rather than cushioning, although the record is less clear for concessional assistance than for more market-based flows (Perry 2011). Donors may find it difficult to distinguish between the effect of policy and external shocks on performance. This should be less of a concern in the case of resource shocks, but project disbursements will also respond pro-cyclically if tied to the availability of counterpart funds. Data lags and bureaucratic inertia can also cause flows to become pro-cyclical even when they are intended to be cushioning. Few donors have instruments to link financing to shocks in an automatic way. Part of the story is of course lack of coordination, and this is complicated by the number of bilateral and multilateral players and the modalities through which aid is delivered. [10]

III. From Aid to Insurance

What might IDA do to help buffer Uganda's development? It cannot insure the country against revenue risk without risking moral hazard because oil output is substantially influenced by government policies. IDA also cannot easily compensate Uganda for changes

[10] Resource rents pose some difficult macroeconomic policy issues for donors. For example, how to respond to counter-cyclical fiscal policy that boosts reserves when resource prices are high? Is prudent management to be encouraged by continuing donor support which will enable even higher savings -- and the accumulation of a sovereign wealth fund that could be raided by a future, less-prudent, government? Or is it better to cut back assistance on the grounds that it is less needed and stand by to increase it again if resource prices plummet and revenue falls? The optimum blend of policies and support can be derived from formal modeling, for example, using a dynamic stochastic general equilibrium (DSGE) framework (Daugher et al 2010) or an inter-temporal optimizing model that permits public investment, recurrent spending, and transfers to the population (Arezki et al 2012) but such exercises leave a lot of unknowns on the table in actual applications.

in the price of its own oil exports since the type of oil it produces -- "waxy crude" is not widely traded on world markets. The best that can be done is to help offset changes in a major benchmark oil prices such as Brent or West Texas Intermediate. Uganda's exports will trade at a substantial and variable discount to either, but the country can still be insulated against large market swings.

A first approach could be to support the use of hedging instruments to transfer price risk away from Uganda. Exchange-traded approaches include futures-based hedges and options; over-the-counter instruments include forwards-based hedges, commodity swaps, commodity bonds or hybrids. Table 2 and Annex 1 provide more information. These products have a number of constraints and limitations, including in some cases limited term and liquidity, but, as noted in Perry 2011, markets for futures, forwards and options extend out several years in the case of oil.[11] Futures-based operations can mitigate wealth risk, but expose participants to large cash-flow risks from margin calls. For a country contracting to sell its oil ahead at a fixed price, these margin calls will be made when market prices rise. In contrast, forward-based hedges involve considerable credit risks, both to Uganda and its counterparties.

One attractive approach could be to support risk-reversal hedging (see Table 2), where the country gives up part of its upside oil price gain to fund the cost of purchasing a put option to hedge the possibility of very low prices. This option introduces flexibility through the different possible choices of the high and low price benchmarks. Even though the approach may not remove all risk a series of such risk-reversal hedges could be made for multiple dates in the future to obtain a more stable revenue stream.

[11] Table 5.1 in Perry 2011 shows that for oil, futures/forward contracts are traded for up to 3-5 years ahead and options up to 2-3 years. In contrast, few contracts for copper are available for longer than one year.

Table 2: Overview of Risk Management Instruments

Product	Benefits	Costs / Risks / Constraints
Forwards	The risk management solution is embedded in the physical supply contract and there is no need for a separate contract / documentation. Pricing of forward contracts can be customized to the needs of the hedger Depending on the pricing formula used, forwards will have same benefits as the financial products described below.	May be complex for government to implement if importers are privately held. Depending on the pricing formulas used, forwards will have same costs/risks/constraints as the financial products described below.
Futures	Provides ability to lock in forward prices through a financial contract. No upfront costs.	Prices are "locked in" and hedger has limited ability to take advantage of positive price movements that may occur in the future. Creates unknown and unpredictable future liability since hedger will owe the market counterparty if the market moves in an adverse direction. Requires financing of a credit line or a credit guarantee and managing cash flow /liquidity requirements to support (potential) daily margin calls.
Options	Provides ability to lock in maximum (minimum) prices while still providing hedger with ability to take advantage of positive price movements that may occur in the future.	Has an upfront cost, which is market-driven and volatile but can range from 5-12% of the underlying price for a 6-18 month coverage.
Risk Reversals	Limits price exposure to within a price band or "collar" that has both a ceiling and a floor. Upfront costs can be lower since hedger is simultaneously buying a call option and selling a put option.	Creates unknown and unpredictable future liability since hedger will owe the counterparty if the market moves below the price floor. Requires financing of a credit line or a credit guarantee. Requires managing cash flow /liquidity requirements to support (potential) daily margin calls.
Swaps	Provides ability to manage two commodity exposures, or financial flows, at the same time. No upfront costs.	Creates unknown and unpredictable future liability. Requires financing of a credit line or credit guarantee. Requires managing cash flow requirements to support (potential) daily margin calls.
Commodity-Linked Bonds or Loans	Could be used on more macro level to connect borrowing or financing programs to the performance of a specific commodity index.	Can be more complex to structure. May not be effective as a hedge for specific commercial exposures.

Source: Yépez-García and Dana 2012. Benefits and Costs/Risks/Constraints are discussed from the point of view of an importer using these instruments to manage against the risk of increasing prices.

IDA could play several roles in helping Uganda to set up such arrangements. First, it could act as a counterpart to absorb or reduce market and credit risk. IDA may be especially well placed to absorb country risk because of the deep and continuing relationships between the World Bank and its clients and also because of the preferred creditor status of the IFIs. Second, IDA could act as a credit enhancer, to help Uganda access over-the-counter instruments to hedge risk. While these instruments do not require margins, they are heavily constrained by credit risk. IDA (or the World Bank) could offer guarantees that would allow potential counterparts to reduce their collateral requirements. Third, IDA could provide grants or highly concessional credits to help finance the costs of purchasing options. Grants could help to defray the costs of margin calls when oil prices rise. The futures contracts might not be expected to cover all of Uganda's revenue risk, so that there would still be some positive fiscal impact from high prices. Part of IDA financing in this situation would then be shifted towards assisting the payment of margin calls on the hedged portion, while reducing its share of financing for development projects. Such support for hedging, with the objective of reducing country risk, would then go together with variable disbursements and offsetting changes in counterpart financing.

How large are the hedging services that IDA might offer to Uganda? This is difficult to estimate since the cost of hedging oil revenue depends on the instruments used, the prevailing market conditions, and the credit-worthiness of the oil producer. In general, the cost of using derivatives (such as options) to hedge price risk tends to be on the low end among the hedging instruments because derivative transactions usually allow high leverage, and thus derivatives are often the choice in hedging oil price. To take an example, Mexico's state-owned oil company, PEMEX, hedged 330 million barrels of oil in 2009 through the purchase of put options at a cost of US$1.5 billion. Using the Mexican experience as a basis, the cost for hedging oil revenue in Uganda during peak production would be about US$200-300 million per year, or 8-12% of the oil revenue, roughly equivalent to the current level of annual IDA disbursements.[12] This is only an illustrative estimate, and further analysis would be required for more accurate costing.

12The cost estimate can vary significantly depending on the hedging instruments and market conditions. This rough estimate assumes that Uganda would follow the same hedging strategy to access the risk market as Mexico did; the market conditions are similar to those for the last quarter of 2009; Uganda's oil price is 80% of the West Texas Intermediate price; the cost range is based on premiums for a 5% Out-of-the-Money and an At-the-Money Asian put option after a transaction cost adjustment of 10%, resulting in a cost of US$4.9-6.6/barrel; and government oil revenue during peak production is about 80% of the gross revenue. Given the preliminary nature of the estimate, the total cost is rounded to the nearest US$50m.

Another possibility would be for IDA to finance the equivalent of catastrophic risk insurance for Uganda against the possibility of a very large decline in benchmark oil prices. Precedents include the OECS-Catastrophe Insurance Project that funded the Caribbean Catastrophe Risk Insurance Facility (CCRIF) to benefit 16 small states against catastrophic weather-related damage. In addition to lowering the cost of self-insurance by pooling risks, reinsurance gave the CCRIF the capacity to pay claims associated with a series of catastrophes of such large magnitude that they were expected to occur only once in every 1,401 years without needing to draw on its own capital for more than US$25 million.[13] Other weather-related insurance projects include Malawi Drought Insurance (2008), the first climate-based insurance offered to an IDA client (re-insured by Swiss Re), and the Southeastern Europe and the Caucasus Catastrophe Risk Insurance Facility.

There is no legal hurdle to the use of IDA resources to buy a hedge against oil price volatility, although it would require the Board's approval. The Bank has been authorized since 1999 to offer commodity swaps to its clients, although no transactions have been concluded as yet.[14] There is also no conceptual difference between the use of IDA resources for payment of weather-related insurance premia and the purchase of a hedge against low resource prices and there may also be useful lessons, including the tradeoff between cost and coverage. It will of course be cheaper to hedge against extreme events with payout only for very large losses.

A second approach would be to hedge the IDA program itself, by making disbursements contingent on oil prices. Within the constraints of IDA envelopes and commitments, disbursements would change in a counter-cyclical way with respect to oil prices. The program could combine policy-based lending, project support and results-based loans, the latter two with variable co-financing. If the oil prices rise, government contributes more; if the prices fall, IDA contributes more. This approach could enable a more tailored approach than that possible through policy-based lending alone. It could help to insulate development programs from shifts in spending priorities that could accompany large swings in the availability of financial resources.

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[13] CCRIF was estimated to have the capacity to withstand an even more severe series of events with a modeled probability of occurring only once in every 10,000 years, although it would require recapitalization in order to continue operating thereafter. World Bank, Implementation Report No: ICR00002332, July 12, 2012.

[14] IDA 2006 notes the possibility of using IDA allocations to purchase market-based derivatives and insurance.

However, there is still the question of how to implement variable disbursement levels in the face of a given country IDA allocation.   One precedent, described in Perry 2011, is the Deferred Drawdown Option (DDO) that provides a credit line available to be drawn down in case of need. This would be very unattractive for an IDA borrower as it requires maintaining headroom in the country program in case the drawdown is needed, as well as financial reserves to provide the headroom. Given the realities of periodic IDA replenishments and the way of process of determining country envelopes, there is no secure way for Uganda to trade low commitments in one year for a larger program at some indefinite time in the future.[15] One way or another, approaches to enable disbursements to respond to oil price scenarios would therefore have to be implemented through a strategy to hedge the IDA program against oil price risks. This is modeled in the next section.

These are only preliminary ideas on the options for helping Uganda cushion large prospective oil revenue shocks. Many detailed questions will arise in the course of further development and implementation.. One concerns the appropriate balance between commitments and flexibility. Any operation to hedge, cushion or insure against future revenue shocks requires a high degree of automaticity to be credible and attractive to the country, as well as truly counter-cyclical. In some cases automaticity may be ensured by the up-front design of the instrument, for example, through the purchase of insurance along the lines of the weather-based projects. On the other hand, as a development institution the Bank would need to retain the ability to respond to changes in the quality of the country's policies and institutions if they occur. Reducing financing flows in years of high oil prices to purchase insurance or hedges that enable lending to expand in years of low prices implies a commitment to release these funds. What if governance has deteriorated substantially in the interim?   One of the advantages of hedging the program, rather than Uganda, is that it gives IDA more opportunity to respond in exactly the same way as it would have done normally, but with funding scaled up or down depending on oil prices.

A second question is whether it might be possible to pool IDA resources between resource-poor and resource-rich countries to help them diversify some of the risk due to volatile oil prices. While Uganda will benefit from high oil prices Malawi will suffer. Depending on the

[15] Uganda can frontload or backload commitments within a given 3 year allocation. While this offers some flexibility, it cannot trade off with certainty between years because the country allocation can be adjusted within the three year period.

emerging distribution of mineral production, it might be possible to embody some hedging of IDA flows in this way, reducing the need for country-level hedging arrangements.[16]

A third question involves the implications of periodic IDA replenishments. The three year term does give more predictability than for most bilateral programs that need to be authorized on an annual basis, but it still means that funds are assured, on average, for less than two years ahead. This confronts the problem that major swings in resource markets are not usually year-to-year but strong multi-year trends with sharp reversals. This may be less of a problem for projects with multi-year commitments, since the funds are already appropriated and hedging can be applied to each successive year of disbursement, but there is still the question of whether it might be possible to leverage WBG creditworthiness to extend the time range of hedging instruments.

IV. Hedging the IDA Program against Oil Price Risk

We now consider approaches towards hedging the IDA program to enable disbursements to vary in response to oil prices in the face of fixed commitment levels. We consider some examples and quantitative parameters for one approach. Annex 1 provides background information.

The first combination is a risk reversal hedge consisting of a put option and two call options. At the beginning of a fiscal year, a country program is agreed, with disbursements at the end of the fiscal year conditional on the implementation of agreed policies and actions by the government. IDA agrees to disburse the program amount if the average benchmark price of oil remains in a pre-agreed range, a larger amount if the price falls below it and less if it exceeds the range. Such an arrangement could be implemented with a put and a single call option, but it is also important to avoid the possibility that IDA could be exposed to unlimited negative cash flows if the oil price soars to very high levels. Some minimum level of disbursement might also be necessary to maintain continuous engagement, even if oil prices are very high. IDA can put a hard limit on the potential negative cash flows by purchasing a second, even more out-of-the-money call option.

[16] The approach might also be considered for some of the Monetary Unions in Africa, including the proposed EAC Monetary Union, that combine resource-rich and resource-poor countries and where a resource boom could trigger an appreciation of the current currency, so reducing the real value of aid to the resource-poor countries.

We derive a formula for an extended risk-reversal hedge consisting of a long put position, a short call position, and a long out-of-the-money call position (Box 1). The total cost of the option portfolio is zero assuming risk neutral contracts. Figure 1 shows disbursements relative to the program size for the price ranges separated by p, c1 and c2. Disbursements exceed the program for prices less than p, equal the program for prices in between p and c1 and decrease as prices increase further, reaching the minimum disbursement level when prices reach c2. The expected net payments, either to IDA or from IDA, will be given by the difference between the program and disbursements weighted by the probability distribution function for the futures price at expiration. Over the entire price range, the net expected payment is zero. Figure 1 also shows disbursements for a modified risk-reversal hedge, with a smoother graduation over the price range and a higher minimum disbursement constraint. This provides less escalated disbursements in the event of very low oil prices and thus a lower level of "catastrophic" insurance.

Box 1. Probability distribution for disbursements of a product based on an extended risk-reversal hedge

We derive a formula for an extended risk-reversal hedge consisting of a long put position, a short call position, and a long out-of-the-money call position. The total cost of the option portfolio is zero assuming risk neutral contracts. Let:

f - Futures price at expiration

f_0 - Current futures price

t - Time to expiration

σ - Volatility

p - Put strike price

c_1 - Call 1 strike price

c_2 - Call 2 strike price

b - Number of barrels hedged

P - Program size (the level of commitments)

D - Disbursement

d - Disbursement proportion ($d = D / P$)

$d_{\min}$ - Minimum disbursement proportion

H_X - Cumulative probability distribution of random variable X

h_X - Probability density of random variable X

N - Cumulative probability distribution of standard normal (Gaussian) random variable

We have four possible ranges for the futures price at expiration, where the following relations hold:

$$\begin{array}{llll} f \le p & \Rightarrow\ D = P + (p - f)b & \Leftrightarrow\ d = 1 + (p - f)b / P & \Leftrightarrow\ f = p + (1-d)(P/b) \\ p \le f \le c_1 & \Rightarrow\ D = P & \Leftrightarrow\ d = 1 & \\ c_1 \le f \le c_2 & \Rightarrow\ D = P - (f - c_1)b & \Leftrightarrow\ d = 1 + (c_1 - f)b / P & \Leftrightarrow\ f = c_1 + (1-d)(P/b) \\ c_2 \le f & \Rightarrow\ D = P - (c_2 - c_1)b & \Leftrightarrow\ d = 1 + (c_1 - c_2)b / P & \end{array} \tag{1}$$

Disbursement is minimal when the futures price exceeds the strike price of the OTM call option. It then follows from the last of equations (1) that the number of barrels hedged must be

$$b = \frac{P(1 - d_{\min})}{(c_2 - c_1)} \tag{2}$$

From (1) and (2) we get the following relations (the notation means the distribution of the price at expiration is conditional on the current price f_0 and of the volatility σ)

$$\begin{array}{ll} H_D(d \mid f_0, \sigma) = 1 - F_F(p + (1-d)(P/b) \mid f = f_0) & d > 1 \\ H_D(d \mid f_0, \sigma) = 1 - F_F(p \mid f = f_0) & d = 1 \\ H_D(d \mid f_0, \sigma) = 1 - F_F(c_1 + (1-d)(P/b) \mid f = f_0) & d_{\min} \le d < 1 \\ H_D(d \mid f_0, \sigma) = 0 & d < d_{\min} \end{array} \tag{3}$$

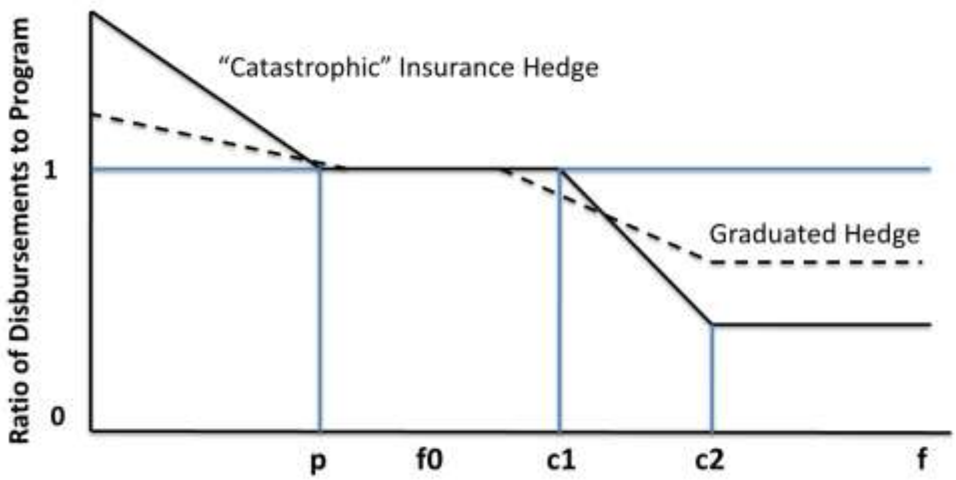
Using the risk-neutral probabilities, we know from Black-Scholes theory (see Nielsen 1992) that the probability $1 - H_F(X \mid S_0)$ that a call option with exercise price X and current price S_0 will be exercised is $N(d_2)$ where

$$d_2 = -\frac{\ln(X / S_0) + (\sigma^2 / 2t)}{\sigma\sqrt{t}} \tag{4}$$

From (3) and (4) we calculate the cumulative distribution function for disbursement percentages as follows:

$$\begin{array}{ll} H_D(d \mid f_0, \sigma) = 0 & d < d_{\min} \\ H_D(d \mid f_0, \sigma) = N\left(-\dfrac{\ln((c_1 + (1-d)(P/b))/f_0) + \sigma^2/2t}{\sigma\sqrt{t}}\right) & d_{\min} \le d < 1 \\ H_D(d \mid f_0, \sigma) = N\left(-\dfrac{\ln(p/f_0) + \sigma^2/2t}{\sigma\sqrt{t}}\right) & d = 1 \\ H_D(d \mid f_0, \sigma) = N\left(-\dfrac{\ln((p + (1-d)(P/b))/f_0) + \sigma^2/2t}{\sigma\sqrt{t}}\right) & d > 1 \end{array} \tag{5}$$

Figure 1. Disbursement relative to Program for Risk-Reversal Hedges



A second combination could be hedging with put options only. Uganda borrows a given amount X which is not immediately disbursed. Conditional on the implementation of certain prior actions and refraining from their reversal during the project period, IDA commits to disburse for the next Y years amounts equal to 0 if the average price of oil exports during a year does not fall below a certain level, and some positive amounts if it does, with these amounts being larger the lower is the average price of oil. To achieve its objective to help maintain macroeconomic stability, the program needs to cover a sufficiently long time period and a sufficiently large portion of oil revenues. This product could be financed through a string of puts (see Annex 1). The most important trade-off is that between the time horizon Y and the portion of the country's oil revenues it helps to hedge. The longer is the former the smaller will be the latter.

To estimate the probability distribution of disbursements we can start from the case when Y=1. Hedging with puts is not costless, and without a zero cost constraint the number of barrels hedged is arbitrary, as long as $pb \leq P$. We include premiums paid in total disbursements, although not all of this is received by Uganda. The mathematical formulation is in Box 2. Figure 2 provides a graphical representation, distinguishing disbursements received by Uganda from total disbursements; the difference is the cost of the put options.

Box 2. Probability distribution of disbursements for the product based on hedging with put options

To estimate the probability distribution of disbursements we can start from the case when Y=1. Hedging with puts is not costless, and without a zero cost constraint the number of barrels hedged is arbitrary, as long as $pb \le P$. We include premiums paid in disbursements. The minimum possible disbursement happens when the puts expire worthless, hence

$$d_{min} = 1$$

There are only two cases to be considered, depending on whether the puts expire worthless or not.

$$\begin{aligned} f \le p \quad &\Rightarrow \quad D = P + (p - f)b \quad \Leftrightarrow \quad d = 1 + (p - f)b / P \quad \Leftrightarrow \quad f = p + (1 - d)P / b \\ p \le f \quad &\Rightarrow \quad D = P \qquad\qquad\qquad \Leftrightarrow \quad d = 1 \end{aligned} \tag{6}$$

The following relations then hold:

$$\begin{aligned} &H_D(d \mid f_0, \sigma) = 0 && d < 1 \\ &H_D(d \mid f_0, \sigma) = 1 - F_F(p \mid f_0, \sigma) && d = 1 \\ &H_D(d \mid f_0, \sigma) = 1 - F_F(p + (1 - d)P / b \mid f_0, \sigma) && d > 1 \end{aligned} \tag{7}$$

Using (7) we obtain the cumulative distribution function of the disbursement proportion:

$$\begin{aligned} &H_D(d \mid f_0, \sigma) = 0 && d < 1 \\ &H_D(d \mid f_0, \sigma) = N(-\frac{\ln(p / f_0) + (\sigma^2 / 2t)}{\sigma\sqrt{t}}) && d = 1 \\ &H_D(d \mid f_0, \sigma) = N(-\frac{\ln((p + (1 - d)(P / b) / f_0) + \sigma^2 / 2t}{\sigma\sqrt{t}}) && d > 1 \end{aligned} \tag{8}$$

The formulas expressing the probability of the disbursement proportion reaching a given level in the single period case are not simple, and in the multi-period case they become highly complex. Since no calls are sold, the disbursement proportion will always be greater or equal then one. As in the one-period case the number of barrels hedged is arbitrary up to a maximum. Let us consider first the two-period case. We make a few simplifying assumptions. The same number $b/2$ of barrels of oil is hedged in each period with puts having the same strike price p . The total premium paid for the puts is pb. We assume the premium is paid in two installments, one in each period. Of the remaining cash, $P - pb$, half is disbursed in each period, plus the profits from that period's long put position. These assumptions have no substantive effects but simplify the analysis considerably. In each period the following two alternatives are possible.

$$\begin{aligned} f \le p \quad &\Rightarrow \quad D_i = P / 2 + (p - f)b / 2 \quad \Leftrightarrow \quad f = p + (1 - 2d_i)(P / b) \\ p \le f \quad &\Rightarrow \quad D_i = P / 2 \quad \Leftrightarrow \quad d_i = 1/2 \end{aligned} \tag{9}$$

The cumulative probability functions of disbursement proportions in the two periods can then be expressed as follows:

$$\begin{aligned} &H_{D_i}(d_i \mid f_{i-1}, \sigma_{i-1}) = 0 && d_i < 1/2 \\ &H_{D_i}(d_i \mid f_{i-1}, \sigma_{i-1}) = N(-\frac{\ln(p / f_{i-1}) + (\sigma_{i-1}{}^2 / 2t)}{\sigma_{i-1}\sqrt{t}}) && d_i = 1/2 \\ &H_{D_i}(d_i \mid f_{i-1}, \sigma_{i-1}) = N(-\frac{\ln((p + (1 - d_i)(P / b) / f_{i-1}) + \sigma_{i-1}{}^2 / 2t}{\sigma_{i-1}\sqrt{t}}) && d_i > 1/2 \end{aligned} \tag{10}$$

Here σ_0 and σ_1 are the current and future volatilities (assumed known with certainty). A total disbursement level $d = d_1 + d_2$ can be achieved in infinitely many ways. The probability density of total disbursement level d is

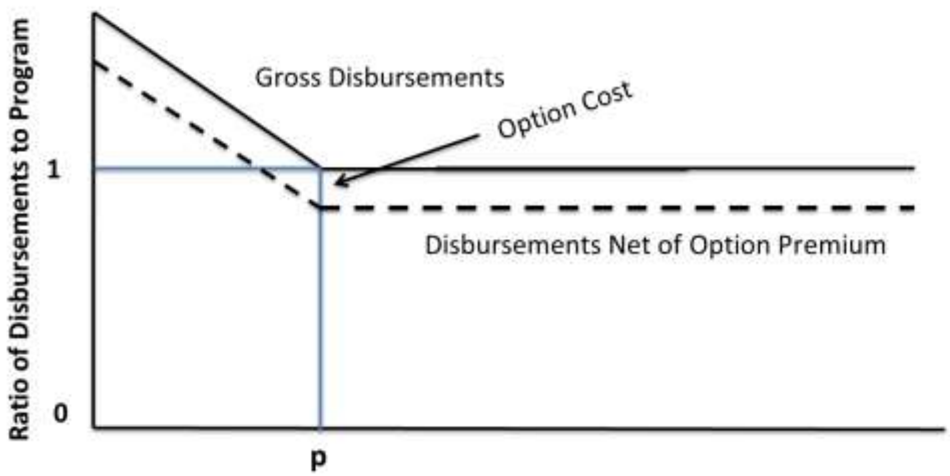
$$\begin{aligned} &h(d) = 0 && d < 1 \\ &h(d) = \int_0^d h_D(x \mid f_0, \sigma_0) h_D(d - x \mid f(x), \sigma_1)\, dx && d \ge 1 \end{aligned} \tag{11}$$

Notice that in (11) the probability density of period two disbursement level $d - x$ is conditional on the futures levels set $f(x)$ consistent with disbursement level x in period one.

There is no analytical formula that represents the relation in equations (11), so numerical integration would be required to compute the cumulative probability function of total disbursement, which is given by:

$$H(d) = \int_1^d \int_0^y h_D(y \mid f_0, \sigma_0) h_D(y - x \mid x, \sigma_1)\, dx \tag{12}$$

Figure 2. Disbursement relative to Program for Put Option Only



To estimate the potential of these approaches we now consider some numerical simulations for disbursements under the risk reversals combination, involving one put and two calls. The probability distribution underlying Table 3 is based on a typical one-year futures price distribution with a standard deviation of 20%. The futures price distribution will not necessarily be stable across longer time periods (Krichene 2008) but this is a reasonable approximation for most periods. Table 3 shows disbursements relative to program commitments for a range of scenarios. The futures price at the time of the contract is the level in November 2013, $105.95. Put exercise prices (the price below which disbursements start to increase above program) range between $80 and $100 and call 1 exercise prices (the price above which disbursements start to fall below program) between $110 and $130. The table also controls for minimum disbursement levels that range between 20% and 60% of the program. The lower is the put exercise price, the more the arrangement approaches "catastrophic" insurance against a collapse in the oil market. The lower are either of the call 1 exercise price or the minimum percentage disbursement, the more ready is Uganda to forego IDA disbursements in the event of high oil prices.[17]

[17] The Call 2 exercise price is not independent, being defined endogenously by the model.

Table 3. Disbursements under the risk reversal instrument (Ratio of disbursement to program)

Futures price: USD 105.95

Put exercise price		80			90			100		
Call 1 exercise price		110	120	130	110	120	130	110	120	130
135	0.6	0.6	0.6	0.675	0.6	0.6	0.997	0.624	1	1
	0.4	0.4	0.4	0.513	0.4	0.4	0.996	0.437	1	1
	0.2	0.2	0.2	0.351	0.2	0.2	0.994	0.249	1	1
105	0.6	1	1	1	1	1	1	1	1	1
	0.4	1	1	1	1	1	1	1	1	1
	0.2	1	1	1	1	1	1	1	1	1
75	0.6	2.116	1.649	1.325	1.87	1.421	1.009	1.376	1	1
	0.4	2.674	1.973	1.487	2.306	1.632	1.013	1.563	1	1
	0.2	3.232	2.298	1.649	2.741	1.843	1.018	1.751	1	1
Expiration price	Minimum disbursement									

Consider first the case of "catastrophic" insurance, where the program is designed to compensate only for very low levels of oil prices below $80. If Uganda is willing to forego a substantial proportion of the aid program when oil prices begin to exceed $110 it can greatly scale up disbursements when prices are low. If prepared to see disbursements sharply reduced to 20% of their program levels in the event of high oil prices it can more than triple disbursements in the event that the realized price is $75, which is about 1.5 standard deviations below the current futures price. Even with a minimum disbursement of 60% of the program, a realized price of $75 would result in disbursements more than double the level of commitments. Given the size of the IDA program relative to Uganda's total oil exports this would not be enough to fully compensate for the decline in exports but it would be quite substantial relative to the loss of fiscal revenue.[18] This "catastrophic" design would not of course insulate against the effects of smaller shortfalls in the export price.[19]

[18] To provide illustrative numbers, assume an IDA program of about 15% of the base level of oil exports and oil tax revenue about 50% of export revenue. The additional IDA disbursements are then equivalent to about 30% of the base level of revenues, comparable to the loss of 29% of oil tax revenue due to the shortfall of the price ($75) below the futures price of $105.9.

[19] There is also the question of how to factor in the risk that IDA's counterparty defaults, leaving IDA unable to deliver on its disbursement contract. One option would be for Uganda to absorb this risk, since the hedging operation is undertaken on its behalf, but this could make the approach less attractive to the country than support for its own hedging strategy.

If the put threshold is raised to $90, disbursements can still reach twice the level of commitments. But this will require both a lower call 1 exercise price (disbursements will begin to taper off at a lower price level) and accepting a lower minimum program in the event that oil prices turn out to be high. Further raising the threshold to $100, only slightly below the initial futures price of $105.95, further constrains the options, and limits the amount of insurance possible in a very low price scenario.

V. Conclusion

The emergence of low-income countries as resource exporters poses a number of challenges for donors. Depending on the size of prospective resource revenues they will need to shift away from their traditional role as funders towards more complex partnerships that address three types of problems. First, programs will be successful if they help countries increase accountability for the use of their resource revenues and improve the quality of spending. This could involve efforts to leverage projects with domestic resources, more emphasis on technical assistance, and more efforts to develop and encourage the use of global norms and standards. Second, donors may face some hard choices over whether to continue to support "priority" sectors if fiscal spending allocations suggest that these are not seen as priorities by the recipient country's government. The third issue, and the topic of this paper, is the need to make aid more counter-cyclical, to help offset some of the increased risk that accompanies a transition to a resource-dependent country.

The paper has set out a number of possible approaches and some financial instruments that could be used to hedge the aid program. They will be less needed of course, in cases where the country is able to pursue counter-cyclical policy itself along the lines of Chile, saving abroad during the booms and dis-saving during the busts. However, comparative research shows that this will be a challenge for many low-income countries, particularly those with weaker institutions that are more likely to remain aid recipients after they discover resources (though some of course might graduate), especially those specialized in a commodity like oil with well-developed futures markets. IDA could be used to assist the country to insure itself using market-based mechanisms. It is also possible to insure the development program itself against large swings in counterpart funding and, while this will involve more complex disbursement arrangements, it may be preferred in cases where there are serious reservations about providing budget support. Either way, simulations suggest that even if an IDA program is modest relative to oil revenues it can be leveraged to provide a considerable level of insurance against year-to-year fluctuations, especially if the country is willing to restrict coverage to "catastrophic" market declines and to give up a substantial part of the aid program when prices are high. Implementing such arrangements would require novel arrangements, both to hedge IDA commitments to enable disbursements to vary in response to oil markets and to design loan agreements with contingent levels of financing. But there appear to be no specific legal barriers in the way and indeed, the principle of such operations has been endorsed by IDA. Some of the approaches can draw on precedent operations that provide for insurance against natural disasters.

There are of course limits to the types of insurance that can be provided through an aid program. Even for an oil exporter it would be impossible to hedge the long swings in oil prices that have tend to occur around every twenty years or so. Self-insurance through the accumulation of large balances in a Sovereign Wealth Fund, combined with determined efforts to diversify the economy, is probably the only way to approach this problem. But not all countries have the institutional conditions to succeed and for many the risk is high that the fund will be raided, and so transfer resources from a more towards a less responsible government.

This paper is only a first effort. More detailed assessments would be needed to move these possibilities towards actual operations.

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Annex 1

Hedging with Futures, Options, and Risk Reversals

This annex presents basic information and a simple formal analysis of the hedging instruments referred to in the paper.

Hedging with Futures

A futures contract is an exchange-traded binding obligation on two counterparts (traders). The "long" side agrees to purchase from the "short" side[20] a certain amount b (e.g., 1000 barrels) of the underlying commodity (e.g., West Texas oil) at the current *futures price* on a future date (the *expiration date*). The futures price is determined by supply and demand at the exchange. The contract's *notional value* is the product of the futures price and the amount of the underlying commodity corresponding to one contract.

At inception a futures contract has no intrinsic value, which would suggest that no initial cash flows are required from either counterpart. Not only this is not true, but in addition a futures position held to maturity may generate positive or negative cash flows on a daily basis. In order to manage their credit exposure, exchanges require that the counterparts to futures transactions post margin. For this purpose a participant is required to open a margin account, separate from its account at the brokerage that executes the trades on its behalf. At trade inception *initial margin* must be posted; typical values are between 2 and 10 percent of the notional value of the futures contract. If the market moves in such a way that the trade becomes profitable the exchange adds cash to the trader's margin account; if the trade has potential losses the opposite occurs: cash is removed from the margin account. There is also a minimum *maintenance margin*, slightly lower than the initial margin, which is recalculated on a daily basis. If cash in the margin account falls below the maintenance margin the trader faces a *margin call*. It is contacted by the exchange and required to add cash to the margin account. If the trader does not comply its positions are liquidated by the exchange. Both types of margin are calculated on a per-contract basis but the exchange may alter requirements depending on market conditions (e.g., periods of very high volatility) and on the value of the underlying contract. Brokers may require margins above those required by

[20] When entering futures transactions one is not "buying" or "selling" futures contracts, but rather entering a contract to buy or sell the underlying commodity. In market parlance the expressions "going long" and "going short" are used to indicate entering positions with a positive or negative exposure to the futures price.

the exchange. We assume that cash on the margin account earns interest at the prevailing risk-free rate.

One-period analysis

In order to clarify the issues we simplify radically the analysis, assuming there is only one period. Time 0 is the beginning and time 1 is the end. All of the country's oil is extracted during the period and sold at time 1. Hedging is undertaken at time 0 and delivery happens at time 1. It is shown below that in this simple framework hedging with futures is fully effective in removing both wealth and cash flow uncertainty.

The price of oil is $p_t, t = 0,1$, the (per period) interest rate is r and the futures price is $f_t, t = 0,1$. We assume that a standard no-arbitrage condition between interest rates, the oil price and futures prices holds:

$$f_0 = p_0(1+r) \tag{13}$$

The values of all variables in equation (13) are known at time 0. It simply states that the oil futures price equals the oil spot price plus interest[21]. The *rationale* for equation (13) is that there are two alternate paths for making a bet (on the long side) on the spot oil price at the futures contract expiration date: a) borrowing sufficient funds to purchase b barrels of oil today and storing the oil until the futures expiration date, and b) going long a futures contract. Alternatives a) and b) should be equivalent from the financial point of view.

A trader who posts margin m when going long a futures contract and holds the position until expiration receives $b(f_1 - f_0) + m(1+r)$ at the futures expiration date. The profit on the trade is therefore $b(f_1 - f_0) + mr$. Considering the high volatility of the oil price the interest earnings can be rounded off and trade profits can be approximated by the difference between the oil price at expiration and at trade inception $b(f_1 - f_0)$. Similarly, the profit for a trader with a short position held to maturity would be $b(f_0 - f)_1 + mr_0 \approx b(f_0 - f_1)$.

[21] In the oil futures market this relation can be violated due to storage costs and other market imperfections. If the futures price is higher (lower) than the no-arbitrage value the market is said to be in *contango* (*backwardation*). Oil futures fluctuate between contango and backwardation, but are on average backwardated. The front contract is more often than not the most expensive one.

We assume that oil output, measured in barrels of oil, at time 1, q_1 is known but the spot and futures prices of oil, which are equalized at that point in time $(p_1 = f_1)$ are uncertain. The country's oil revenue $R_1 = p_1 q$ is therefore also uncertain. By hedging itself with futures the government could completely eliminate all uncertainty about its revenue (net of hedging gains and losses) at time 1. If at time 0 the country would short $n_0 = q_1 / b$ futures contracts and post initial margin (a negative revenue) $c = mn_0$ then at expiration its total revenues would be

$$R_1 = p_1 q + n_0 b(f_0 - f_1) + mn_0(1+r) = f_0 q + mn_0(1+r) \tag{14}$$

Equation (14) shows that the country's revenue at time 1 could be decomposed into three parts: a) oil production valued at the futures price $f_0 q$, b) the initial margin mn_0, and c) margin interest $mn_0 r$. All of these three components are known with certainty at time 0. Hedge profits or losses due to oil price variations perfectly offset variations on the revenues from oil during the period. Also, there are no margin-related issues since the whole position is liquidated at the end of the period. In this one-period framework all wealth and cash flow risk is eliminated.

Multiple trading periods

The one-period analysis would only be applicable if the exchange did not recalculate the required margin until the expiration date. In practice margins are recalculated on a daily basis. This raises the possibility of cash flow uncertainty as the country could face margin calls or receive excess cash into its margin account. Below we show that although the country should be able to effectively hedge its oil wealth using futures margin variation may generate significant cash flows in intermediate trading dates.

To better understand the issues, consider the case in which there are two periods, the futures expiration date is at the end of period 2 but there is trading and margin requirements recalculation at times 0 and 1. Assume, for simplicity, that the interest rate r is fixed and known for both periods[22]. In this framework equation (13) becomes

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[22] Alternatively we could work with the weaker assumption that the second period interest rate is known at time zero. The magnitude of the effect of uncertainty about interest rates on futures prices is small for a volatile

$$f_0 = p_0(1+r)^2 \tag{15}$$

Also, assume that the per-period oil output rate q is constant, all of the country's oil will be extracted during the two periods, and the amounts available will be sold and delivered at the end of each period. At time 0 the total production for the two periods is hedged, so the country goes short a total of $n_0 = 2q/b$ futures contracts. Define the country's oil wealth at time t W_t as the sum of oil stored plus oil on the ground, both valued at the spot oil price, plus the value of the margin account (which includes profits and losses on hedges). It will be seen that hedging can virtually eliminate all uncertainty about W_1 and W_2. On the other hand, even with one single intermediate trading date between inception and expiration the country could have a negative total cash flow in a scenario of extremely large first-period oil price increases. That is, a margin call could be so large as to exceed all of the country's revenue from oil deliveries in the first period. Still, futures hedging would virtually eliminate wealth uncertainty, so any margin calls should be taken as "money in the bank" that will be recovered later under all scenarios.

Oil related wealth at time 1 can be decomposed as the sum of the value of oil already extracted and sold $p_1 q$, the present value of future oil production $f_1 q/(1+r)$ and cash c_1 on the margin account, which can be further decomposed into hedge earnings from futures price variation $n_0 b(f_0 - f_1)$ and initial margin including accrued interest $mn_0(1+r)$. Since, in analogy with equation (13),

$$f_1 = p_1(1+r) \tag{16}$$

we can write

$$c_1 = n_0 b(f_0 - f_1) + mn_0(1+r) \tag{17}$$

$$W_1 = 2p_1 q + c_1 \tag{18}$$

underlying commodity like oil whose price does not directly depend on interest rates. Of course for futures on fixed income instruments or derivatives the uncertainty about future interest rates is fundamental for price determination and cannot be overlooked.

Using (15), oil wealth at time 1 reduces to

$$W_1 = 2p_1q + 2(p_0(1+r) - p_1)q(1+r) + mn_0(1+r) = 2p_0q + 2(p_0 - p_1)qr + mn_0(1+r) \quad (19)$$

Of the three terms in the right-hand side of (19) only the middle one is not known with certainty at time 0. This is due to the presence of the spot oil price at time 1[23].

At time 1 the country sells its first-period oil output at the spot price and liquidates half of its futures position. The resulting cash flow is exactly one half of its oil wealth, as given by (19). Accordingly, this portion of the country's cash flow at time 1 (as well as the remaining oil wealth) shares the aggregate oil wealth low uncertainty level. However, the margin on the country's remaining futures position has changed, which requires additional cash flows. Indeed, after the country liquidates half of its futures positions, from (13), (16) and (18), the remaining cash in the margin account is

$$c_1' = c_1 - \frac{W_1}{2} = (p_0 - p_1)q(1+r) + \frac{mn_0(1+r)}{2} \quad (20)$$

This balance is highly uncertain as its volatility (standard deviation) equals the volatility of the full hedge of one period's oil output[24]. In particular, if the margin account balance c_1' falls below the maintenance margin the country will be required to post additional margin. We assume that regardless of the profitability of the futures trade the country will keep as

[23] This term represents a small gain or loss stemming from the path taken by the oil price between times 0 and 2. If the oil price drops in period 1 then the country will have excess margin at time 1 and earns interest on that margin during period 2. Conversely, if the price goes up in period 1 the country has to satisfy margin calls and gives up the interest the cash used for that purpose would earn in period 2, since that cash is transferred to the counterpart via the exchange. However, this term is of second order of magnitude. If the spot price remained steady this term would be exactly zero. Even if the spot price had a very large move, say, 50%, and the trading period was very long, say, one year, at current interest rates (say 2% *per* annum) this term would represent only 1% of the total notional amount of the hedge. Higher interest rate levels would not change this picture significantly.

[24] The reader may puzzle over our apparently conflicting statements about the uncertainty of the country's oil wealth and margin account, since both depend on the variation of spot prices between times 0 and 1. The reason for the asymmetry is that for the country's oil wealth the spot price variation is multiplied by a small number (the interest rate for the period) while for the margin account the spot price variation is multiplied by one plus the interest rate, a much larger number.

little cash as possible in the margin account, and therefore bring back the margin to the initial margin level[25] mn_0. The resulting cash flow is then

$$(p_0 - p_1)q(1+r) + mn_0 r \tag{21}$$

Letting g_t stand for total cash flow at time t, we then have that the country's total cash flow at time 1, from selling oil, liquidating half of its futures positions, and bringing back margin account cash to the initial margin level is, from (19) and (21),

$$g_1 = \frac{W_1}{2} + (p_0 - p_1)q(1+r) + mn_0 r = p_0 q + (p_0 - p_1)q(1+2r) + \frac{mn_0(1+r)}{2} \tag{22}$$

Looking at the right-hand side of (22) one sees that the cash flow at time 1 is highly volatile. It is easy to check that if the price of oil doubles $(p_1 = 2p_0)$ total cash flow becomes almost zero. Even larger oil price increases would lead to negative cash flows.

Moving on to period 2, we see that a one-period framework is now applicable: the country is short $n_0/2$ futures contracts at the price f_0 and has posted margin $mn_0/2$. The country's wealth and revenues are therefore effectively hedged during period 2.

We can consider three alternative scenarios for cash flow:

Scenario 1: The oil price stays constant or fluctuates very little between times 0 and 1 – In this scenario the second tem on the right-hand side of (22) is small. If the price goes up between times 0 and 1 any margin calls will be small and will be easily met if the country has some cash reserves held for this purpose. If the price goes down only a small amount of excess cash will be available to be withdrawn from the broker's account. Total cash flow, to a first approximation, equals the product of oil output and the spot price at time 0.

Scenario 2: The oil price goes up sharply. – Since the country has a short hedge position it has large losses on the hedge (the second term on the right-hand side of (22) is negative and large in absolute value) and faces similar margin calls. Unless the country has substantial cash reserves set aside for the purpose of meeting margin calls its futures positions will be

[25] Strictly speaking the country could keep the margin at or above the maintenance margin. Since the initial and maintenance margins are only slightly different our assumption simplifies the notation and does not have a substantive impact on the analysis.

liquidated by the exchange (or the broker). It is important to notice that the country's wealth does not decrease in this scenario. The cash spent in margin calls is matched by gains in the value of the remaining oil output and the negative cash flow at time 1 is offset by a correspondingly larger cash flow at time 2. The additional cash flow at time 2 will obtain even if the oil price reverts to its initial level p_0 or even falls below that level. This is because the country is (almost) perfectly hedged during period 2.

<u>Scenario 3: The oil price goes down sharply.</u> – The country accumulates large profits in its margin and brokerage accounts (the second tem on the right-hand side of (22) is positive and large). Again, the country does not become wealthier in this scenario since the excess margin will be used to offset the drop in cash flow at period 2.

Hedging With Options

An option is a contract between two counterparts in which one counterpart has the right (but not the obligation) to buy (or sell) a predetermined amount of a certain commodity (the *underlying*) at a certain price (the *strike price*) at a future date[26] (the *expiration date*) while the other counterpart has the obligation to sell (or buy) the commodity if required. The counterparty that has the right is said to be "long" the option and the other counterpart, which has the conditional obligation is "short"[27] the option, regardless of whether the option is a right to buy or sell. Options that give the right to purchase a commodity are commonly called *calls*, and options that give the right to sell a commodity are called *puts*. Thus, there are four possible combinations: a trader can be long a call, short a call, long a put, or short a put.

If the underlying price is currently equal to the strike price the option is said to be *at-the-money*. For a call, if the underlying price is above (below) the strike price, the option is said to be *in-the-money* (*out-of-the-money*). For a put, if the underlying price is above (below) the strike price, the option is said to be *out-of-the-money* (*in-the-money*). The *intrinsic value* of an option is its value in case it is immediately exercised. Thus, the intrinsic value of a call is the difference between the underlying price and the strike price and the intrinsic value of a put is minus that quantity. Out-of-the money options have zero intrinsic value. An option should only be

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[26] Options that can only be exercised at the expiration date are called "European" while "American" options can be exercised at any date on or before the expiration date. In most cases exercising an American option before the expiration date is irrational from the financial point of view. Here we consider only European options.

[27] For options (but not for futures) "to write" means "to short". For example, the expressions "writing a call" and "shorting a call" have the same meaning.

exercised if it has positive intrinsic value at the expiration date, that is, if it is in-the-money[28]. The *time value* of an option is the difference between its premium and its intrinsic value. Options that are very much out-of-the money and are close to expiration have small time value as they are unlikely to be exercised. Since their intrinsic value is zero these options are almost worthless. From put-call parity (see below), this implies the value of very much in-the-money options will be close to the underlying price. The losses on long put or call option positions are bounded by the option premium: the worst-case scenario is the option is not exercised and expires worthless. The losses on short put positions are also bounded since the underlying price cannot fall below zero. Losses on short call positions are potentially unbounded.

Options-based hedging strategies have one significant disadvantage when compared to futures-based strategies: lack of availability or liquidity of long-dated contracts. The popular perception that options strategies are costlier than futures strategies is not supported by finance theory: the initial outlays should be, on average, eventually recovered and the expected value[29] of both futures and options trades is zero. On the other hand, options-based strategies have several advantages over futures-based strategies. The country has much greater flexibility in shaping its hedging program. Trade-offs involving initial outlays (the net amount spent on premiums), maximum downside and upside, and exposure to margin calls become available to be exploited. A cash-rich country could purchase a string of at-the-money puts on different expiration dates, never face any margin calls and keep a huge upside. A country that faces initial cash constraints could go short risk reversals (see below) and thus accept some limited upside and downside risk and some exposure to margin calls. By varying the out-of-the-moneyness of puts and calls the country could shape its downside and upside (wealth) risk exposures as well as its cash flow uncertainty.

Only the counterpart that is long the option is exposed to credit risk, so there is no reason it should post collateral (margin). This characteristic sharply distinguishes long option positions, regardless of whether the option is a call or a put, from futures positions: a long position held to maturity only generates cash flows at the trade and expiration dates. Also, from the point of view of the option buyer, credit risk on long exchange-traded options positions (that is, the risk that the exchange might not honor the trade if the option is exercised) is usually disregarded. On the other hand, the counterpart that is short the option

[28] We are abstracting from dividends, storage cost and other complicating issues.

[29] Using the risk-free probability distribution.

is usually (and certainly if the option is traded at an exchange) required to post collateral (margin) in a similar fashion to a futures trader.

Put-call parity (Put – Call = Forward) is a simple formula relating options to forward contracts, which are, from the abstract finance point of view, approximately equivalent to futures. Thus, for example, a long call position can be synthesized by going long futures and buying a put and a long futures position can be replicated by purchasing a call and selling a put. Thus, put-call parity implies that anything that can be accomplished with futures can also be accomplished with options. An arbitrage argument justifies the put-call parity relation. One can lock the purchase price p of a commodity on a future date T in two alternative ways: a) enter a forward contract with price p expiring at T, and b) purchasing a call and writing a put both with strike price p expiring at T. Both strategies should have the same cost, which will be zero if p equals the market forward price at trade inception.

The Black-Scholes formula, valid under ideal conditions, is a relation between the underlying price, its volatility, the strike price, the time to maturity, the interest rate, and the option premium of a put or call option. Given knowledge of the values of five of these six variables the formula can be used to calculate the value of the remaining variable. The Black-Scholes formula is widely used by options traders, most frequently to calculate the *implied volatility* of the option, which is the volatility level that is compatible with the current values of the other variables that enter the formula.

The *option premium* is the amount paid for the option. Unlike margin deposits which are just a transfer of an asset (cash) between accounts (from a bank account to a margin account) the option premium is usually considered a real cost that will not be recovered regardless of the time path of the option premium. While entering a futures contract is costless, the associated bet also has zero expected value. One has to pay the option premium to obtain options exposure but the expected value of that exposure should be equal to the premium paid. In this sense, the options trade, as a whole, also has zero expected value.

One-period analysis

In order to better understand hedging with options, we first look at a one-period framework. For long option positions this is actually all that is needed since cash flows only take place at the trade and expiration dates. Time 0 is the beginning and time 1 is the end. All of the country's oil will be extracted during the period and sold at time 1. Hedging is undertaken at time 0 and delivery takes place at time 1. A plain-vanilla strategy is one in which only one of the four types of options positions is entered, with a single strike price.

The country can hedge itself using in-the-money, at-the-money, or out-of-the money options. The most important risk for the country is a drop in oil price. The country can hedge this risk either by purchasing puts or selling calls on oil. Selling calls is not desirable or feasible in practice for several reasons. First, the country would have to post margin and be subject to margin calls. Further, its gains from hedging would be bounded by the option premium. If the oil price drops sharply the hedge revenues would be insufficient to compensate the country for the losses. Accordingly, we restrict our analysis to put-based hedges. Put-call parity implies that in-the-money puts are approximated by short futures positions, which were already analyzed. We therefore restrict the analysis to at-the-money and in-the-money options.

Let π_t be the option premium at time t. At time 0 the country purchases puts to hedge its oil production q, at a cost of $v_t = \pi_0 q$. At time 1 the country's revenue will be

$$R_1 = p_1 q + \max(s - p_1, 0)q = \max(p_1, s)q \qquad (23)$$

Here s is the option strike price. The left-hand side of equation (23) shows the revenues from selling the oil on the spot market and also selling the option at (or just before) expiration for its intrinsic value. The right-hand side shows that the same revenues can be obtained by choosing one of two alternatives: if the oil price is above the strike price at time 1 the country lets the option expire and sells its oil on the spot market, otherwise it exercises the option and deliver the oil to the option counterpart.

From equation (23), the country's revenues at time 1 are uncertain but bounded from below by the product of the strike price and the period's oil output. Uncertainty is therefore reduced. If the hedging instrument was at-the-money at time 0 the country is guaranteed to sell its oil output at a price at least equal to the spot price p_0. The country would only have "an upside." If the acquired puts were out-of-the-money at the trade date the country keeps the upside (if oil prices go up) and has limited downside if the oil price goes down. In either case there is an asymmetry that is valuable from the country's point of view. The price paid for this valuable asymmetry is the option premium.

Risk reversals

The cost of the acquired puts could be reduced by giving up some of the potential upside from high oil price scenarios. In order to better understand how such a strategy would work we introduce the concept of *risk reversals*.

Put-call parity shows that a long futures position is approximately equivalent to an options portfolio composed by a long call position and a short put position. The options should have the same strike price (not necessarily equal to the futures or the spot price) and also should have the same expiration date as the futures contract. If both options are at-the-money (and therefore borderline out-of-the-money) such an options portfolio is a specific example of a *risk reversal*, which is an options portfolio combining a long out-of-the-money call position and a short out-of-the-money put position. The futures hedges discussed in Section 0 are therefore approximately equivalent to short risk reversal positions in which both options positions are exactly at-the-money.

Futures positions have zero value at inception and the same should be true of risk reversals that replicate futures positions. If the strike prices of the put and call options in a risk reversal are equidistant from the current price[30] of the underlying then the risk reversion should also have approximately zero net cost. For the short risk reversal position established by a commodity hedger this means the revenue from selling calls would be approximately equal to the expenditure on puts[31]. Although options traders frequently restrict themselves to (approximately) zero cost risk reversals there is no reason an oil producing country seeking to hedge its oil revenues should follow this practice. Nevertheless it is a useful case to illustrate the tradeoffs that a country would need to make in order to self-insure against losses from a sharp decrease in oil prices.

[30] Some definitions of risk reversals require this equidistance condition, which is satisfied in the borderline case in which both options are at-the-money. In practice it is almost impossible to establish risk reversals under this strict definition using exchange traded options, which have a finite menu of strike prices. Our definition is more general as it allows any pair of out-of-the-money strike prices.

[31] *Volatility skewness* would make the puts more expensive than the calls. Since we allow non-equidistant strike prices and trades with net cost significantly different from zero we do not dwell on this technical issue.