Realignment of Debt Service Obligations and Ability to Pay in Concessional Lending: Feasibility and Modalities

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Abstract

We consider schemes which have the potential to increase the flexibility of heavily indebted primary producing countries in meeting their debt service obligations by making debt service repayments contingent on the world prices of the commodities they export. The result would be that countries would repay more in high price years and less in low price years. This would facilitate debt service by gearing it towards "ability to pay" and would offset the variability of export earnings. It is straightforward to generalize these schemes to allow for imported commodities, such as oil, so that repayments would be reduced in years of high oil prices and increased in years of low oil prices. Because the schemes operate by accelerating and retarding debt repayments relative to the existing schedule, they would be *ex ante* broadly neutral for the lenders.

The financial structure of these schemes is that of an overlay in which existing debt contracts are augmented by a set of floating for fixed swaps, where the swap prices are defined in terms of the world prices of the export commodities. It would be feasible for the lending institutions to offset the fixed price exposure they assume under these swaps either on commodity futures markets, where these are available, or through appropriate OTC contracts. The required scale of the swaps can be determined through a straightforward regression-based procedure.

The key question is how effective these arrangements would be in easing debt service and in offsetting the variability of commodity export earnings (and also oil import expenditures). We do this through counterfactual simulation of the debt service of ten moderately or highly indebted commodity-dependent African economies (Benin, Burkina Faso, Burundi, Cameroon, Ghana, Kenya, Madagascar, Malawi, Rwanda and Tanzania). The results are mixed. The schemes do ease the debt service burden and can also offset the variability of export earnings. However, changes in export earnings are not always related to changes in world commodity prices – both because of differences between world prices and the prices obtained by individual exporters, and because of quantity variation. Also, because concessional debt service is only a fraction of export earnings, large variations are required in debt service to offset export revenue fluctuations. Further, there is considerable variation in outcomes across countries with Burundi generating the most favourable and Benin the least favourable outcomes.

The overall implication is that one needs to be clear about objectives. If the scheme is aimed solely at easing concessional debt service, it can be successful, but may be an over-elaborate means of achieving this end. If instead, the objective is that of offsetting variations in countries' export earnings, using concessional debt as a lever, there are probably superior means of achieving this.

1. Introduction

We consider schemes which have the potential to increase the flexibility of heavily indebted primary producing countries in meeting their debt service obligations. We ask how such schemes should be structured and consider how effective they can be in assisting indebted countries in meeting their obligations to service concessional debt.

The structure of the paper is as follows. In section 2, we discuss the structure of the problem we are analyzing and discuss modalities through which it may be addressed. We argue that a swap or swaption overlay structure to existing concessional debt has the potential to allow countries to offset export revenue movements through variations in their concessional debt service, and in Section 3 we examine how these structures may be implemented. In section 4, we show that the quantitative hedge overlay parameters from appropriate regression estimates. In section 5, we outline a money-metric measure for evaluating the resulting welfare improvements in a consistent manner across countries. Then, section 6 reports simulation results for ten severely indebted African countries, and in Section 7 the general features of these simulation results are discussed in greater detail. Section 8 concludes. An appendix is devoted to a more detailed examination the simulated performance of the hypothetical scheme in relation to three specific countries – Benin, Burundi and Ghana

2. Structure

Indebted countries may benefit significantly if their debt service obligations can be matched more closely with either their export revenues or their export prices. In this section, we set out some of the issues of principle that should guide construction of and choice between such schemes.

Concessional debt service typically shows relatively little cyclical variation over time. Export earnings are highly variable and, because commodity prices are at least to some extent mean reverting, this variation is in part cyclical. The main objective of the schemes we investigate in this paper is to more closely match the debt service obligations facing indebted governments with their ability to meet these obligations. Because schemes to smooth export earnings have, in general, proved either unsuccessful or not financially viable,[1] this involves unsmoothing concessional debt service.

It is necessary to specify the objective more precisely. Alternative aims might be

[1] There are two routes to smoothing export revenues – price stabilization and compensatory finance. International commodity agreements, which set out to stabilize prices, are reviewed in Gilbert (1987, 1996). These have all either lapsed, broken down or been abandoned. The main compensatory finance schemes are the IMF's Compensatory Finance Facility (CFF), discussed by Finger and DeRosa (1980), Goreux (1980), Lim (1987, 1991) and IMF (2003); and the EU's Stabex scheme, discussed by Hewitt (1983, 1987, 1993), Aiello (1999) and Collier *et al.* (1999). Brun *et al*. (2001) compare the operation of the two schemes. The CFF has been too subject to conditionalities to prove attractive to borrowers, while Stabex was so slow in disbursing that its operations became pro- rather than counter-cyclical.

- reduction in the variability of country's debt-export ratios; or
- reduction in the variability of the foreign exchange resources that a country has available after meeting debt obligations.

The debt sustainability literature has typically operated in terms of the former concept which has the merit of direct comparability across countries – see, for example, World Bank and IMF (2001), and Edwards (2001, 2003). However, for any particular country, the latter measure gives a more immediate measure of the impact of debt service payments.

We have posed these objectives in terms of variabilities, but it is arguable that what is important is avoidance of bad outcomes, whether in the form of high debt service to export ratios or low residual foreign exchange variability. In practice, these two objectives are likely to be similar if it is also required that reduced debt service in poor times is matched by increased debt service in good times. The former, variance reduction, objective is simpler to formalize, so we will work with this in what follows.

A fundamental choice is to whether we should measure countries' ability to pay in relation to their export revenues or to the world prices of the commodities they export, noting that prices are clearly a major driving force of revenues. In favour of a link to export revenues, these would debt service payments more closely with debtor counties' ability to pay. A price link will fail to insure borrowers against quantity shocks, and will give to "basis risk" if the country's export price moves differently from the world price.

In favour of a price link, we note that export revenues are only known with a one or two-year lag while prices are observed immediately. Schemes, such as the EU's Stabex scheme, which have operated in terms of export revenues, have been slow to disburse and this lack of timeliness has resulted in disbursements becoming pro- and not counter-cyclical (Collier *et al*., 1999; Brun *et al*., 2001). Basing the scheme on prices would increase timeliness. Further, basing the scheme on export revenues could also result in governments being rewarded for changes in the quantum of exports for which they may be directly or indirectly responsible. It may also give rise to incentives to manipulate reported trade statistics. Concerns about moral hazard will typically force lenders to impose conditionality clauses on borrowers, and the negotiation of these conditionalities is a major reason for the lack of timeliness in disbursements from revenue-based compensation schemes. These moral hazard considerations strengthen the argument for a price rather than a revenue link. Further, a price link introduces the possibility for the lenders of using market-based hedge transactions to offset their exposure. We discuss these issues at greater length in section 6 below.

These considerations appear to us to argue on balance for a price rather than an export revenue basis for the scheme provided that price variations account for a sufficiently large proportion of revenue variations for this to be useful. That is an empirical issue. Our contribution to this debate is to look at what can be attained from price-based schemes.

Historically, indebted countries have typically borrowed from a range of official and non-official lenders. Some official loans are completely concessional, others are non-

concessional and the majority are part concessional and part non-concessional. This latter group can be split into concessional and non-concessional components. So long as we focus on highly indebted countries, it is reasonable to suppose that, in the future, debt service will come to predominantly reflect concessional lending as non-official lending has ceased to be available to these countries – see Sachs (2002). For this reason, and because our concern is to devise a scheme which may be implemented in a simple and straightforward way, we consider only concessional lending.

We shall not be directly concerned with issues of debt forgiveness. The schemes we consider leave contractual obligations unaltered. They operate through postponement of debt service payments in periods in which export prices or earnings are low, and bringing such payments forward in periods in which they are high. We show that these schemes may be viewed as an overlay of a set of floating for fixed commodity swaps. As with all swaps, these may be structured to have zero initial value. The arrangement may therefore be seen as a costless or near-costless means of increasing the flexibility and decreasing the burden of servicing concessional debt. However, we shall bring in forgiveness by asking what level of forgiveness would leave borrowing countries indifferent between the current and proposed arrangements.

There is a related issue which turns out to be of major practical importance. We have structured the proposed intervention in terms of a swap-based overlay on top of scheduled debt service payments. This structure envisages that scheduled payments in any year will be modified upwards or downwards in relation to the country's export prices. An alternative proposal sees the size of debt payments being determined primarily by the country's ability to pay, as measured by its export prices. This version of the scheme would see repayments in any particular year becoming sufficiently high or low (perhaps even negative) so as to stabilize the foreign exchange objective. (In practice we will impose a zero floor and a symmetrically defined ceiling on repayments). This version of the proposal lacks a swap interpretation. Instead, debt service simply becomes an accounting device to determine when the arrangement will terminate.

The difference between the two variants of the proposal is important because concessional debt service is relatively small in proportion to export earnings. If debt service is to be used as the instrument for stabilizing export earnings, this will involve a significant leverage of the fluctuations in commodity export prices or earnings to generate a noticeable impact on foreign exchange availability in the indebted countries.

Developing countries which lack domestic oil resources may find that oil imports pre-empt a significant proportion of their export revenues. Other developing countries import much of their grain requirements. Both groups of countries are vulnerable to upward movements in these import prices. This suggests it may be sensible to consider extension of the scheme to cover important imported commodities. This extension turns out to be relatively straightforward. The schemes we consider below treat commodity exports and imports symmetrically.

Commodity prices have exhibited a downward trend relative to the prices of manufactures, and more recently also in nominal terms, for at least a century and probably longer. However, the pace of this fall varies from commodity to commodity, and, even more markedly, from one decade to another. This negative trend is generally regarded as resulting from the effects of productivity-enhancing technical change in production and intermediation processes, which, in the case of manufactures, is partly reflected in higher product quality and specifications. It seems likely that most primary prices continuing to fall relative to manufactures prices, but there is no reliable means of knowing by how much and which commodities, if any, will be exceptions to this pattern. This trend poses problems for any attempt to link debt service payment to commodity prices.

Concessional loans generally have long maturities (20-40 years) with initial grace periods of 10 or more years. It is clearly not possible to forecast likely levels for any commodity price over this type of horizon. This implies that extreme caution should be exercised in making commitments in relation to the absolute level of any price over a horizon of this length. It would be considerably more straightforward and less risky to confine the objective to one of matching the cyclical pattern of debt service obligations to those of export prices or earnings. In such a scheme, countries are assisted in adjusting to short to medium term fluctuations in their export revenues, but need to make other provisions to adjust to longer term structural changes in prices. An alternative justification for this separation is that it is inappropriate to address long term adjustment problems through insurance-type mechanisms. The cost is that the arrangements we discuss can contribute relatively little to issues of debt sustainability over the longer term. It may be suggested that structural adjustment grants or lending are the more appropriate instruments to assist countries in diversifying away from products whose prices are in long term decline.

3. Commodity Swaps and Swaptions

The basic structure of the instrument we consider is that of a commodity swap – see Hull (1997, p.131). Floating-for-fixed interest rate swaps, sometimes known as “plain vanilla swaps”, are the most widely traded interest rate derivative instruments. High quality borrowers have a comparative, as well as an absolute, advantage in borrowing at fixed interest rates relative to lower quality borrowers. (This is because lenders will require the flexibility to raise rates against low quality borrowers if their positions further deteriorate). However, these borrowers will welcome the opportunity to swap out some of their floating interest rate exposure in favour of fixed rates, and high quality borrowers will be able to reduce their overall borrowing costs by agreeing to such swaps. Commodity swaps extend this principle from interest rates to commodity prices.

One way of thinking of the commodity swap proposal is to see it as an extension of the practice, which already exists for some multilateral lending, of structuring a loan in terms of a basket of currencies. The currency basket approach allows the borrower to match the currency composition of its debt service obligations to the currency exposure of its export revenues. This is formally equivalent to augmentation of the original loan with a set of currency swaps (euros or yen for dollars).

The principle of commodity swaps may be illustrated by reference to the gold loan market. Many fledgling gold mining companies finance mine developments by taking out gold loans. Under such arrangements, they borrow a specified quantity of gold from a broking house, but effectively from central banks which wish to mobilize gold reserves, and use the monetary value of the borrowed gold to finance their activities. When the loan matures, they either deliver newly mined gold to the broker (and hence back to the lending central bank), or more normally, repay the current monetary value of the gold loan principal. There will be a gold interest rate. The advantage of this arrangement for the mining company is that it combines a financing and a hedging transaction – provide the mine produces, it can repay its loans whatever the gold price. Participating central banks earn interest on otherwise unremunerative gold reserves. A gold loan may be considered as a normal currency loan plus a fixed-for-floating gold swap in which the mining company assumes a floating rate liability.

How does this apply to poor indebted countries? Most poor countries remain highly dependent on a small number of primary commodity exports, and indeed, this may be one reason why they remain poor. We may consider such countries as having an asset (their primary commodity export revenues) which is exposed to one or more floating commodity prices. Their liability structure is currently fixed, in the sense that debt service is independent of the commodity prices. They will benefit by swapping out this fixed rate exposure for a floating rate exposure which matches their floating commodity price exposure.

Should the scheme aim to provide a comprehensive coverage of a country's export and import commodities or confine itself just to the major export and import commodities? In what follows, we confine attention on the most important exports and on oil imports because

- many less important commodity exports lack clearly defined international prices;
- the focus on a small number of major export and import commodities works towards a simple and easily understood structure;

Inclusion of less important export and import commodities would have a relatively small effect on outcomes.

Note that the commodity swap structure is simply an organizing principle and does not have any necessary or even likely implication that contracts of this sort can be achieved through a set of market swaps. We return to this issue later. Irrespective of whether or not there are any market-based offsetting arrangements, there are three clear advantages of this formalization:

- It emphasizes the applicability of standard financial theory of hedging to the structuring of the instruments;
- It allows valuation of the instruments under standard assumptions; and
- It underlines that the proposed contractual modifications are natural extensions of instruments which already exist and are traded in the market place.

Acknowledging these advantages, it is nevertheless important that we do not allow these structures to straitjacket the proposals which we consider.

Consider a loan of \$$A$ which matures in period T. Scheduled repayments are S_1, S_2 … S_T. For a typical IDA loan, $T = 40$ and

$$S_t = \begin{cases} 0 & 0 < t < 10 \\ 0.02A & 10 \le t < 20 \\ 0.04A & 20 \le t < 40 \end{cases}.$$

These payments are fixed. Consider a floating price P_t with initial level (at loan inception) P_0. A corresponding floating rate loan overlay would require payments of $R_t = \left(\frac{P_t}{P_0}\right) S_t$ with the consequence that repayments would be higher than on the corresponding fixed loan when P is high and lower when low. More generally, suppose a fraction $\lambda \ge 0$ of the original loan is swapped into the floating loan. Repayments are

$$R_t = \left[\lambda\left(\frac{P_t}{P_0}\right) + (1-\lambda)\right] S_t = \left[1 + \lambda\frac{P_t - P_0}{P_0}\right] S_t = (1 + \lambda p_t) S_t \qquad (1)$$

where $p_t = \frac{P_t - P_0}{P_0}$. Equation (1) makes the swap interpretation of the structure explicit.

Alternatively, if the instrument is the anticipated level of exports $\tilde{X}_t$, the swap would require payments of $\lambda\left(\frac{P_t - P_0}{P_0}\right)\tilde{X}_t$. Total debt service would be

$$R_t = \lambda\left(\frac{P_t - P_0}{P_0}\right)\tilde{X}_t + S_t = \left(1 + \frac{\lambda}{\psi_t} p_t\right) S_t \qquad (2)$$

where $\psi_t = \frac{S_t}{\tilde{X}_t}$, the ratio of the original level of debt service to anticipated exports. In what follows, we measure anticipated exports from a moving average of past levels of exports. Under the cap-floor scheme we set out above to ensure that modified debt service does not depart over far from the original debt service levels, equation (2) becomes

$$R_t = \begin{cases} 2S_t & \text{if} \quad \lambda p_t > \psi_t \\ \left(1 + \frac{\lambda}{\psi_t} p_t\right) S_t & \text{otherwise} \\ 0 & \text{if} \quad \lambda p_t < -\psi_t \end{cases} \qquad (3)$$

Commodity swaption structures are a variant of the commodity swap structure considered above. They are premised on the principle that any scheme should aim to cope only with exceptional and not normal price movements.

A swaption is an option on a swap. A floating-for-fixed swaption may either be a call (the right to swap into floating from fixed) or a put (the right to swap into fixed from

floating). We shall consider collar-type structures in which the borrowing country is long a set of out-of-the-money calls and short an equal number of out-of-the-money puts. because both set of options are out-of-the-money, debt service payments will be unaffected for moderate variations in the commodity price.

The swaption repayment scheme corresponding to the swap scheme in equation (1) may be expressed as

$$R_t = \begin{cases} \left[1+\lambda\dfrac{P_t-(1+\theta)P_0}{P_0}\right]S_t & if \quad (1+\theta)P_0 < P_t \\ S_t & if \quad (1-\theta)P_0 \le P_t \le (1+\theta)P_0 \\ \left[1-\lambda\dfrac{(1-\theta)P_0-P_t}{P_0}\right]S_t & if \quad P_t < (1-\theta)P_0 \end{cases} \tag{4}$$

The middle row of equation (4) shows that in the band in which the commodity price is within ±θ% of P_0, debt service payments are unchanged from those under the standard currency loan. If the price falls short of $(1-\theta)P_0$, debt service is reduced in relation to the proportion α of this shortfall. Correspondingly, at prices above $(1+\theta)P_0$, debt service is increased in relation to the proportion α of the excess. This may be expressed more succinctly as

$$R_t = \left[1+\lambda\max(p_t-\theta,0)+\lambda\min(p_t+\theta,0)\right]S_t \tag{5}$$

Equations (4) and (5) makes explicit that the original loan for $\$A$ has been modified by adding a short position of calls on $\$\lambda A$ in the floating rate loan with strike price $(1+\theta)P_0$ and a long position of puts on $\$\lambda A$ in the floating rate loan with strike price $(1-\theta)P_0$. These repayments are illustrated for a simple example (P_0=100, P_*=(1-θ)P_0 =85, P^*=(1+θ)P_0 =115, λ=½) in Figure 1, which also illustrates a simple swap-based scheme.

Commodity swaption-based schemes are reminiscent of band stabilization schemes operated in fixed exchange rate currency regimes and of the buffer stock commodity stabilization schemes operated in tin (until 1985) and natural rubber (until 1999) – see Gilbert (1987, 1996). These structures may be extended to use export revenues as the instrument, but once the caps and floors are taken into account, the algebraic expressions become too complicated to be very useful.

The structures outlined above may be extended to include imported commodities, in particular petroleum. Countries importing these commodities may experience difficulties in meeting scheduled loan repayments in periods when imported commodity prices are high. This is achievable by allowing borrowing countries to make commodity-based loans to the lenders, or to take collar positions in such loans. These loans again have swap-based or swaption-based structure.

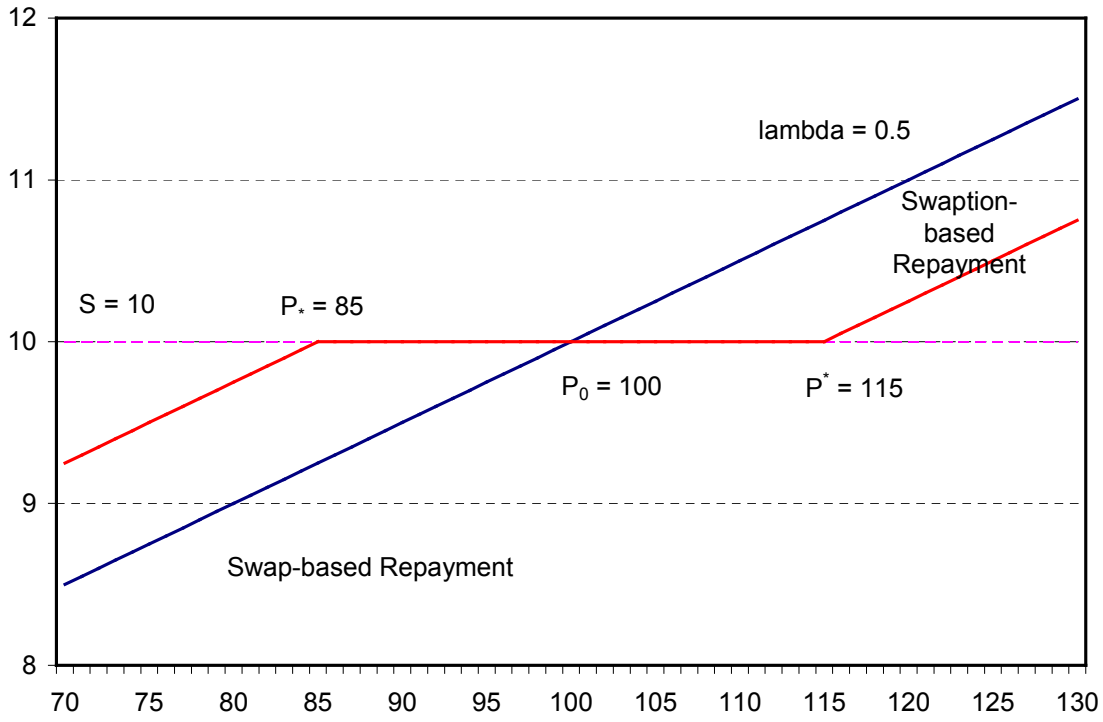

Figure 1: Swap-based and Swaption-based Price Conditionality

Write the oil import price as Q_t with initial (loan contract or inception date) price of Q_0. Write $q_t = \dfrac{Q_t - Q_0}{Q_0}$. Then a swap-based scheme, generalizing that defined by equation (1), is given by

$$\begin{aligned} R_t &= \left[\lambda\left(\frac{P_t}{P_0}\right) - \mu\left(\frac{Q_t}{Q_0}\right) + (1-\lambda+\mu)\right] S_t \\ &= \left[1 + \lambda\frac{P_t - P_0}{P_0} - \mu\frac{Q_t - Q_0}{Q_0}\right] S_t = (1 + \lambda p_t - \mu q_t) S_t \end{aligned} \tag{6}$$

One way of thinking about this structure is to see the original fixed repayment loan as increased by the fraction μ%, which is then lent back to the lender in the form of an oil-based or grain-based loan. The borrowing country receives fixed payments on $μA value of this component of the loan, but makes oil- or grains-linked payments to the lender. Similarly, the corresponding scheme in which exports are the instrument is governed by the equation

$$R_t = \begin{cases} 2S_t & \text{if} \quad \lambda p_t - \mu q_t > \psi_t \\ \left[1 + \dfrac{1}{\psi_t}(\lambda p_t - \mu q_t)\right] S_t & \text{otherwise} \\ 0 & \text{if} \quad \lambda p_t - \mu q_t < -\psi_t \end{cases} \tag{7}$$

The extension of equation (6) to the swaption-based scheme is defined by

$$R_t = \left[1 + \lambda \max\left(p_t - \theta, 0\right) + \lambda \min\left(p_t + \theta, 0\right) - \mu \max\left(q_t - \theta, 0\right) - \mu \min\left(q_t + \theta, 0\right)\right] S_t \quad (8)$$

where we have defined the bands symmetrically for import and export prices. The borrowing country is long the call and short the put in the export price but short the call and long the put in the import price.

The poor quality of oil import causes major problems for the extension of the scheme to imported oil. We comment on these problems below in section 6 with specific reference to Benin and Ghana. These information problems make it difficult to estimate appropriate hedge ratios for oil imports may also lead to underestimation of the beneficial effects of the schemes we investigate.[2]

The swap and swaption schemes considered above would give borrowing countries the benefit of repayments based on floating commodity prices for the entire lifetime, perhaps up to 40 years, of a concessional loan. If, as we anticipate is likely, commodity prices continue to decline, this would be a very considerable benefit, but one achieved at the expense of the lending countries. But it would also impose upon them the risk that scarcity might eventually strike reversing the downward trend of the past century. These risks will probably not be countenanced, certainly be lenders, but possibly also not by borrowers. In any case, as we noted in section 1, risk sharing instruments of this sort are not the most appropriate for coping with long term adjustment problems. For these reasons, we modify the instrument structures so that, in technical terms, they have time-varying strike prices.

We may think of the initial price P_0 in the above schemes as being the contract strike price. In this sense, these are fixed strike instruments. Generalization to a floating strike is straightforward, simply by replacing P_0 and Q_0 in equations (1-3) by time-subscripted prices P_t^{av} and Q_t^{av}. This notation reflects the judgment that P_t^{av} and Q_t^{av} will be moving averages of past prices.

This generates a 2x2 matrix of possibilities:

		Contract type	
		Swap	*Swaption*
Strike type	*Fixed strike*	Floating for fixed swaps	Floating for fixed swaptions
	Variable strike	Floating for moving average swaps	Floating for moving average swaptions

The upper row defines the schemes considered in equations (1-8) and Figure 1. In what follows, we confine attention to schemes defined by the lower row of the table.

[2] Information is even less complete for the value of oil exports. Cameroon is the only country we consider which has significant oil exports. Valuation of reported tonnages of oil exported from Cameroon at world prices gives rise to figures which in many years are inconsistent with the reported dollar value of total exports.

Finally, we note three practical issues which will need to be addressed and which might lead to modification of the swap-swaption structure outlined above.

- Concessional lenders will probably wish to put a zero floor on debt serviced in any particular year. Lenders would probably wish to find some other way to address the problem of export prices becoming so low (or import prices so high) that a scheme would generate a net payment from the lender to the borrower. We incorporate a zero floor in the simulation results we report in section 4.
- The use of a moving average estimate of the underlying trend price is intended to ensure that, on average, interventions triggered by the scheme are as likely to be positive, entailing accelerated repayment of debt, as negative, involving postponement. In any particular case, however, payments will be higher or lower than under current currency-based loans, perhaps markedly so. If the principle is that these scheme aims only to postpone or accelerate debt repayment, it will be necessary to modify the swap or swaption structure with provisions to ensure that the aggregate payment is not affected. This would require premature termination, in the case of accelerated payments, and extension, in the case of retarded payments.
- This last problem may be exacerbated by the negative drift in commodity prices – see Grilli and Yang (1988). This will have the result that a moving average trend estimate will tend to be a few percent too high. It would be possible to address this by deflating the moving average, perhaps by around 5%, but it is less clear that this would be an appropriate procedure for oil, the major import commodity for poor countries, where scarcity considerations may offset the price-reducing impact of productivity advances.

4. The Hedge Ratio

In this section, we ask, How large should a swap position be in relation to a country's concessional debt service? For simplicity, we focus on a country with a single major export, with export share α and price P, and for which oil imports have price Q and notional share γ in total exports.[3] We also focus on a straightforward commodity swap structure, as defined by equation (4), with nominal value $\$A$. That structure swaps out $\$\lambda A$ of the loan into a floating-for-fixed swap in terms of the price of the export commodity, and undertakes a reverse swap of $\$\mu A$ into a floating-for-fixed swap defined in terms of the import price commodity. The borrowing country becomes long in exposure to the variable commodity export price but short in exposure to the variable commodity import price. The question we have asked may be rephrased in terms of finding the appropriate values for the hedge parameters λ and μ.

[3] In most highly indebted, total imports considerably exceed total exports with the difference covered by grants, remittances and capital inflows. Expressing oil imports as a share of exports rather than imports implies equivalence between an extra dollar spent on oil and a dollar lost from a lower value of commodity exports.

The most simple starting point for the analysis would be the share-based hedge which sets the export commodity swap parameter λ equal to the export share α and the oil import swap parameter μ equal to the "share" γ of oil imports in total exports. This choice is appropriate if cross correlations are unimportant – i.e. the commodity export price does not affect other export or oil imports, and the oil price does not affect exports. These hedge ratios may be applied either to the level of concessional debt service or to the projected level of exports or imports (probably on the basis of trend extrapolation). In the latter case, the swap is geared up in proportion to the inverse of the ratio of debt service to exports. In either case, it is straightforward to extend this to cases in which there is more than a single export or import commodity.

Hedging using the export and oil import shares effectively adopts a unit (dollar for dollar) hedge ratio. The most basic hedging theory teaches that hedge ratios will normally differ from unity – see, for example, Hull (1997, pp.35-7). The variance minimizing hedge ratios, *h* and *k* for the export and import commodities respectively, will depend on the correlation between changes in the revenue stream to be hedged and changes in the price used to hedge this stream, and on the relative volatilities of the revenue stream and the hedge price. Furthermore, hedging using export shares considers the export and import side hedges independently. This is only valid if changes in the export and import commodity prices are mutually uncorrelated, if the changes in the export price are uncorrelated with changes in import expenditures and if changes in the import price are uncorrelated with changes in export revenues. These are strong requirements. Where these conditions do not hold, a portfolio approach is required which takes into account the covariance structure of the prices, export revenues and import expenditures.

Although it is possible to derive analytic formulas for the variance-minimizing hedge under these more general conditions, it is simpler to derive the hedge ratios empirically by multiple regression of the quantity whose variance one wishes to minimize on the relevant prices. We do this for quantity $X - O - S$, which we interpret as residual forex availability. The precise regression takes as dependent variable $\frac{X_t - \tilde{X}_t}{\tilde{X}_t} - \frac{O_t - \tilde{O}_t}{\tilde{X}_t} - \frac{S_t - \tilde{S}_t}{\tilde{X}_t}$ where a tilde indicates a centered five year moving average. This is regressed on the similarly defined export price deviation $p_t = \frac{P_t - \tilde{P}_{t-4}}{\tilde{P}_{t-4}}$ and the oil price deviation $q_t = \frac{Q_t - \tilde{Q}_{t-4}}{\tilde{Q}_{t-4}}$, where, however, the price moving averages are four year moving averages defined over the period *t*-6 to *t*-3. Backdating of the moving averages is required to ensure that the contracts are hedgable.

An advantage of the regression approach is that we can also apply it to calculate hedge ratios for different minimization objectives where exact formulas are unavailable. In particular, we are interested in looking at the variance of the debt service to export ratio $\frac{S}{X}$. We modify this ratio by including oil import expenditures in the numerator, as

competitive with debt service. Consider a 1% decline in revenue for a commodity export which reduces total export expenditure X by α%. This decline will be offset by a decline in debt service by α%. On the other hand, a 1% rise in expenditure oil import expenditure O will require a 1% offsetting decline in debt service. To ensure symmetry, we therefore scale oil import expenditure by its share of total exports, γ. The appropriate ratio to consider is therefore $s = \frac{S + \gamma O}{X}$. We obtain hedge ratios by regressing deviations from the centered moving average trend of s, $s_t - \tilde{s}_t$, on the prices p_t and q_t defined above.[4]

Regression-based weights should generate a superior hedge to the share-based weights in the presence of correlations between commodity prices and oil prices and if these prices influence other expenditure and receipt items. The practical problem is whether it is possible to rely on these weights being constant over time. There will always be a worry that particular hedge ratios estimated over short samples of often poor quality data can generate hedges that may be less good than those obtained by use of simple export and import shares. The apparent superiority of the regression-based weights may therefore be illusory. We therefore report results based on both share and regression-weights. The former may be thought of as providing a lower bound and the latter an upper bound on attainable performance.

We estimate variance minimizing hedge weights for the swap-based schemes but not for the swaption or the reduced activity schemes. The nonlinearities associated with these two schemes implies that optimization would need to be within a Monte Carlo simulation framework. We do not pursue that direction in this paper.

5. Welfare Analysis

We need a criterion by which to judge the relative success of different schemes. This is particularly important because of the differences which are likely to emerge between schemes which aim to minimize the variance of free forex and those which look at the debt-service to export ratio (as modified to take oil imports into account).

We propose to ask what reduction in debt service would leave countries indifferent between the reduced but otherwise unmodified debt service payments and debt payments under the proposed schemes but without any overall reduction. This provides a common metric in which alternative schemes can be evaluated both within and across countries. The measure depends on change in the variability of free foreign exchange (forex, $X - O - S$).[5] It may be expressed either in percentage terms or as a dollar reduction.

Let social welfare W have three components:

- the expected utility from consumption C of subsistence goods Z,

[4] Regressions were performed over the period 1985-2009 (1999 for Cameroon because of lack of data).

[5] The measure ignores any net transfers which might take place on the basis that these are required to sum to zero in dollar, if not in NPV, terms over the lifetime of the loans.

- the expected utility obtained from imported consumer goods *M*, and
- the expected utility of consumption of oil imports.

We suppose that the social welfare function is additively separable between the first of these components and the remaining two.

$$W = EU(M) + EV(Z,O) \tag{9}$$

Ignoring, for simplicity, remittances, aid and capital inflows, the balance of payments constraint is $X = M + O + S$ social welfare becomes

$$W(\lambda,\mu) = EU(X - S(\lambda,\mu) - O) + EV(Z,O) \tag{10}$$

Maximization of social welfare with respect to the two parameters λ and μ is equivalent to maximization of $EU(X - S(\lambda,\mu) - O)$. The assumption of additive separability implies that we do not need to consider the second right hand side term in equation (10).

Write the expected utility level obtained in the absence of intervention (i.e. λ = μ = 0) as u_0. For any pair of values of λ and μ, we may define the reduction $\delta(\lambda,\mu)$ in debt service that the country would regard as equivalent, in social welfare terms, to the reduction in variability resulting from the choice of non-zero values for λ and μ. This reduction is defined implicitly be the equation

$$EU(X - S(\lambda,\mu) - O) = EU(X - (1-\delta)S_0 - O) \tag{11}$$

where $S_0 = S(0,0)$, the non-intervention level of debt service. Expanding (11) around λ = μ = 0, we obtain

$$\tfrac{1}{2}u_0''Var[X - S(\lambda,\mu) - O] = \tfrac{1}{2}u_0''Var[X - S_0 - O] + u_0'\delta S_0 \tag{12}$$

Write the reduction (measured as positive) in the proportionate variance as

$$\Delta = \frac{Var[X - S_0 - O] - Var[X - S(\lambda,\mu) - O]}{\bar{X}^2} \tag{13}$$

where $\bar{X} = EX$, the expected level of exports, which we shall interpret as the moving average trend. Then

$$\delta = \frac{R\Delta}{2\psi} \tag{14}$$

where $\psi = \frac{S_0}{\bar{X}}$, the ratio of debt service to exports, and $R = -\frac{\bar{X}u_0''}{u_0'}$, the coefficient of partial risk aversion – see Zeckhauser and Keeler (1970).[6]

[6] The coefficient of partial risk aversion is related to the more standard coefficient of relative risk aversion ρ as $R = \frac{\rho\bar{X}}{\bar{Y}}$ where $\bar{Y} = EY$, the expected level of income. The equivalent expression for δ in terms of the relative risk aversion coefficient is $\delta = \frac{\rho\Delta}{2\xi}$ where $\xi = \frac{S_0}{\bar{Y}}$, the ratio of debt service to income. This expression is exactly equivalent to that given in equation (14). The substantive issue is whether it is more plausible to regard partial or relative risk aversion as constant across countries with different export to GDP ratios. We prefer to work with constant

The disadvantage of this approach is that it necessarily depends on an assumed risk aversion coefficient. If countries are highly risk averse, they will be willing to pay a lot for even a small degree of risk reduction, while if they have low risk aversion they would prefer even a small reduction in overall debt service to a large reduction in uncertainty. In what follows, we use a conservative value of unity for the partial risk aversion coefficient. Use of a higher value for risk aversion, perhaps 2.5, would increase the valuation of the risk reduction benefit proportionately.

6. Simulations

We have performed historical simulations, over the period 1984-2000, of schemes of the form outlined above for a set of ten severely and moderately indebted African countries. The countries are

Benin	Ghana	Rwanda
Burkina Faso	Kenya	Tanzania
Burundi	Madagascar	
Cameroon	Malawi	

This group of countries was selected from the set of all countries classified by the World Bank as severely or moderately indebted and which in addition satisfied the following three criteria

- Service on concessional debt is a sufficiently large proportion of total debt service to allow the scheme to have a significant impact on overall debt service.[7]
- The country has at least one export commodity making up 10% of total exports or one import commodity accounting for 10% of total imports.
- The country publishes statistics on total imports and exports, with at most a few gaps, which allow calculation of the required hedge ratios.

Application of these three criteria reduced an original candidate list of many more countries to the ten listed above.[8]

In section 3, we set out a range of alternative designs. We need to choose a more limited number of schemes for simulation. In what follows, we will report on two schemes:

A. A commodity swap scheme, as defined by equation (6), with price deviations measured relative to a four year moving average of past prices lagged one year (ie the moving average of prices five, four, three and two years previously).[9]

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partial risk aversion on the argument that the export to GDP ratio should not be a major determinant of the debt reduction equivalent of a reduction in the variability of the debt service to export ratio. Recognizing that partial risk aversion must be lower than relative risk aversion, we take a uniform low value of unity for this parameter.

[7] Source for debt data: World Bank.

[8] Sources for export revenue and import expenditure data: aggregate exports and imports, IMF (*International Financial Statistics*); agricultural commodities: FAO. Gold export values and petroleum imports and export values were estimated by multiplying volume statistics (see footnote 14) by the appropriate world prices scaled down by 5% in the case of petroleum exports.

[9] Source for price data: IMF (*International Financial Statistics*).

B. A swaption scheme, as defined by equation (8) and relating to the same moving average with a ±θ% band (strike prices θ% above and below the moving average price trend). We set θ = 15%.

We consider these schemes as implemented in relation to concessional debt service and trend exports. In each case, we consider both share-based and regression-based hedge parameters.

Simulation results are tabulated by country in Tables 8-11 – see end of paper. Tables 8 and 9 take as objective the minimization of the variance of countries' residual forex whereas Tables 10 and 11 are based on minimization of the debt service to export ratio, modified to include oil imports. In Tables 8 and 10 the instrument is the original level of debt service while Tables 9 and 11 report simulations in which the instrument is the lagged export revenue moving average. For each country and both hedging schemes, results are provided for each of the swap-based scheme (scheme A), the swaption scheme (scheme B) using a ±15% threshold.

Table 1
Median Summary Statistics for Simulation Exercises
Swaption Schemes (Scheme A)

Minimization Objective	Instrument	Share-based positions		Regression-based positions	
		Variance reduction	Value	Variance reduction	Value
$Var(X-O-S)$	Scheduled repayments S	16%	0.4%	1.5%	0.7% $0.4m
$Var\left(\frac{S+\gamma O}{X}\right)$	Scheduled repayments S	0.8%	$0.3m	0.1%	0.3% $0.1m
$Var(X-O-S)$	Trend exports $\tilde{X}$	1.5%	1.0%	2.3%	3.2% $1.0m
$Var\left(\frac{S+\gamma O}{X}\right)$	Trend exports $\tilde{X}$	-2.0%	$0.5m	0.5%	1.0% $0.5m

The table summarizes the median results for the Scheme A simulations reported in from Tables 8-11. Row 1 of the table relates to Table 8, row 2 to Table 9 etc. In each case, the variance reductions, which are given in percentage points, relate to the objective function specified in the first column – results are comparable across rows 1 and 3 and 2 and 4, but not between odd and even numbered rows. Values are given as percentages of scheduled debt service and as dollar values using a common assumed unit value for the partial risk aversion coefficient.

X is the total dollar value of export revenues, O is the dollar value of oil import expenditures, S is the dollar value of total concessional debt service and γ is the sample average ratio of O to X.

The simulation results differ markedly across countries but are fairly consistent across alternative schemes in any given country. These differences across countries motivate an alternative focus on average benefits. Our preference is to focus on median benefits, interpretable as the benefit to the average country, rather than on the (typically higher) sample average which is heavily influenced by the Burundian and Rwandan performance. Median benefits for the swap scheme (scheme A) are listed in Table 1.

- The schemes generally do give some reduction in the target variances – typically of the order of 1%-2%. The debt-service based hedge is as effective as the export-based hedge in reducing the variance of the augmented debt service to export ratio, but only around half as successful in reducing the variance of the free forex measure.
- Because our valuation metric is based on free forex, seen as financing discretionary imports, the higher variance reductions deriving use of anticipated export revenues as a hedging base approximately doubles scheme valuations. However, these remain small at around 1%-3% of debt service. A higher assumed risk aversion coefficient could raise these valuations to the 2½%-10% range. Even relatively large reductions in the variability of the augmented debt service to export ratio only translate into relatively small welfare improvements.
- Use of regression-based weights rather than export and import share weights generates a more marked variance reduction when the minimization objective is the variance of free forex than when the objective relates to the augmented debt service to export ratio. As noted, the problematic nature of this procedure relates to the structural constancy of the regression weights.

Overall, the most important conclusions that follow from the results summarized in Table 1 are the small extent in variability and hence the low size of the overall benefits derivable from the scheme, and the relative superiority of gearing the scheme to export revenues rather than scheduled debt service in terms of the dollar valuation of the interventions.[10]

The second interesting comparison is between the swaps scheme (Scheme A) and the swaptions scheme (Scheme B). In Table 2 we report this comparison for the schemes which aim to minimize the variance of free forex ad which adopt hedge ratios derived from regressions. The relative ranking of the alternatives is the same for other choices and these can be inferred from the detailed results reported in Tables 8-11. The results reported in Table 2 show the swaps scheme, Scheme A, to be uniformly superior to the other two schemes in terms of both variance reduction and the value of the associated welfare change. These results confirm that the results reported in Table 1 are reliable in relation to the other design parameters and to overall valuation of the interventions. We acknowledge that these estimates depend on the choice of a particular bandwidth parameter θ, which we have taken as $\pm 15\%$. Other choices may give different results.

[10] This latter conclusion is a direct consequence of the definition of the utility function used to evaluate the benefits. The more substantial point is that it is quite difficult to think of a sensible utility specification in terms of the debt export ratio particularly if this is also to acknowledge the importance of oil imports.

Table 2 **Comparison of Alternative Schemes: Median Simulation Benefits** Objective: Minimization of $Var(X-O-S)$ Regression-based weights			
	Instrument	Scheme A (swaps)	Scheme B (swaptions)
Variance reduction % benefit $ benefit	Debt service S	1.5% 0.7% $0.4m	0.3% 0.2% $0.1m
Variance reduction % benefit $ benefit	Trend exports $\tilde{X}$	2.3% 3.2% $1.0m	1.4% 1.1% $0.7m
The table summarizes the median results for the Scheme A simulations reported in from Table 8 (rows 1-3) and Table 10 (rows 4-6). The variance reduction is given in percentage points. Values are given as percentages of scheduled debt service and as dollar values using a common assumed unit value for the partial risk aversion coefficient. X is the total dollar value of export revenues, O is the dollar value of oil import expenditures, and S is the dollar value of total concessional debt service			

Table 3 summarizes the benefits of the best performing scheme (objective of minimizing $Var(X-O-S)$, export instrument, regression weights) for the ten countries in our sample. Of the ten countries considered, Burkina Faso, Burundi, Malawi and Rwanda are seen as obtaining greatest benefit from the proposed scheme.[11] Estimated benefits are very low in Benin, Ghana and Kenya.

Table 3 **Summary Benefits by Country**					
	Scheme A	**Scheme B**		**Scheme A**	**Scheme B**
Benin	- 2.6%	- 1.7%	Kenya	0.4%	0.9%
Burkina Faso	3.6%	6.6%	Madagascar	3.0%	2.4%
Burundi	4.7%	5.8%	Malawi	5.2%	1.2%
Cameroon	3.3%	1.0%	Rwanda	5.7%	3.8%
Ghana	0.8%	- 0.1%	Tanzania	1.4%	0.7%
The table summarizes the benefits, expressed as a percentage of scheduled debt service, of the simulation results reported in Table 10, columns 7-9.					

[11] Benefits are calculated over the ten year period 1991-2000. The simulation results for Rwanda exclude the civil war years 1994 and 1995. The results are much less favorable without this exclusion.

Up to this point, we have considered only the potential benefits of the proposed schemes. They also have costs. The principal cost is the unsmoothing of flows from borrowing countries to the concessionary lenders. Here, we focus on the impact on IDA, the most important of these lenders. The impact is charted in Figure 2 which looks at Scheme A (swap based) schemes using regression weights using respectively the debt service and the anticipated (trend) export instruments. The figure compares the total debt repayments to IDA from the ten countries in our simulation sample with actual historical repayments over the simulation period 1991-2001.

There is a stark contrast between the impact of the scheme when the debt service instrument is adopted with that when the export instrument is used. Use of the debt service instrument results in relatively small net departures of debt repayments from their historical time path – the maximum divergence is $19m (in 2001). By contrast, use of the export instrument generates much larger divergences - $154m in 2000 and $189m in 2001. The consequence is that, at the start of the current decade, IDA would be receiving one third of its current debt service payments from qualifying countries.

One reason for the large size of these figures is that there is relatively little offsetting – there is a large common factor in commodity price cycles. Net flows average 69% of gross flows in the scheme which uses debt service as instrument and 65% in the scheme which uses anticipated exports. The main element of offsetting in our sample comes from Cameroon whose oil export revenues are negatively correlated with commodity export earnings and oil import expenditures in the other countries in our sample.

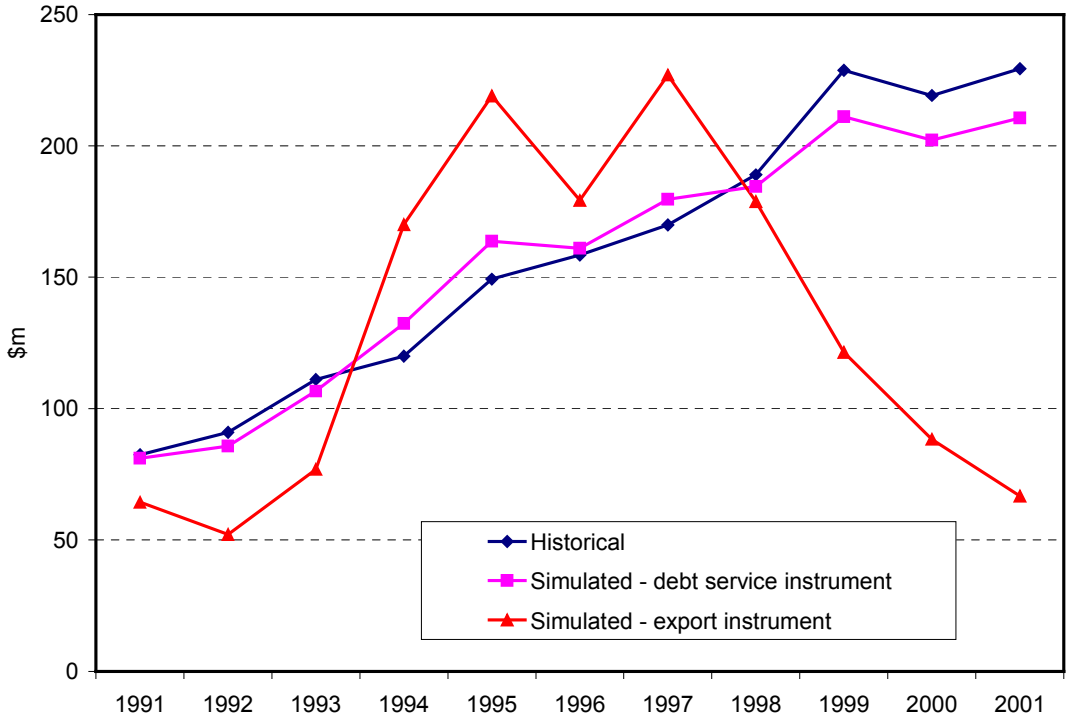

Figure 2: Historical and simulated repayments of IDA concessionary debt, 1991-2001

These results necessarily indicate a major question mark against the scheme using trend export revenues as the instrument. Table 1 suggests that the potential benefits from use of the export instrument are perhaps two to three times those from using the debt service instrument, but the disruption of IDA finances is many times larger than this. The choice appears to be between a scheme which imposes a relatively small disruption on IDA finances but which generates a low expected level of benefits to participating countries, and an alternative which imposes much greater disruption on IDA for benefits which, although larger, remain low.

If a scheme along one of these two lines eventually comes to be proposed, it will be necessary to extend these calculations to NPV calculations, and perhaps also to look at IDA's VaR (Value at Risk) under the scheme. We have not done this, in part because such an exercise requires assumptions about how, and to what extent, IDA would offset its commodity risk exposure on the (exchange or OTC) financial markets. We believe such offsetting to be feasible, at least with regard to the principal commodities we consider.[12] However, offsetting will not be costless and offsetting costs must be expected to rise with the size of the position to be offset.

To summarize, the best performing scheme in our simulations was the swaps scheme based on anticipated (i.e. trend) export earnings and using regression-based weights. This gave benefits which we evaluate conservatively as equivalent to concessional debt service reductions of between zero (Benin) and 5¾% Rwanda). The median benefit is around 2¼% of concessional debt service. Use of a less conservative risk aversion parameter could double or perhaps even treble these estimated benefits, but that would be an upper bound. In particular, use of hedge ratios estimated from historic data is likely to over-estimate the extent of risk reduction attainable in the future.

Simulation of the resulting IDA flows indicates only a modest degree of offsetting across commodities. Tying the scheme to a debt service instrument implies relatively low disruption of payments to IDA. By contrast, use of trend exports as the hedging basis results in IDA assuming a high degree of commodity price risk with the potential for major disruption of its net repayment flows.

Overall, the simulation results may be seen as positive, in the sense that feasible adjustments of concessional debt service in relation to commodity export and import prices can improve the situation of highly indebted commodity-exporting countries, but negative, in that the estimated size of this benefit is relatively small.

[12] There should be little problem with respect to coffee and cocoa. Tea and tobacco lack organized futures markets and would be more problematic. Cotton is in an intermediate position. Note that although concessional loans typically have long maturities, it would only be necessary to hedge at such time as the moving average price trends become revealed. IDA would therefore only need to hedge its positions a few years ahead, but would do this on a rolling basis.

7. Discussion of the Results

We have investigated three possible reasons for the mixed results reported in section 6. These are

- variability in concessional debt service over time;
- movements in the price basis (the difference between local and world prices); and
- quantity variation.

Our judgment is that it is the second and third of these factors, and in particular the third, which are largely responsible for the relatively low value that we estimate indebted countries would put on the proposed scheme.

Concessional debt service has tended to increase over time for the countries in our sample, in some cases relatively fast. This is particularly true of Ghana, Kenya, Malawi and Tanzania – see Figure 3 – and to a lesser extent of Madagascar. At the same time, debt relief under the HIPC programs has resulted in declines in debt service in participating countries. In Figure 3, this effect is most apparent for Malawi and Tanzania. The result is to introduce sharp variability into otherwise smooth debt service paths. This prompts the question of whether the schemes we are investigating might generate larger benefits if these sources of variability were removed.

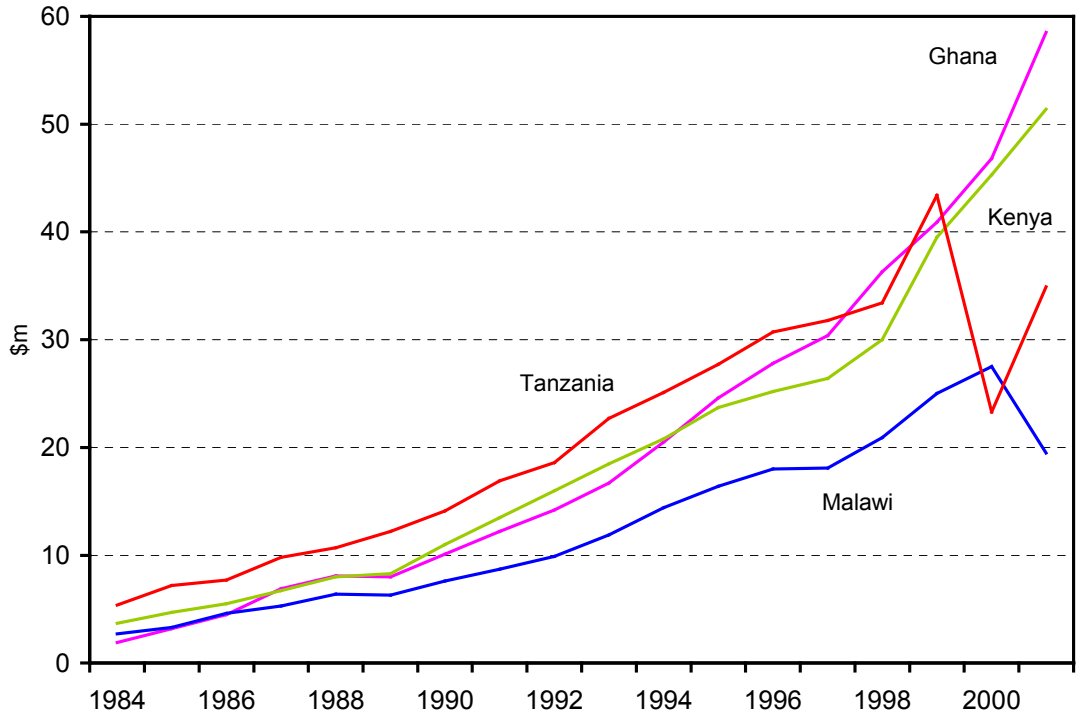

Figure 3: Total Concessional Debt Service ($m), 1984-2001, Selected Countries

We examined this question by setting concessional debt service to its average value over the period 1984-2001 throughout the entire period. We looked in particular at the results

reported in Table 10 and using regression-based hedge ratios – the most favorable set of results reported in section 6. The results of this exercise were mixed. For seven of the ten countries, this substitution led to a further deterioration in performance, but for three (Burkina Faso, Burundi and Malawi) there was an improvement. These are three of the four countries for which the scheme performed best, and in two of these cases (Burkina Faso and Burundi), the improvement was considerable – see Table 4 which repeats Table 3 using constant concessional debt service levels.

Table 4
Summary Benefits by Country Assuming Constant Scheduled Debt Service

	Scheme A	Scheme B		Scheme A	Scheme B
Benin	- 2.3%	- 2.7%	Kenya	0.2%	0.8%
Burkina Faso	8.6%	10.8%	Madagascar	-1.8%	-3.9%
Burundi	6.2%	7.8%	Malawi	5.5%	1.7%
Cameroon	2.3%	0.7%	Rwanda	4.1%	2.7%
Ghana	0.8%	- 0.5%	Tanzania	1.1%	0.1%

The table summarizes the benefits, expressed as a percentage of scheduled debt service, of the simulation results reported in Table 10, columns 7-9 but with the 1984-2001 average scheduled debt service substituted for the historical levels.

These results lead us to conclude that, in countries where the proposed scheme would work well, our estimate of its potential value is probably too low. At the same time, variability in concessional debt service does not appear as the major reason for weak performance in those countries for which the scheme works poorly.

Table 5
Correlation of Commodity Export Unit Values with World Prices

Country	Commodity	Correlation	Commodity	Correlation
Benin	Cotton	0.55		
Burkina Faso	Cotton	0.61		
Burundi	Coffee	0.87		
Cameroon	Coffee	0.93	Cocoa	0.91
Ghana	Cocoa	0.92		
Kenya	Coffee	0.85	Tea	0.92
Madagascar	Coffee	0.97		
Malawi	Tobacco	0.55		
Rwanda	Coffee	0.73	Tea	-0.26
Tanzania	Coffee	0.84	Cotton	0.60
	Tea	0.69		

The table gives the correlation of deviations of commodity export unit values from centered five year moving averages and the correspondingly defined deviations of the world prices from their moving averages. Sample: 1985-2001.

We now turn to the second factor we have identified which may account for poor performance. Basis risk is the risk that the price which one is using to hedge certain

transactions does not move perfectly with the price that one is attempting to hedge. Our concern in this context is that the prices countries obtain for their commodity exports may not be highly correlated with the international prices which we are using in order to construct the required commodity swaps. Table 5 reports these correlations.[13] The table shows the long term hedging basis to be generally good for coffee and cocoa and poor for cotton and tobacco. The correlations for tea are mixed.

Coffee and cocoa are actively traded on international futures markets in London and New York. These prices are widely disseminated and serve the exporters who purchase in developing country markets. Cotton is traded in New York, but the New York price relates primarily to the protected US market. We take the *Cotton Outlook* (Liverpool A) price as benchmark, but this price is based on a survey of supposedly representative trades and is, in that sense, less transparent than a futures market price. It is also less widely disseminated. We use US import unit values as the world tobacco price. It is unsurprising that this is only modestly correlated with Malawian export unit values. Tea is more complicated because there is an active cash market in Mombasa, Kenya, and this price is well correlated with Kenyan unit values. The correlation with Tanzanian unit values is less good, and that with Rwandan unit values is actually negative.

Table 6
Relative Importance of Price and Quantity Variability

Country	Commodity	Price	Quantity	Commodity	Price	Quantity
Benin	Cotton	14.6%	22.1%			
Burkina Faso	Cotton	14.6%	24.9%			
Burundi	Coffee	20.2%	25.1%			
Cameroon	Coffee	21.7%	18.3%	Cocoa	11.6%	15.1%
	Petroleum	17.9%	24.1%			
Ghana	Cocoa	11.6%	17.1%	Gold	7.2%	7.4%
Kenya	Coffee	20.2%	19.0%	*Petroleum*	*17.9%*	*20.9%*
	Tea	15.2%	10.0%			
Madagascar	Coffee	21.7%	19.2%	*Petroleum*	*17.9%*	*21.6%*
Malawi	Tobacco	7.7%	11.7%			
Rwanda	Coffee	20.2%	32.3%	Tea	15.2%	26.8%
Tanzania	Coffee	20.2%	16.5%	Cotton	14.6%	22.7%
	Tea	15.2%	6.2%	*Petroleum*	*17.9%*	*19.7%*

The table gives the standard deviations of the deviations of world prices and the volume of exports or imports, in each case measured relative to a centered five year moving average. Figures for petroleum imports appear in italics. Missing or unreliable data prevent calculation of the variability of the implied quantum of oil imports for all sampled countries except Kenya, Madagascar and Tanzania. Sample: 1985-2001.

We turn finally to the third factor, quantity variation. Price-based schemes insure countries against movements in prices but not against quantity variations. Table 6

[13] The table excludes gold and oil since for these two commodities we construct export and import values by multiplying quantities by world prices.

compares the extent of price and quantity variations for the major commodity exports of the ten countries in our sample.[14] The table also gives comparable figures for petroleum imports for the three countries for which these data are available. Considering only the export statistics, price variability averages 15.9% whereas quantity variability averages 18.7%, and in 12 of the 17 tabulated country-commodity pairs, quantity variability exceeds price variability. Furthermore, this is also true in the three cases where we have reliable oil import data. Overall, quantity and price variability appear to be of comparable magnitude, with the prevalent tendency being for quantity variability to exceed price variability.

Of course, price and quantity movements will not be independent, and some of the quantity variation may be the consequence of price variations. We may analyze the extent to which this limitation is important by means of a simple decomposition. Using a different notation from the remainder of this paper, write the export revenue from a commodity as *R*, its price as *P* and the quantity exported as *Q*. We use lower case letters to denote the demeaned logarithms of the corresponding upper case variables. It follows that

$$r = \ln R - \overline{\ln R} = \left(\ln P - \overline{\ln P}\right) + \left(\ln Q - \overline{\ln Q}\right) = p + q \tag{15}$$

Denote $\sigma_x^2 = Var(x)$ for any variable *x* and the covariance $\sigma_{xy} = Cov(x, y)$ for any pair of variables *x* and *y*. Finally, write the quantity-price regression as $q = \beta p + u$. Since *p* and *u* are uncorrelated by construction, it follows that

$$\sigma_r^2 = (1+\beta)^2 \sigma_p^2 + \sigma_u^2 = \left(1 + \frac{\sigma_{pq}}{\sigma_p^2}\right)^2 \sigma_p^2 + \sigma_u^2 \tag{16}$$

The ratio $\frac{\sigma_u^2}{\sigma_r^2} = 1 - \frac{\left(1 + \frac{\sigma_{pq}}{\sigma_p^2}\right)^2 \sigma_p^2}{\sigma_r^2}$ measures the extent of revenue variation that cannot be explained by contemporaneous price deviations and must therefore be attributed either to movements in the price basis or to uncorrelated quantity movements. Table 7 gives this ratio for the commodity exports we have considered in the simulation exercises. In general, prices explain less than 50% (and in some cases substantially less than 50%) of revenue movements.

Quantity variability appears to be the major reason for the relatively weak performance of the schemes we have considered. Quantity variability undermines any non-discretionary hedging scheme. This conclusion is not new but previous research, particularly that by Goreux (1980) and Lim (1991), which derived the same implication has not received adequate attention. In the most comprehensive study, Lim (1991) found that "volume instability is more pronounced than price instability at the country level". According to Lim, the major cause of quantity uncertainty was country-specific supply factors such as weather conditions, strikes (for mineral commodities) and socio-political factors.

[14] Sources for volume data: agricultural commodities: FAO; gold: World Bureau of Metal Statistics; petroleum: International Energy Association.

Table 7 Estimated Importance of Quantity and Basis Variation				
Country	**Commodity**	**Correlation**	**Commodity**	**Correlation**
Benin	Cotton	80%		
Burkina Faso	Cotton	67%		
Burundi	Coffee	40%		
Cameroon	Coffee Petroleum	44% 97%	Cocoa	39%
Ghana	Cocoa	78%	Gold	55%
Kenya	Coffee	64%	Tea	55%
Madagascar	Coffee	34%		
Malawi	Tobacco	59%		
Rwanda	Coffee	84%	Tea	76%
Tanzania	Coffee Tea	51% 21%	Cotton	88%
The table gives the proportion of the variance of deviations of log commodity revenues from centered five year moving averages which *cannot* be explained by deviations in international prices from centered five year moving averages – see equation (16). We interpret this measure as stating the importance of quantity and basis variations. Sample: 1985-2001.				

In summary, both basis and quantity risk appear to be significant problems for price-based schemes of the form we consider in this paper. More generally, however, movements in world prices typically account for less than half the variation in commodity export revenues for indebted countries. The implication is that non-discretionary hedges based on world prices will not offer very adequate insurance against revenue fluctuations at the aggregate level.[15]

In an appendix, we look in detail at three of the ten countries for which we have conducted simulations: Burundi (the country for which the scheme performs best), Ghana (an intermediate example) and Benin (the country for which the scheme performs least well). The objective is to draw general lessons in relation to the merits and problems of the proposal.

Each of the three countries we have considered tells a different story. The common element is that movements in international commodity prices are not, in general, the major factor responsible for movements in reported export revenues and import expenditures, even in countries which are highly dependent on these commodities. This is partly because of basis risk and partly because of unrelated quantity variations.

[15] There is no direct implication for hedging by producers. A particular producer may be well informed about his production level even if there is considerable quantity variation at the national level. This would also extend to basis risk to the extent that basis risk reflects quality variation which the farmer can reasonably anticipate.

- In Burundi, where coffee prices do account for a significant proportion of the variation of coffee revenues, there were two major falls in revenue over the nineteen nineties which were not due to price movements.
- In Ghana, movements in commodity export and oil import revenues relate more to structural factors as to price movements.
- In Benin, data quality issues are sufficiently acute as to lead to the worry that the results may be dominated by accounting errors, preventing any clear substantive conclusion beyond the concern that the local and world cotton prices appear too weakly related for a hedge scheme to be viable.

None of this implies that price effects are unimportant. Rather, the arguments underline that these are not the only important factor. But these factors do explain why schemes, such as those we consider, which relay only on prices, may be less effective than one might have hoped.

8. Conclusions

We have asked the question of whether it is possible to increase the flexibility of heavily indebted primary producing countries in meeting their concessional debt service obligations. The answer to this question is that this can in principle be done by augmenting existing concessional debt agreements by a set of floating-for-fixed commodity swaps or swaptions. These should take the form of "variable strike" instruments in which the "fixed" price is an estimate of the underlying trend price, probably implemented through a moving average of past prices. Modifications of this sort certainly appear feasible.

Feasibility does not imply effectiveness. Countries may already have methods for coping with commodity price variability, even at the macroeconomic level, and these may be undermine by hedging arrangements. Of even greater importance, different countries are subject to a large number of shocks (for example, demand shocks, exchange rate changes and political disturbances), and the effects of these shocks may dominate those of commodity price shocks. The issue of whether a particular country would have benefited from a scheme of this sort, for example over the past decade, is therefore primarily empirical. We have investigated this for ten commodity dependent severely or moderately indebted African countries.

The scale of the benefits varies from country to country. Using a fairly conservative money metric, the proposed instrument turns out to be worth the same as a cut in debt service payments of between zero and 5%. The median value across our sample is between ½% and 2¼% depending on scheme design. Use of a less conservative risk aversion parameter could raise these estimates by a factor of two or, conceivably, three. However, those scheme which are seen as generating the highest (1%-5%) benefits adopt hedge positions in relation to trend exports rather than contractual debt service commitments, and the additional benefits generated by these schemes turns out to be at the expense of a disproportionately large disruption of debt service payments to the concessionary lenders, and in particular to IDA. One is therefore confronted by a choice between schemes which impose relatively low costs on the lenders but generate

correspondingly low benefits to the borrowers, and alternatives which generate higher, albeit still modest, benefits, but at the expense of very considerable and potentially costly disruption of flows to lenders.

We have looked in some detail at the reasons for the relatively weak performance of these price-based schemes. The main reason appears to be that movements in international prices are only one of several factors that generate movements in countries' reported commodity earnings. In general, world prices account for less than half of total revenue movements. Quantity variations and variations in local prices relative to those in world markets also play an important role. In particular, quantity variation is typically at least of the same order of importance as price variation in accounting for variations in countries' commodity export revenues. Schemes, such as those we consider, which are based on world prices, cannot offer protection against these other factors.

The summary answer to the question we have posed is that it is possible to modify the terms of concessional debt service so that it more closely matches countries' abilities to make these payments, but this will only be of value to a subset of indebted countries. Schemes based on these principles cannot be a universal panacea and, if they are introduced, this should be on a discretionary, country-by-country, basis. But even where such a scheme would be useful, its value would be relatively modest – we estimate as equivalent to a reduction of less than 10% in concessional debt service payments.

It is important that the policy community is clear as to what it is aiming to achieve. If the objective is to ease debt payments, it may be preferable to consider further debt relief rather than attempting to make the service of existing debt more palatable. On the other hand, if the objective is to provide commodity-exporting countries, or their governments, with a measure of insurance against the impact of adverse revenue fluctuations, it is arguable that this may be better achieved through a compensatory finance mechanism, notwithstanding despite the well known problems (timeliness, moral hazard etc) that arise in connection with these schemes.

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Table 8
Simulation Summary Statistics (1991-2000)

Objective: Minimization of $Var(X - O - S)$ Instrument: S

	Actual	Scheme	Share-based Weights			Regression-based weights		
	standard deviation		standard deviation	welfare change %	welfare change $m	standard deviation	welfare change %	welfare change $m
Benin	17.5%	A	17.6%	-0.2%	-$0.1m	17.6%	-0.2%	-$0.1m
		B	17.6%	-0.1%	-$0.0m	17.6%	-0.1%	-$0.0m
Burkina Faso	35.9%	A	35.1%	1.6%	$0.5m	34.5%	2.6%	$0.8m
		B	35.3%	1.2%	$0.3m	35.0%	1.8%	$0.5m
Burundi	28.2%	A	23.1%	5.1%	$1.0m	24.7%	3.6%	$0.7m
		B	24.1%	4.2%	$0.8m	25.5%	2.8%	$0.5m
Cameroon (1991-99)	9.5%	A	9.3%	0.4%	$0.3m	9.2%	0.6%	$0.5m
		B	9.5%	0.0%	$0.0m	9.4%	0.1%	$0.1m
Ghana	20.0%	A	19.9%	0.3%	$0.3m	20.0%	0.1%	$0.1m
		B	20.0%	0.1%	$0.1m	20.0%	-0.0%	-$0.0m
Kenya	5.3%	A	5.0%	0.2%	$0.2m	5.0%	0.2%	$0.2m
		B	5.0%	0.2%	$0.2m	5.1%	0.2%	$0.2m
Madagascar	26.6%	A	26.5%	0.2%	$0.1m	26.0%	1.0%	$0.5m
		B	26.7%	-0.1%	-$0.1m	26.2%	0.6%	$0.3m
Malawi	12.3%	A	11.6%	0.9%	$0.3m	11.8%	0.7%	$0.2m
		B	12.1%	0.2%	$0.1m	12.2%	0.1%	$0.0m
Rwanda (not 1994-95)	19.1%	A	15.8%	3.5%	$0.5m	16.0%	3.2%	$0.5m
		B	17.4%	1.8%	$0.3m	18.4%	0.8%	$0.1m
Tanzania	12.1%	A	11.6%	0.4%	$0.3m	11.6%	0.4%	$0.3m
		B	11.7%	0.3%	$0.2m	11.9%	0.1%	$0.1m
Average	*18.7%*	A	*17.6%*	*1.2%*	*$0.3m*	*17.6%*	*1.2%*	*$0.4m*
		B	*17.9%*	*0.8%*	*$0.3m*	*18.1%*	*0.6%*	*$0.2m*
Median	*18.3%*	A	*16.7%*	*0.4%*	*$0.3m*	*16.8%*	*0.7%*	*$0.4m*
		B	*17.5%*	*0.2%*	*$0.2m*	*18.0%*	*0.2%*	*$0.1m*

The standard deviation measures the standard deviation of the approximated ratio of debt service to exports, less a proportion of oil imports – see text.
The welfare change is calculated as the percentage and dollar values of the reduction in concessional debt service which would yield the same welfare improvement as the proposed modifications to concessional debt contracts. All welfare changes assume a unit coefficient of partial risk aversion and would be increased proportionately for higher values of this coefficient.

Table 9
Simulation Summary Statistics (1991-2000)

Objective: Minimization of $Var\left(\frac{S+\gamma O}{X}\right)$ Instrument: S

	Actual	Scheme	Share-based Weights			Regression-based weights		
	standard deviation		standard deviation	welfare change %	welfare change $m	standard deviation	welfare change %	welfare change $m
Benin	4.5%	A	4.6%	-0.3%	-$0.1m	4.5%	-0.1%	-$0.0m
		B	4.5%	-0.0%	-$0.0m	4.5%	-0.0%	-$0.0m
Burkina Faso	10.1%	A	9.5%	1.6%	$0.5m	9.7%	0.6%	$0.2m
		B	9.6%	1.2%	$0.3m	10.0%	0.3%	$0.1m
Burundi	17.3%	A	13.9%	5.1%	$1.0m	16.1%	1.7%	$0.3m
		B	14.4%	4.2%	$0.8m	16.4%	1.3%	$0.3m
Cameroon (1991-99)	1.4%	A	1.2%	0.4%	$0.3m	1.3%	1.5%	$1.1m
		B	1.3%	0.0%	$0.0m	1.2%	0.2%	$0.2m
Ghana	5.5%	A	5.4%	0.3%	$0.3m	5.5%	0.0%	$0.0m
		B	5.5%	0.1%	$0.1m	5.5%	0.0%	$0.0m
Kenya	2.1%	A	1.8%	0.2%	$0.2m	2.1%	0.0%	$0.0m
		B	1.9%	0.2%	$0.2m	2.1%	0.0%	$0.0m
Madagascar	12.4%	A	12.4%	0.2%	$0.1m	12.3%	0.4%	$0.2m
		B	12.6%	-0.1%	-$0.1m	12.4%	0.2%	$0.1m
Malawi	1.5%	A	1.3%	0.9%	$0.3m	1.4%	0.0%	$0.0m
		B	1.4%	0.2%	$0.1m	1.5%	0.0%	$0.0m
Rwanda (not 1994-95)	5.9%	A	3.4%	3.5%	$0.5m	5.6%	0.5%	$0.1m
		B	4.4%	1.8%	$0.3m	5.8%	0.1%	$0.0m
Tanzania	5.0%	A	4.4%	0.4%	$0.3m	4.8%	0.1%	$0.1m
		B	4.5%	0.3%	$0.2m	4.9%	0.1%	$0.0m
Average	*6.6%*	A	*5.8%*	*1.2%*	*$0.3m*	*6.3%*	*0.5%*	*$0.2m*
		B	*6.0%*	*0.8%*	*$0.2m*	*6.4%*	*0.2%*	*$0.1m*
Median	*5.3%*	A	*4.5%*	*0.4%*	*$0.3m*	*5.2%*	*0.3%*	*$0.1m*
		B	*4.5%*	*0.2%*	*$0.2m*	*5.2%*	*0.1%*	*$0.0m*

The standard deviation measures the standard deviation of the approximated ratio of debt service to exports, less a proportion of oil imports – see text.
The welfare change is calculated as the percentage and dollar values of the reduction in concessional debt service which would yield the same welfare improvement as the proposed modifications to concessional debt contracts. All welfare changes assume a unit coefficient of partial risk aversion and would be increased proportionately for higher values of this coefficient.

Table 10
Simulation Summary Statistics (1991 2000)

Objective: Minimization of $Var(X - O - S)$ Instrument: $\tilde{X}$

	Actual	Scheme	Share-based Weights			Regression-based weights		
	standard deviation		standard deviation	welfare change %	welfare change $m	standard deviation	welfare change %	welfare change $m
Benin	17.5%	A	19.0%	-2.9%	-$0.8m	18.8%	-2.6%	-$0.7m
		B	18.4%	-1.8%	-$0.5m	18.4%	-1.7%	-$0.5m
Burkina Faso	35.9%	A	33.6%	4.2%	$1.2m	34.0%	3.6%	$1.1m
		B	33.6%	4.4%	$1.3m	32.3%	6.6%	$1.9m
Burundi	28.2%	A	25.7%	2.7%	$0.5m	23.6%	4.7%	$0.9m
		B	22.5%	5.6%	$1.1m	22.3%	5.8%	$1.1m
Cameroon (1991-99)	9.5%	A	8.8%	1.5%	$1.1m	7.7%	3.3%	$2.5m
		B	9.7%	-0.5%	-$0.3m	9.0%	1.0%	$0.8m
Ghana	20.0%	A	19.9%	0.2%	$0.2m	19.7%	0.8%	$0.8m
		B	20.0%	0.2%	$0.2m	20.1%	-0.1%	-$0.2m
Kenya	5.3%	A	4.8%	0.3%	$0.4m	4.6%	0.4%	$0.5m
		B	4.0%	0.8%	$0.8m	3.8%	0.9%	$0.9m
Madagascar	26.6%	A	27.6%	-1.5%	-$0.7m	24.6%	3.0%	$1.5m
		B	26.8%	-0.3%	-$0.2m	25.1%	2.4%	$1.2m
Malawi	12.3%	A	8.0%	5.4%	$1.6m	8.2%	5.2%	$1.6m
		B	10.5%	2.5%	$0.7m	11.4%	1.2%	$0.4m
Rwanda (not 1994-95)	19.1%	A	12.9%	5.9%	$0.9m	13.1%	5.7%	$0.9m
		B	13.9%	5.1%	$0.8m	15.4%	3.8%	$0.6m
Tanzania	12.1%	A	11.6%	0.4%	$0.3m	10.2%	1.4%	$1.2m
		B	11.1%	0.7%	$0.6m	11.2%	0.7%	$0.6m
Average	*18.7%*	A	*17.2%*	*1.6%*	*$0.5m*	*16.5%*	*2.6%*	*$1.0m*
		B	*17.1%*	*1.7%*	*$0.5m*	*16.9%*	*21%*	*$0.7m*
Median	*18.3%*	A	*16.0%*	*1.0%*	*$0.5m*	*16.0%*	*3.2%*	*$1.0m*
		B	*16.2%*	*0.8%*	*$0.7m*	*16.9%*	*1.1%*	*$0.7m*

The standard deviation measures the standard deviation (about its moving average trend) of the difference between exports and the sum of debt service and oil imports – see text.
The welfare change is calculated as the percentage and dollar values of the reduction in concessional debt service which would yield the same welfare improvement as the proposed modifications to concessional debt contracts. All welfare changes assume a unit coefficient of partial risk aversion and would be increased proportionately for higher values of this coefficient.

Table 11
Simulation Summary Statistics (1991-2000)

Objective: Minimization of $Var\left(\frac{S+\gamma O}{X}\right)$ Instrument: $\tilde{X}$

	Actual	Scheme	Share-based Weights			Regression-based weights		
	standard deviation		standard deviation	welfare change %	welfare change $m	standard deviation	welfare change %	welfare change $m
Benin	4.5%	A	7.0%	-3.4%	-$0.9m	4.5%	-0.0%	-$0.0m
		B	5.9%	-2.2%	-$0.6m	4.5%	-0.0%	-$0.0m
Burkina Faso	10.1%	A	10.2%	4.2%	$1.2m	8.2%	2.8%	$0.8m
		B	8.7%	4.4%	$1.3m	9.3%	1.4%	$0.4m
Burundi	17.3%	A	19.6%	2.7%	$0.5m	14.3%	4.9%	$0.9m
		B	15.5%	5.6%	$1.1m	14.2%	4.4%	$0.8m
Cameroon (1991-99)	1.4%	A	3.3%	1.5%	$1.1m	1.4%	1.3%	$1.0m
		B	2.0%	-0.5%	-$0.3m	1.2%	0.2%	$0.2m
Ghana	5.5%	A	7.0%	0.2%	$0.2m	5.3%	0.1%	$0.1m
		B	6.1%	0.2%	$0.2m	5.5%	-0.0%	-$0.0m
Kenya	2.1%	A	3.7%	0.3%	$0.4m	1.6%	0.3%	$0.3m
		B	3.2%	0.8%	$0.8m	1.8%	0.2%	$0.2m
Madagascar	12.4%	A	15.0%	-1.5%	-$0.7m	11.0%	3.3%	$1.6m
		B	13.9%	-0.3%	-$0.2m	11.4%	2.8%	$1.4m
Malawi	1.5%	A	6.1%	5.4%	$1.6m	1.1%	0.2%	$0.1m
		B	2.5%	2.5%	$0.7m	1.2%	0.2%	$0.1m
Rwanda (not 1994-95)	5.9%	A	9.7%	5.9%	$0.9m	5.0%	1.5%	$0.2m
		B	5.6%	5.1%	$0.8m	5.6%	0.4%	$0.1m
Tanzania	5.0%	A	7.5%	0.4%	$0.3m	4.1%	0.7%	$0.6m
		B	5.7%	0.7%	$0.6m	4.5%	0.3%	$0.3m
Average	*6.6%*	A	*8.9%*	*1.6%*	*$0.5m*	*5.7%*	*1.5%*	*$0.6m*
		B	*6.9%*	*1.6%*	*$0.4m*	*5.9%*	*1.0%*	*$0.4m*
Median	*5.3%*	A	*7.3%*	*1.0%*	*$0.5m*	*4.8%*	*1.0%*	*$0.5m*
		B	*5.8%*	*0.8%*	*$0.7m*	*5.0%*	*0.3%*	*$0.2m*

The standard deviation measures the standard deviation (measured about its moving average trend) of the ratio of debt service to exports, less a proportion of oil imports – see text.
The welfare change is calculated as the percentage and dollar values of the reduction in concessional debt service which would yield the same welfare improvement as the proposed modifications to concessional debt contracts. All welfare changes assume a unit coefficient of partial risk aversion and would be increased proportionately for higher values of this coefficient.

Appendix: Country Studies

Burundi

Burundi is the country for which the proposed schemes would have performed best, with the possible exception of Rwanda where the analysis is complicated by the civil war. Burundi's major export is coffee. This accounted for an average 79% of its total export revenues over our simulation period of 1991-2000. This coffee was almost entirely of the arabica variety. The cost of oil imports averaged 31% of total export revenues over the same period. Figure A1 graphs these receipts and expenditures. It is apparent that, in Burundi, coffee export revenue is highly variable while oil import expenditures are quite smooth. The major coffee revenue declines in 1993 and 1996 are arrowed for future reference.

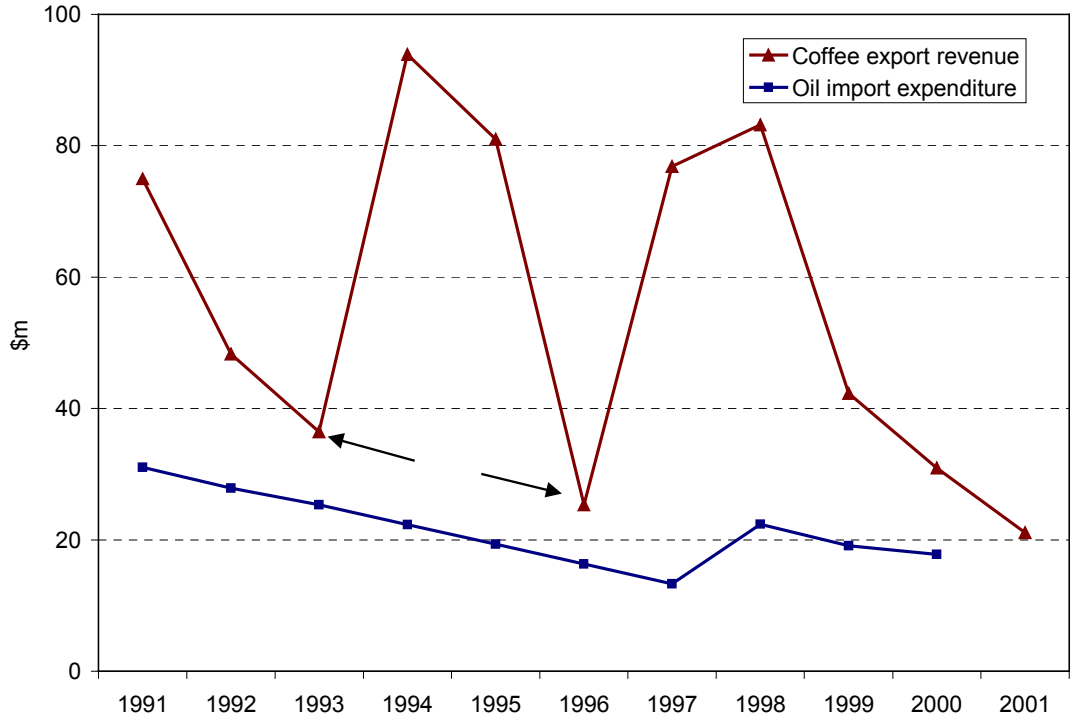

Figure A1: Burundi - Coffee export revenue and oil import expenditures, 1991-2001

Figure A2 shows Burundi's concessional debt service over the longer period 1984-2001. As bilateral concessional lending has declined, repayments of concessional debt have come to be dominated by IDA. The overall volume of concessional debt repayments has grown over time and Burundi's concessional debt service to export ratio has also increased to a 2001 level of 42%.

Figure A3 graphs the arabica (left hand axis) and petroleum prices (right hand axis) over the simulation period. Coffee prices were high in the mid-nineties but plummeted in 1999. At the same time, petroleum prices rose sharply from a previously relatively stable level. Table 5 emphasizes that Burundi generally experiences a very satisfactory hedging

basis relative to the New York price for arabica coffee. However, movements in that price only explain around 40% of movements in coffee revenue – see Table 7. In that context, it is important to note that the coffee price rose slightly in 1993 from its depressed 1992 level, and in 1996 fell back moderately from a high 1995 level – see arrows.

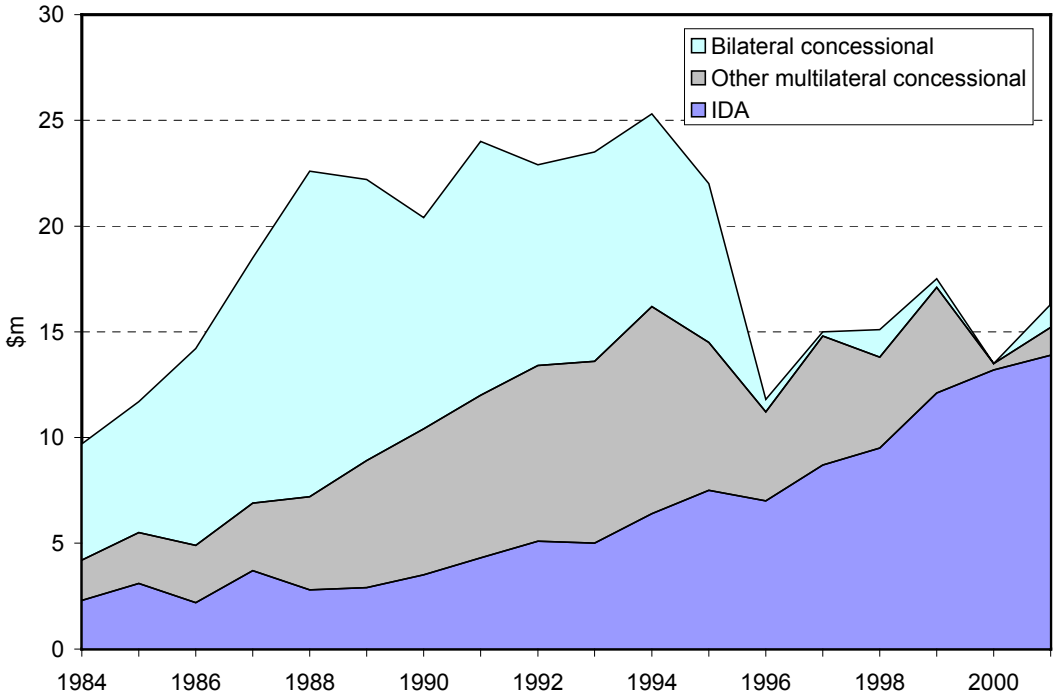

Figure A2: Burundi - Concessional debt service payments, 1984-2001

Coffee export revenues were highly positively correlated with the world arabica coffee price (r = 0.57) but oil import expenditures were weakly negatively correlated with the world oil price (r = -0.17).[16] These correlations imply that any hedge should primarily relate to coffee and not to oil. The regression-based hedge ratios are 48% for coffee and 22% for oil, both less than their respective shares in total export revenues. The oil hedge parameter reflects a statistically significant negative correlation between the oil price and coffee exports (r = -0.48) which implies, paradoxically, that although a short oil hedge will not protect oil import expenditures, it will hedge coffee export revenues.

[16] Here and elsewhere, reported correlations relate to the longer period 1985-2000 in order to give greater precision. All correlations relate to deviations from centered five year moving average trends.

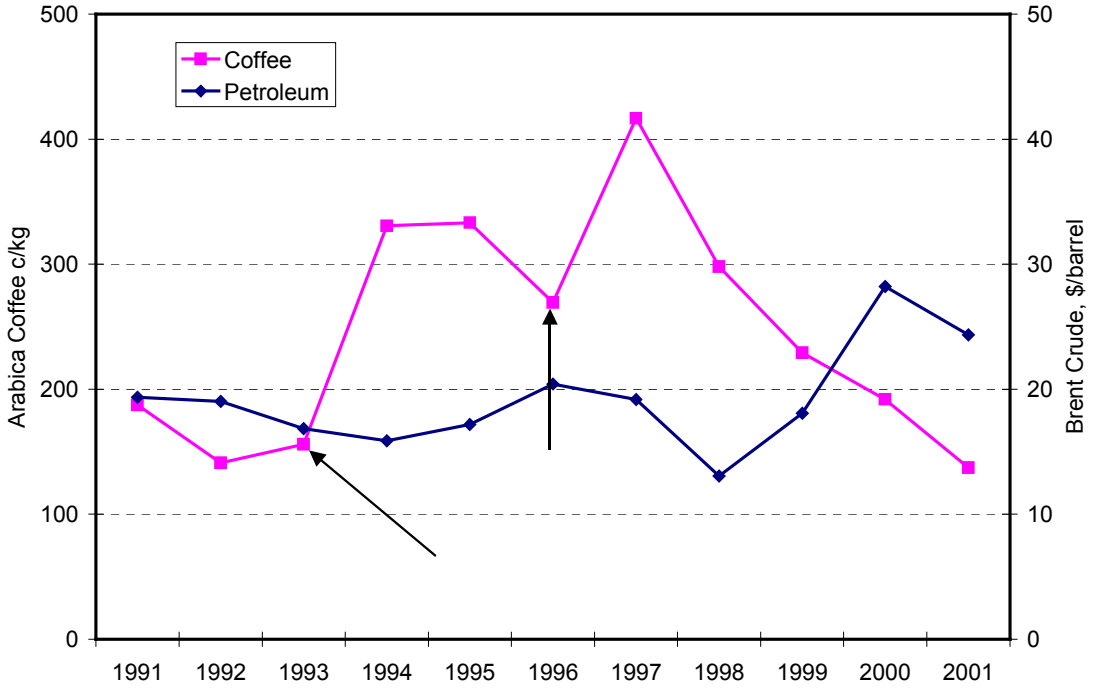

Figure A3: Burundi - Commodity export and import prices

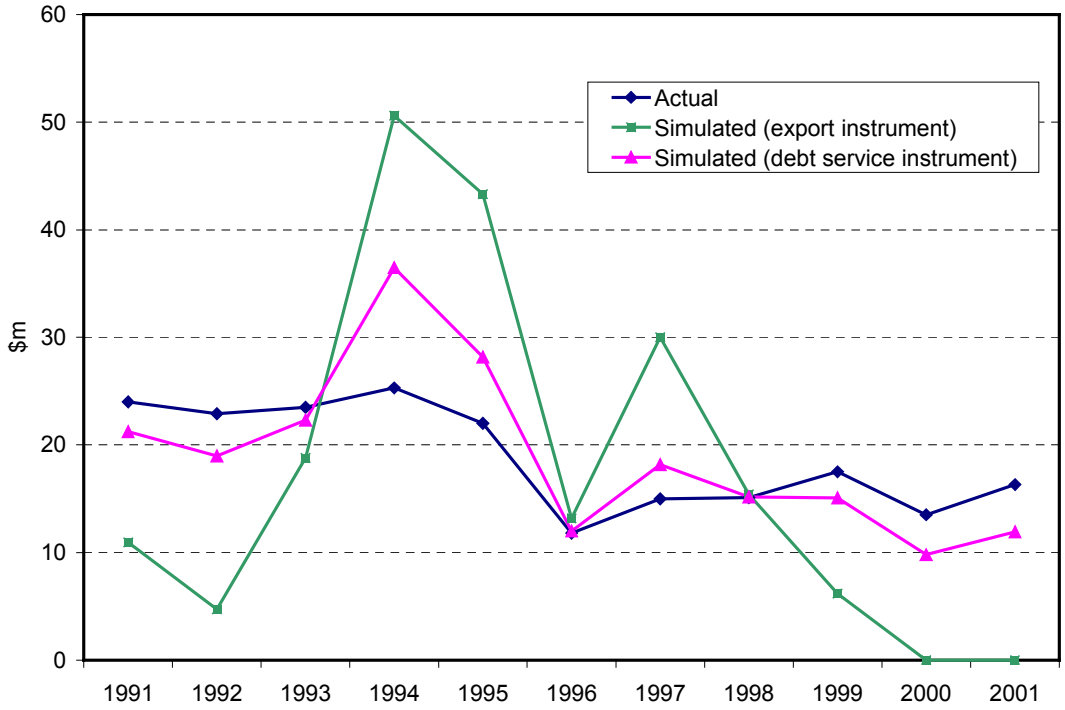

Figure A4: Burundi – Actual and simulated concessional debt service

Figure A4 compares Burundi's simulated concessional debt repayments under the export-based swap scheme A (using regression weights) compared with historic repayments.

Payments are lower in five years, higher in three and broadly similar in three. In particular, no repayments would have been made in the final two years of the sample (2000 and 2001) which saw the coincidence of low coffee and high oil prices. Figure A4 also graphs simulated debt service using debt service levels rather than exports as the instrument. Relative movements are similar to those generated by the export-based scheme, but they are much smaller and the effects are lower. Finally, Figure A5 graphs the resulting quantity of free foreign exchange in the two simulated environments. The schemes are both somewhat successful in reducing the variability of this quantity, but neither does anything in relation to the sharp falls in coffee revenue in 1993 and 1996 which were not primarily related to price movements – recall that the coffee price rose slightly in 1993 and fell back modestly but at a high level in 1996.

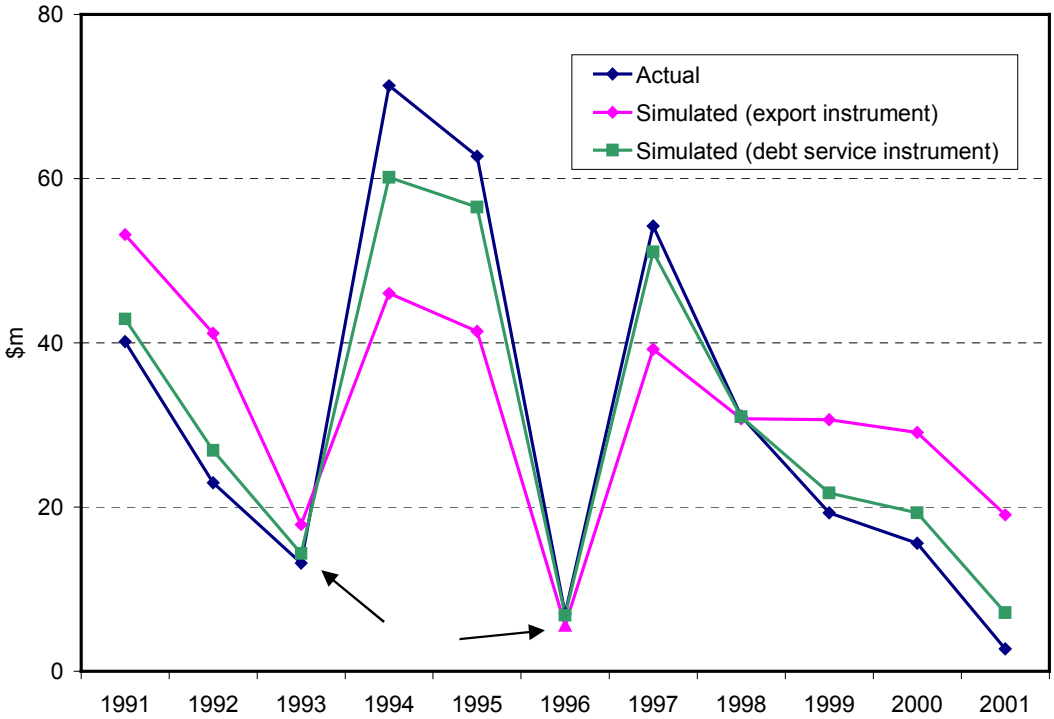

Figure A5: Burundi – Actual and simulated free foreign exchange

Overall, a Burundi scheme would have operated reasonably well but would nevertheless have failed to cope with two major revenue movements which were not (or were only slightly) determined by changes in world prices.

Ghana

The proposed schemes perform only moderately well in Ghana. Ghana has two major commodity exports – gold, which accounted for an average 40% of its total export revenues over our simulation period of 1991-2000, and cocoa, which accounted for 25% of export revenues. The cost of oil imports averaged 24% of total export revenues over the same period. Figure A6 graphs these receipts and expenditures. Note that we estimated oil import figures by linear interpolation over the period 1993-95. The poor quality of oil import and export data is not unique to Ghana and is a major limitation on

our ability to infer appropriate oil hedge ratios. Gold revenues fluctuate only mildly around a steady upward trend, while cocoa revenues and (so far as we can tell) oil import expenditures are more volatile.

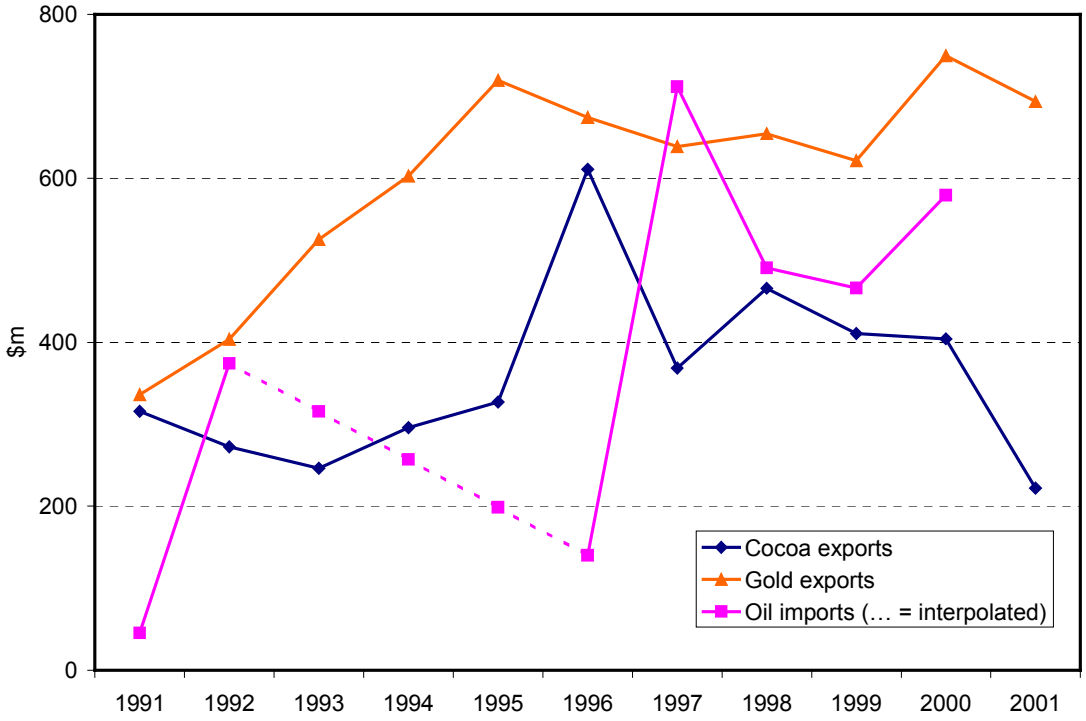

Figure A6: Ghana – Gold and cocoa export revenue and oil import expenditures, 1991-2001

Figure A7 shows Ghana's concessional debt service over the period 1984-2001. Bilateral concessional lending has been important in Ghana, but it has recently declined, and concessional debt repayments are now dominated by IDA – see also Figure 3. Although the overall volume of concessional debt repayments has grown over time, this has only been in line with export revenues and Ghana's concessional debt service to export ratio has only increased modestly to a 2000 level of 10%.

Figure A8 graphs the cocoa and gold prices (left hand axis) and petroleum prices (right hand axis) over the simulation period. Both export prices were moderately favorable until the mid-nineties but gold fell from 1995 and cocoa, more sharply, in 1999. At the same time, petroleum prices rose sharply from a previously relatively stable level. Table 5 shows that Ghana typically enjoys an excellent hedging basis with the world cocoa price, and the same must also be true of gold where we do not have the unit value data required to undertake that calculation. By contrast, prices only explain around 22% of changes in cocoa revenues and 45% of changes in gold revenues.

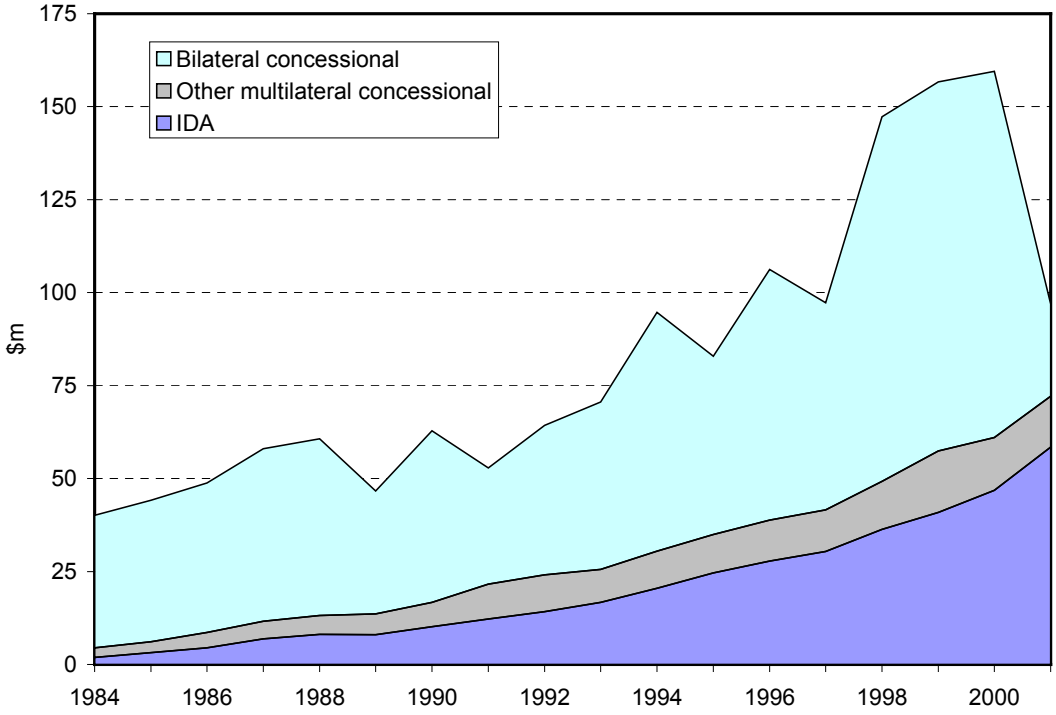

Figure A7: Ghana - Concessional debt service payments, 1984-2001

Ghanaian cocoa export revenues exhibit a weak negative correlation with the world cocoa price (r = -0.10) while gold exports show a positive correlation with the gold price (r = 0.46). Oil import expenditures were weakly negatively correlated with the world oil price (r = -0.13). The low cocoa correlation reflects the hedging practices of Cocobod, the monopoly-monopsony state cocoa marketing board, which sells around three quarters of the crop forward.[17] These correlations imply that any hedge should primarily relate to gold and not to cocoa or oil. The regression-based hedge ratios are 42% for gold (close to its export share), 8% for cocoa (much less than its export share) and zero for petroleum, where the regression estimates would have implied a negative hedge ratio.

Figure A9 compares Ghana's simulated concessional debt repayments under the export and debt service-based swap schemes A (using regression weights) compared with historic repayments. Payments are lower in eight of the years and higher in just three years. The payments under the debt-service based scheme move in the same way as those under those in which trend exports are the instrument, but the impacts are much smaller. The relatively low ratio of concessional debt service to exports is sufficient to cause the welfare impact of the debt service-based scheme to be negligible – see Table 3.

[17] Ashanti Gold Fields Corporation, the major private sector gold mining company, also sells its gold forward but this will not be evident in the way we have imputed gold revenues – see previous footnote.

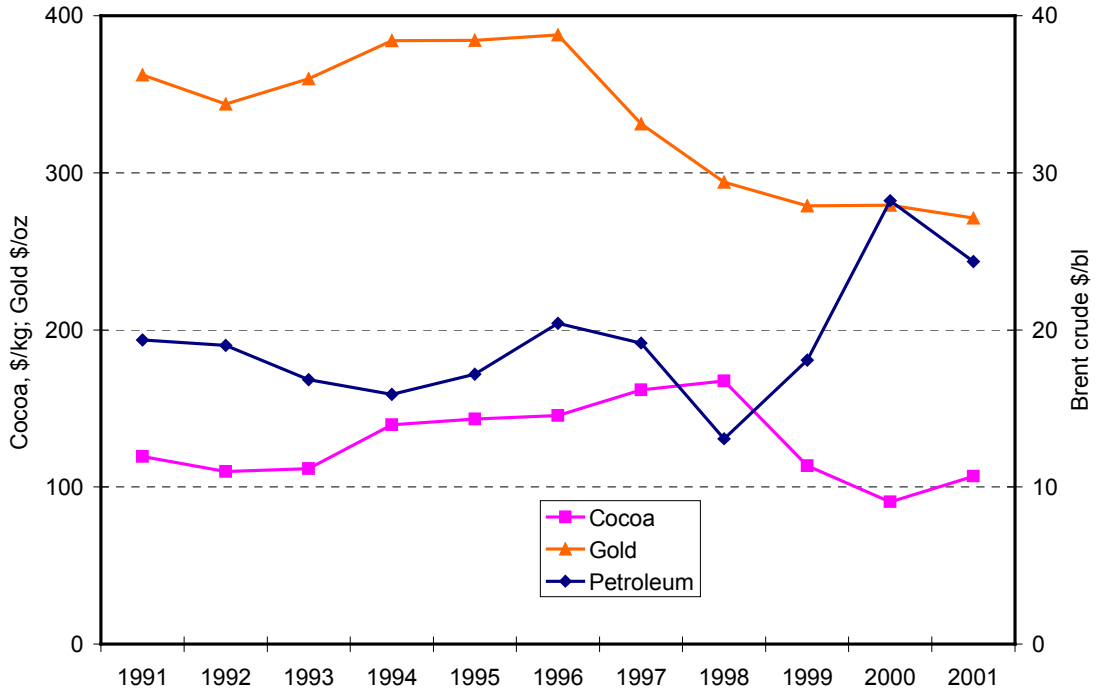

Figure A8: Ghana - Commodity export and import prices

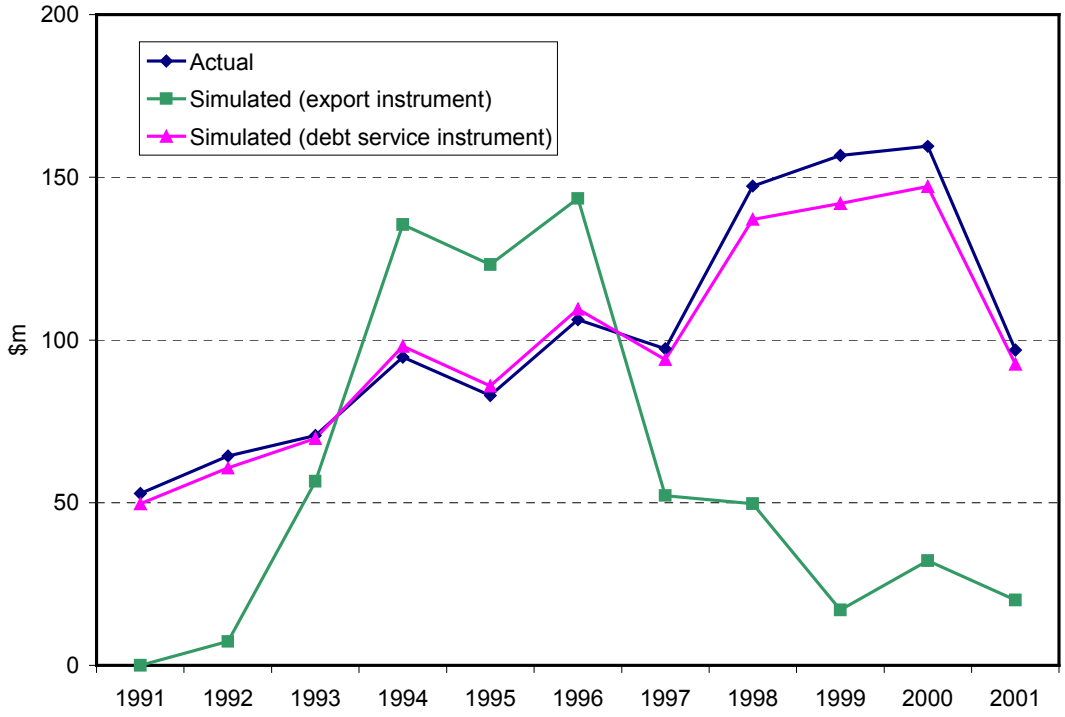

Figure A9: Ghana – Actual and simulated concessional debt service

Finally, Figure A10 graphs the resulting quantity of free foreign exchange in the two simulated environments. Export revenues grew faster than oil import and debt service expenditures through the first half of the nineteen nineties releasing foreign exchange for other uses. This trend came to a stop in 1996, with export revenues dropping to a lower level for the remainder of the decade. This fall was partly due to a fall in cocoa prices and to lower gold prices, but also partly reflected high oil consumption in what had become a richer and more successful economy, and to the fact that the rate of growth of gold production had declined as mine expansion plans were completed. These changes appear to be as much structural as due to cyclical price movements, and schemes driven by cyclical price movements therefore only offer modest improvements.

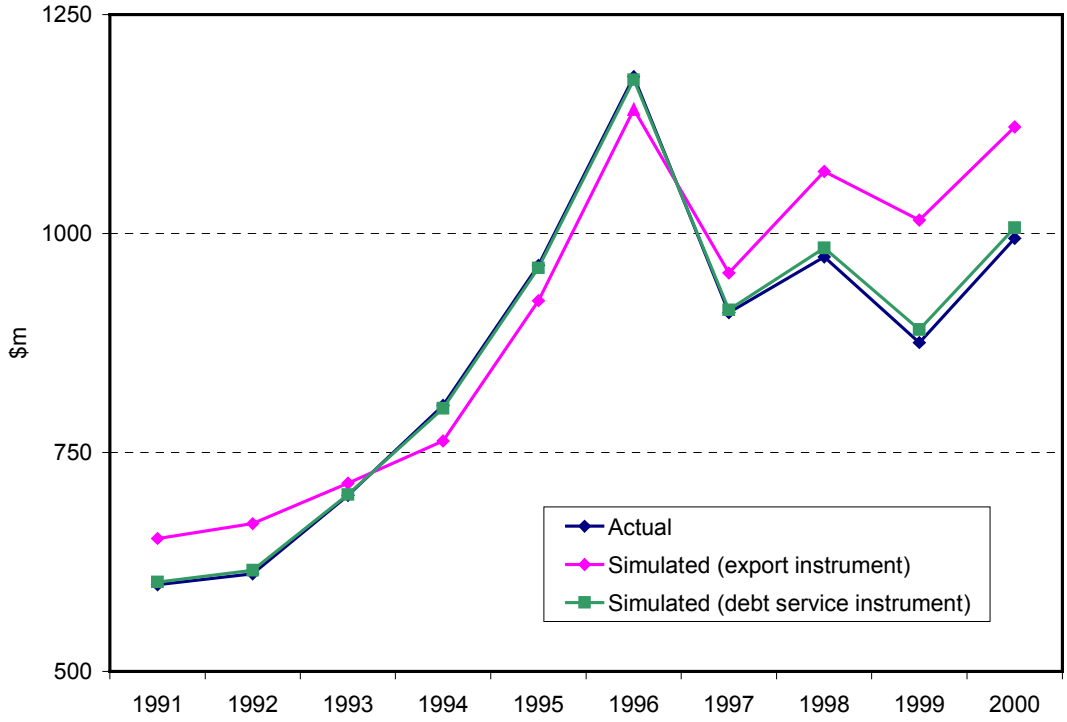

Figure A10: Ghana – Actual and simulated free foreign exchange

The overall conclusion of the analysis is that any difficulties Ghana may have experienced in meeting debt service payments on concessional debt in the nineteen nineties, and we are not aware that were such difficulties, were not primarily due to movements in its export or import prices. In this light, it is unsurprising that the schemes we have considered fail to generate much value.

Benin

Benin gives the poorest results of the ten countries in our sample. Benin's major export is cotton, which accounted for an average 35% of its total export revenues over our simulation period of 1991-2000. The cost of oil imports averaged 16% of total export revenues over the same period. Figure A11 graphs these receipts and expenditures. Note

that we estimated oil import figures by linear interpolation over the period 1991-93.[18] The data show both cotton revenues and oil import costs to be highly variable.

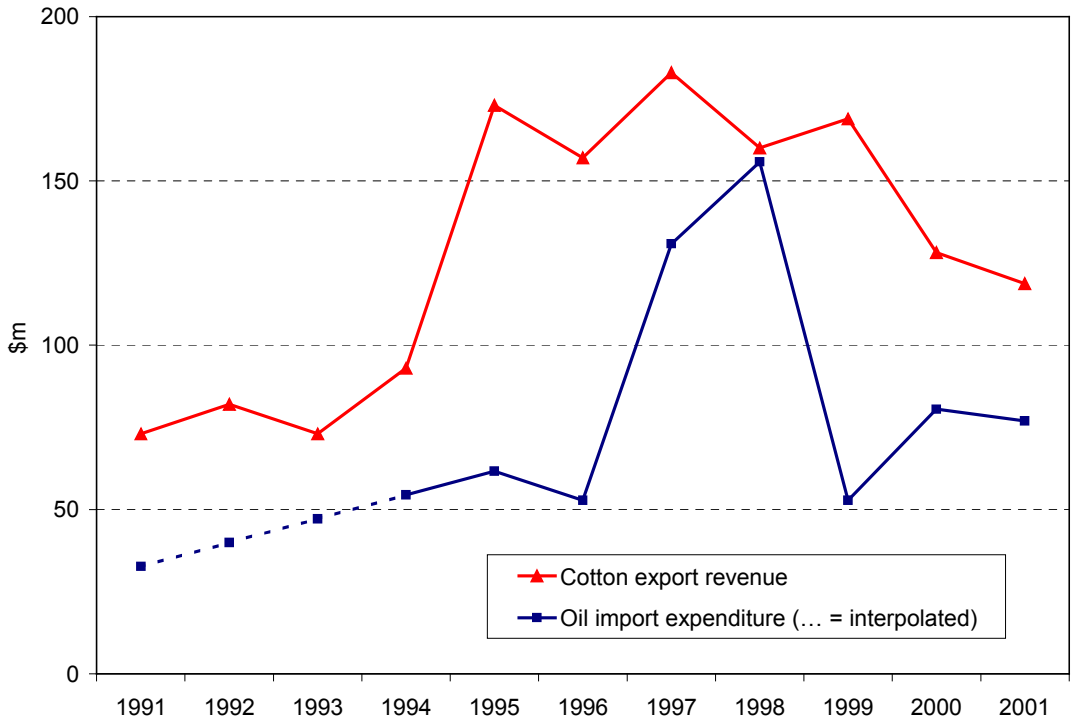

Figure A11: Benin –cotton export revenue and oil import expenditures, 1991-2001

Figure A12 shows Benin's concessional debt service over the period 1984-2001. Concessional debt repayments have grown over time to reach a pre-HIPC maximum of 11% of export revenue in 2000. The African Development Bank is as important as IDA as a recipient of concessional debt repayments.

Figure A13 graphs the cotton cocoa price (left hand axis) and petroleum price (right hand axis) over the simulation period. The cotton price is an index based on a survey of supposedly representative transactions, and it is not clear whether this will correspond closely to then price obtained by Benin's ginneries. The cotton price achieved its highest level in 1995 since which time it has been depressed. As already noted, oil prices rose sharply in 2000 and 2001. The Benin cotton price is poorly correlated with our world price – see Table 5 – and movements in the world price explain just 20% of Benin's cotton revenues – see Table 7.

[18] Data on the quantities of oil imported are available for these years, but we judged them to be incredible both in terms of their absolute levels and relative to the reported value of total imports.

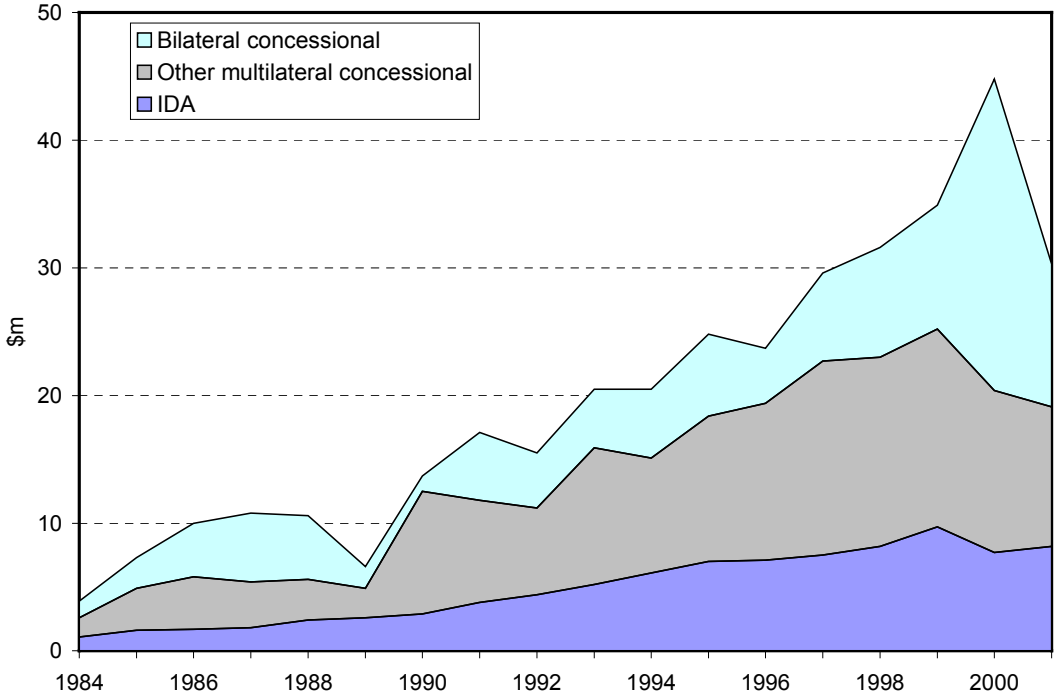

Figure A12: Benin - Concessional debt service payments, 1984-200

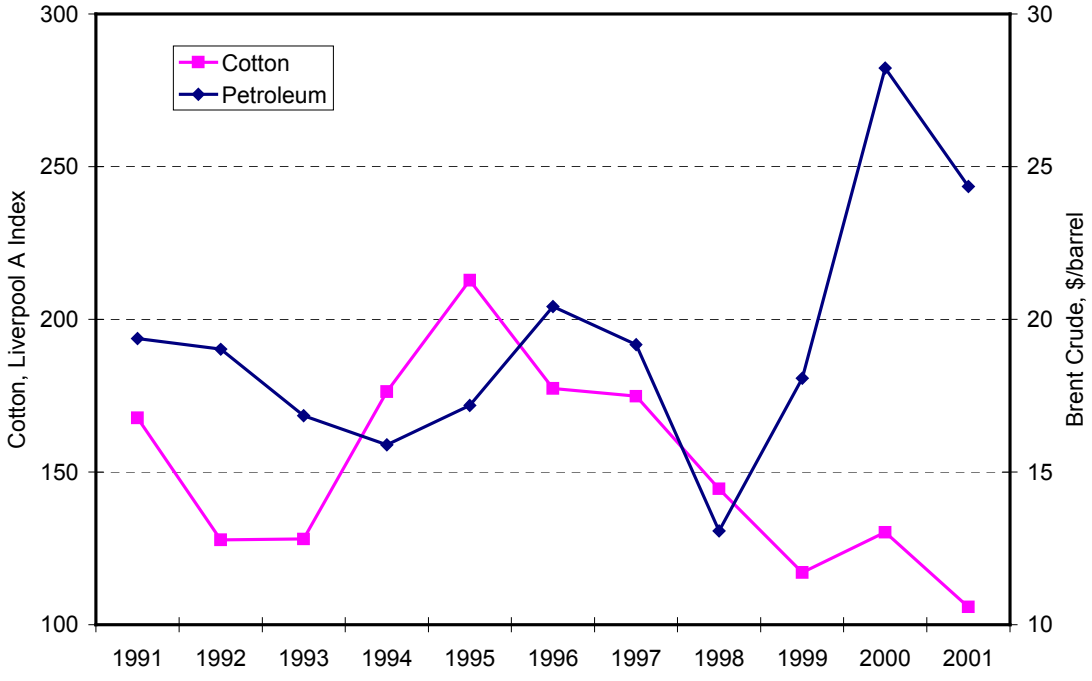

Figure A13: Benin - Commodity export and import prices

Benin's cotton revenues show only a modest positive correlation with the international cotton price (r = 0.33) while oil import expenditures were weakly negatively correlated

with the world oil price (r = -0.22). These correlations imply that any hedge should primarily relate to cotton rather than oil. However, the regression-based hedge ratios are 35% for cotton, 16% for oil, close to their shares of total exports.

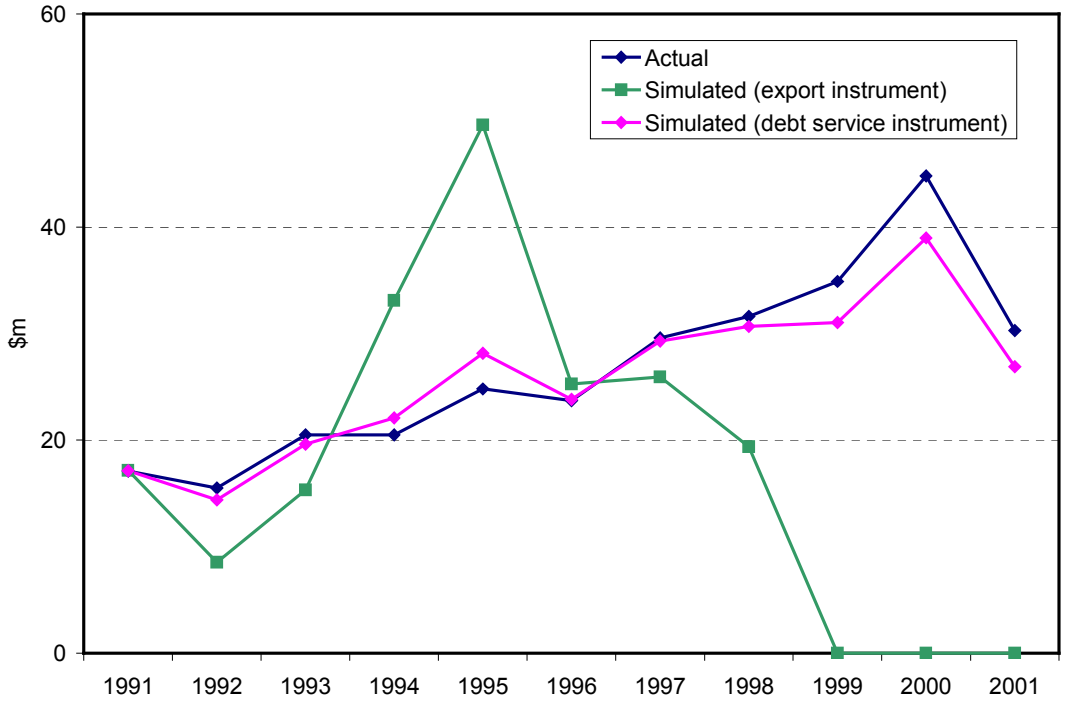

Figure A14: Benin – Actual and simulated concessional debt service

Figure A14 compares Benin's simulated concessional debt repayments under the export and debt service-based swap schemes A (using regression weights) compared with historic repayments. Payments are lower in five of the years and higher in just two years, with the remaining four years showing little change. The payments under the debt-service based scheme move in the same way as those under those in which trend exports are the instrument, but the impacts are much smaller.

Finally, Figure A15 graphs the resulting quantity of free foreign exchange in the two simulated environments. Movements in this quantity are dominated by the low initial figure in 1991 and the high spike in 1996. Neither of these large movements appears related to either the cotton or the oil price. In the absence of alternative explanations, we believe they may primarily result from poor quality national accounting data rather than to any underlying real movement in the economy.[19] Furthermore, Benin's cotton unit values are poorly correlated with world prices. For these reasons, we are not persuaded that the negative outcomes in the Benin analysis reflect more than inadequate data quality. We therefore simply note that data of reasonable quality are a prerequisite for any form of informed policy analysis.

[19] We believe this particularly for the 1996 spike which reflects an anomalously high reported value for total exports. This observation remains true even after a recent large downward adjustment of a previously published figure.

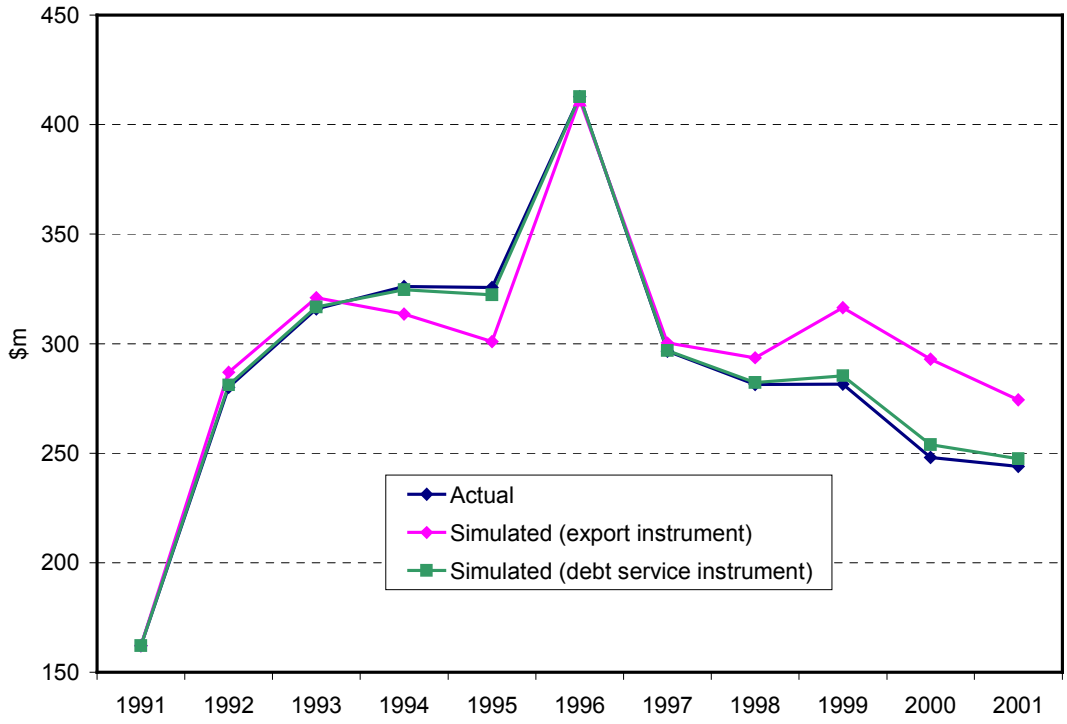

Figure A15: Benin – Actual and simulated free foreign exchange