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ARE OIL WINDFALLS A BLESSING OR A CURSE?

POLICY EXERCISES WITH AN INDONESIA-LIKE MODEL

by

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ABSTRACT

The value of large, unpredictable terms-of-trade gains to mineral exporting countries has been much debated. This paper uses a computable general equilibrium model of an Indonesia-like economy to assess the "value" of oil windfalls over a 20-year horizon. The model is simulated and optimised subject to a variety of assumptions on macroeconomic clearing, institutional constraints on economic policy and the ability to predict the world oil market.

The results indicate the critical importance of policy in determining the realised value of windfall gains. A "base run" is first constructed, to represent absorption policies characteristic of a representative oil exporter. Used in this manner, the windfall is insufficient to satisfy hopes for accelerated growth such as those common among exporters in the mid-1970s. Permitting optimal lending and borrowing abroad increases its value considerably, particularly if the nonoil economy is not able to adjust to rapidly falling effective demand without experiencing unemployed factors of production.

The possibility of capital flight, spurred on by restrictive domestic financial policies and anticipation of the need to realign the real exchange rate when oil revenues fall shortens the adjustment period and can involve heavy cost if fiscal policy is not stabilising.

Overoptimistic predictions of future oil revenues are shown to have seriously adverse consequences, particularly if the nonoil economy adjusts to falling demand through underemployment and capital flight is provoked.

Overall, the results indicate a large downside risk attached to reversible terms of trade gains. It is not difficult to construct realistic policy scenarios which result in negative overall valuation of oil windfalls. These results accord with, and to some degree explain, the conclusions of comparative study which suggest that gains to producer countries from higher oil prices have been quite limited.

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ARE OIL WINDFALLS A BLESSING OR A CURSE? POLICY EXERCISES WITH A MODEL OF INDONESIA

Table of Contents

List of Tables

List of Figures

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ARE OIL WINDFALLS A BLESSING OR A CURSE? POLICY EXERCISES WITH AN INDONESIA-LIKE MODEL 1/

I. Introduction and Overview.

This paper addresses the problems of economic management faced by oil producing countries through terms of trade fluctuations, and the "value" of windfall gains when their use is constrained by political and administrative factors. Oil exporters, among them Indonesia, have experienced extraordinary fluctuations in foreign exchange availability since 1973. The first oil price hike conferred a windfall equivalent, on average, to 33% of non-mining GDP on a sample of six producers: Gelb (1984).2/ By 1978 this had fallen to 15%. The second oil price rise over 1979/80 raised the windfall back to 27%; it was then halved by the oil glut of 1982-84. Are such windfalls a blessing, with potential to create a diversified, dynamic, modern economy (the universal objective of developing oil exporters)? Or are the difficulties of economic management through uncertain windfall gains so severe as to erode their large ex-ante value, perhaps to the point of turning them into a net liability?

The contribution of high-rent mineral sectors to development has been much debated: for example, see Hirschmann (1958), Amuzagar (1982), Nankani

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1/ The exceptionally helpful contribution of Perry Beider and Arne Drud to this work are gratefully acknowledged. The model was solved using CONOPT which is supported by the Analytic Support Unit, Development Research Department: see Drud (1983).

2/ The producers are: Algeria, Ecuador, Indonesia, Nigeria, Trinidad and Tobago and Venezuela. Expressed as a percentage of GDP the windfall would have been far larger for the capital surplus producers.

(1979), Harberger (1981), Levy (1978) and Forsyth and Kay (1980). The range of views is wide:

> "..I had a vision of La Gran Venezuela..." Carlos Andres Perez, President of Venezuela, 1974-78.
>
> "..We are dying of indigestion...I call petroleum the Devil's excrement...waste, corruption, consumption and debt, debt we shall have for years. We are putting our grandchildren in debt." Juan Pablo Perez Alfonso, Venezuelan oil minister and founder of OPEC, 1978.[1/]

The performance of oil exporters after 1972 indicate the critical importance of policy in determining the ultimate value of the windfall. Although different countries adopted considerably different strategies, some responses were common. Producer governments received about four-fifths of the windfall, came under intense pressure to spend rapidly, and transformed most of their oil income into domestic public investments. About 60% of these were infrastructural and much also went to heavy industry. Hastily planned and implemented, the average quality of public capital formation appears to have been low, with serious cost overruns and delays: Murphy (1983). During the boom, real exchange rates appreciated and in most countries nonoil output skewed towards the nontraded sectors. Nonoil exports stagnated, imports grew rapidly and dependence on oil increased. Meanwhile, during 1972-81 the nonoil economies of the oil exporters grew only 0.9% faster than had middle income developing countries over the 1960's, and they failed to match their own (admittedly exceptional) growth performance over 1967-72.

The heightened vulnerability of the exporters was revealed by the downturn in world oil markets. Absorption-reducing policies implemented to

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1/ Karl (1982), pp. 16-19.

adjust to falling oil income moved exporters into severe recession, a consequence of asymmetric macroeconomic adjustment. Real exchange rates, prices and wages did not respond flexibly to the drop in terms of trade as they had on the upswing. Labor markets slackened and urban unemployment began to preoccupy governments. The rhythm of public investment was again disrupted, often at the high cost of unfinished plant.

Capital flows amplified the destabilising swings of oil income. Projections of future oil prices have tended to follow current trends. Expectations have usually been proven seriously wrong, and have thus destabilised the capital account. Rising prices increased public and private access to foreign loans, but in periods of falling prices anticipation of devaluation prompted capital outflows, particularly from countries which maintained open capital markets and fixed interest rate ceilings. In 1982 the equivalent of 7% of Venezuela's GDP is estimated to have been sent abroad. Several exporters including Mexico, Venezuela and Nigeria experienced debt crises as the world oil market turned down after 1980.

Despite adjustment costs and destabilising feedbacks, some might argue that oil windfalls <u>must</u> be a bonus because they relax resource constraints and so expand the range of choice. But this view disregards the close connection between resource availability and other constraints on decision-making. In principle, governments have an almost infinite range of choice in disposing of oil rents; in practice this is not the case. The perceived range of choice has been far narrower, both over intertemporal allocation and across uses at a point in time. Further, a country's perceived choice set is heavily conditioned by its recent history, and shifts with the availability of revenues. Not all options feasible with low revenues remain politically acceptable as revenues increase.[1/]

The present analysis therefore has two objectives:

(a) to identify constraints most likely to reduce the realised value of oil windfall gains, and assess how they might be relaxed;

(b) given such systemic constraints and macroeconomic adjustment asymmetries, to consider "second-best" use of windfall gains and their value when their use is "realistically" constrained.

The quantitative framework used to analyse these issues is a six sector computable general equilibrium (CGE) model of an Indonesia-like economy, described in Gelb (1985). The model economy is dualistic, with value-added sharing in the "traditional" sectors. Over a 20 year period government disposes of oil windfalls "optimally" or according to rules which represent political and administrative constraints. Simulation is considered as totally constrained optimisation.[2/] The private sector, consisting of firms and one household, reacts to government policies and relative prices.

The model has several distinctive features. It permits endogenous regime-shifting, to capture macroeconomic adjustment asymmetries in the real exchange rate and real wage. Certain wages and prices rise more easily than they fall, so that the response of the nonoil economy to increasing and

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1/ For this reason certain governments have sought to mask the true extent of their windfalls while others have obscured the extent of their saving abroad by redefining expenditures to include anticipated future spending. Gelb (1986) reviews the main priorities of six capital importing oil exporters and the impact of windfall gains on public choice.

2/ An important methodological difference between the present work and some which have preceded it such as Dervis, Martin and van Wynbergen (1983) is the treatment of optimised runs as simulation with progressive slacking-off constraints. This assists interpretation of results and permits the use of models with greater structural and institutional detail at the cost of a less theoretically "clean" treatment.

falling oil prices may be different. It embodies a richer set of intertemporal linkages than most CGEs. In addition to the conventional updating of capital stocks through investment and of foreign debt through borrowing and lending abroad, production functions are shifted by "infrastructural" public investment which also locks government in to future recurrent spending obligations. The efficiency of capital formation falls as investment decelerates or accelerates from its trend growth path.

Section II describes how model runs are evaluated, using a criterion function of discounted private consumption and terminal nonoil output. This is treated in more detail in Annex I.

Dynamic simulations are reported in Sections III - VII. Initially we assume:

(a) perfect foresight;

(b) no endogenous private capital flows;

(c) constraints on public saving of oil revenues abroad;

(d) smooth, symmetric (neoclassical) adjustment of the nonoil economy to changes in effective demand.

A "base simulation" represents the null trajectory under policy considered to be empirically representative. Over the oil boom government does not lend abroad or borrow heavily against future oil income and allocates revenues to public investment. The "values" of the windfall in a range of uses but subject to the above assumptions are then compared. The experiments also indicate policy determinants of the extent to which oil booms are likely to accentuate economic dualism.

Section IV relaxes assumption (d), allowing for both "Keynesian" and "Classical" underemployment of factors through (i) downward stickiness of modern-sector wages and (ii) slow adjustment of the relative price structure (the real exchange rate).

In section V (c) is relaxed; government can now lend or borrow abroad. It optimises its absorption time-profile according to two criteria, one "social" and the other "private," the latter with a higher rate of time preference.

Section VI also relaxes (b). It is assumed that private capital flows respond to changes in the real exchange rate. Rapid depreciation of the real exchange rate (which will require nominal devaluation if prices are sticky downwards) is postulated to send private savers scurrying to place funds abroad. This accelerates the contraction of domestic effective demand.

Section VII also relaxes assumption (a). Euphoric projections of future oil prices (6% real growth, the projection which underlay Mexico's decision to borrow heavily against future oil income in 1979, 1980 and 1981) are revised following the peak of the oil boom. Policies are optimised subject to the initial projection and must then be re-optimised when they turn out to be wrong. This permits the impact of large prediction errors to be distinguished from those of political and other constraints on lending abroad and the use of windfall gains.

Finally, Section VIII summarizes conclusions. While some (notably those concerning income distribution) relate rather closely to such Indonesia-specific features of the model as the specification of labor markets most are more widely applicable.

II. Optimisation and Valuation

It is hard to argue that economies evolve according to the criterion of optimising a long-run objective function. Many futures markets are lacking; uncertainty increases as the time horizon extends. There is also the question of whose objective function society is presumed to maximize. To link simulation and optimisation it is necessary to be clear on the relationship between a particular objective function and a given simulation. Within a given set of constraints, simulation run x is termed compatible with valuation function u(.) if x is the optimal solution with criterion u or "close" to it. Otherwise, we can consider u(.) to be an imposed valuation criterion.

Policy assessment is quite different for compatible and imposed criterion functions. For example, suppose that u_1 is compatible with a base run of the model but that u_2 has a far lower rate of time preference. Policies which then allocate an oil windfall to investment will be judged more favorably by u_2 because the savings rate in the absence of oil income is "suboptimal." But care must then be taken in using u_2 as an indication of the priorities of those responsible for the savings decision; it represents an "imposed judgment."

Annex II presents details of optimisation procedures and the inverse optimum problem of determining a function u_1 within a given class of valuation functions which is compatible with a reasonable base run. Only main points are noted here.

The objective is taken to be to maximise the discounted value of the log of private consumption per head valued at base year prices.1/ There is no allowance for the pattern of income distribution. The first part of the valuation function is therefore:

1/ An alternative would have been to value the integral of the underlying utility function. Although this is more consistent from the perspective of optimisation, base year price valuation was chosen to permit a closer link between valuation, simulations and the comparative analysis in Gelb (1984).

$$V_1(c) = \sum_{t=1}^{9} \ln(c/n)(1-r)^t$$

where r is a rate of pure time preference and n is exogenous population. Eac period is two years.1/

Because of different rates of technical change across sectors and constrained oil sector output the model does not reach a true steady state even when world oil prices are constant. The terminal condition problem is solved in a crude but apparently effective way. From a range of simulations it was ascertained that the aggregate nonoil economy in the final period was approximately Cobb-Douglas with labor and capital exponents of 0.5. This is used to approximate the relationship between the overall capital/output and output/labor ratios. A high (8%) growth trajectory in the post-horizon perio is assumed; the consumption path is then valued as a quadratic function of real nonoil terminal output:

$$V_2(y_{10}), \text{ where } V_2 = a_1 y_{10} - a_2 y_{10}^2$$

a_1 and a_2 are constants derived from the parameters of the steady growth path. The overall valuation function is then:

$$u = V_1(c_1, c_2, \ldots c_9) + V_2(y_{10}).$$

1/ Public consumption is not valued explicitly but enters into the objectiv through the higher levels of productivity made possible by government spending which maintains past public investment.

Within this class of objective functions it is interesting to estimate the discount rate which would make the private savings trajectory of a reasonable base run (described below) close to optimal. Labor-abundant Indonesia has a large share of surplus in GDP (Gelb (1985) Tables 1A and 1B). Returns to capital therefore must have been fairly high.1/ Unless constrained by absorption limits the optimal private savings rate will then rise very sharply towards its asymptote unless the private rate of discount i high. In common with other optimal growth models, the present one tends to approach its quasi-steady-state too rapidly, given what is known and expected of the evolution of savings rates from time series and cross-country study.

To permit reasonably slack private absorption limits which do not totally dominate simulations it is necessary to raise private time preference to 14.5% per year to obtain a valuation function, u_1, which is compatible with an appropriate base run.2/ Because of its derivation from the private saving decision, u_1 is termed the "private valuation function."

A similar function u_2 with arbitrary time preference rate of 3% is used as an indication of "social" welfare. Valuations have also been made at a range of intermediate discount rates.

1/ If the rate of return were assumed to be low, the magnitude of the implie capital stocks would be so large as to make growth almost independent of capital formation, since technical change would have to explain nearly al of the non-labor growth component.

2/ This rate is not implausible for private savers facing imperfect capital markets and risk (from which the model abstracts). It corresponds to an expected payback period of 5 years, which is not out of line with investment criteria used by firms in developed ...

III. Flexprice Policy Simulations

3a. A Base Run

In the 20-year "base run A" outlined in Table 1 the economy effects transition from low to middle income. The private saving rate rises by 0.5 percentage points per year from 15% to 25%[1] and a broad-based tax on all nono income is instituted as fiscal capacity improves with the level of developmen World oil prices rise by 134% over the first four years then decline symmetrically back to their original real level. Windfall gains from this trajectory are not dissimilar to those of many exporters after 1975. Domestic oil prices are held constant, one third of world prices before the boom.

In the initial period, foreign debt is equal to exports. Throughout the simulation interest and amortisation rates are assumed to be 3% and 20% respectively. Borrowing is a fairly steady trend, set at empirically representative levels for oil countries. Debt is smoothly rolled over and interest payments are financed by capital inflows without being accounted as recurrent spending.[3] Each unit of past public investment evokes subsequent

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1/ This progression is suggested by cross-country norms of Chenery and Syrquin (1975).

2/ Indonesia's base year 5% level of nonoil taxation represented only about half of the international norm for countries at the equivalent level of development; fiscal performance in the base run progresses at a "normal" rate but Indonesia does not catch up to the norm for a middle income country. Lotz and Morss (1977) and Tait, Gratz and Eichengreen (1979) estimate fiscal norms for countries at various stages of development.

3/ In the mid 1970s Indonesian debt/export ratios were around unity, but because almost all borrowing had been at concessional terms the ratio of actual debt service (interest and amortisation) to debt was far lower tha 23%. This value was selected as representative for developing countries to take into account the prospect that as development proceeds Indonesia will borrow more on representative commercial terms. To introduce time-varying interest and amortisation charges would complicate interpretation of model debt-service ratios and add nothing substantive. At the end of the simulation the public debt/export ratio is 1.44.

annual recurrent costs of 0.05.[1/] Residual revenues and borrowed funds are then allocated to new investment.

Because of rising labor participation rates, technical progress, effective public investment, expanding foreign demand for Indonesian manufactures and a successful program of import substitution in manufactures,[2/] growth is rapid. Real nonmining output grows at 8.3%, total GDP at 7.3% because the oil sector grows at only 4.9%. Growth is concentrated in the modern sectors, particularly manufacturing. After an initial surge of 25%, the real exchange rate (an index of domestic prices relative to the world price of manufactures) overshoots slightly as world oil prices fall then returns to unity and remains almost constant.

After the third period the tax system is insufficiently buoyant to compensate for the steady loss of oil revenue. By year 20 oil exports are almost eliminated by growing domestic demand at subsidized prices and oil tax revenues almost vanish. The share of government in total investment falls from 52% to only 23%. On the trade side, the falloff in oil exports is compensated mainly by import substitution and export expansion in manufactures. With food imports balanced by primary exports, a manufactured export surplus, achieved after 16 years, finances a growing deficit on the nonfactor service account.

1/ This constraint can be interpreted as necessary for public investment to have its postulated favorable effects on output. It implies that costs of budgetary fluctuations enter through inefficiency of new public investments rather than through poor use of existing capacity.

2/ Import substitution is defined as the ability to satisfy a larger share of domestic demand with home goods at constant prices. The constant-price share of manufactured imports is assumed to shrink by 3% per year over the simulation. The constant price demand for Indonesian manufactured exports rises at 15% per year.

Despite this optimistic growth scenario and although the economy adjusts smoothly via flexible wages and prices, the effect of falling oil income over years 5-9 is considerable. It takes seven years for modern sector wage rates to recover to their peak levels. Growth of real private consumption/head slumps from 6.3% to 2.3% as oil prices fall; real investment, which had been rising at 13.7% in the upswing, grows at only 3.5% in the downturn. At the height of its acceleration the marginal efficiency of public investment is pushed to nearly zero but its average efficiency is still two thirds of its maximum. Less volatile private investment retains high marginal and average efficiency.

3b. The "Value" of the Windfall Under Alternative Policies

Holding foreign borrowing at its base run levels, Table 2 summarizes the value of the windfall with three alternative policies. Adjustment of the economy is still through flexible wages and prices; food is importable.

In the base run, A, government responds to revenue changes through public investment. Run B is similar but world oil prices are static. Runs C and D respectively simulate disposal of the windfall through food subsidies and direct transfers to the private sector. The subsidies and transfers are assumed to become institutionalised. They grow at 8% for the last 5 periods after peaking with oil income in period 3, so that public investment is progressively squeezed. In run E world oil prices are static but demand for Indonesian manufactured exports shifts out at 20% per year, 5% more rapidly than in other runs.

First, compare A and B. The oil windfall leads to a 7% increase in private consumption at the height of the boom. Real public investment doubles in four years but the impact on terminal nonoil output is rather small, only 1.6%. Even if absorptive capacity constraints on public investment were completely eliminated, the difference in terminal output would be only 3%. This is not because public investment is irrelevant--it contributes the equivalent of one half the growth effect of exogeneous technical change, and without it terminal output would be 21% lower than in the base run. But growth is mostly determined by increases in the labor force, private capital formation, exogenous technical change and the gains from shifting workers out of labor-surplus to modern sectors.

Runs C and D are preferred to base run A in terms of the private objective u_1, but not when judged by the "social" criterion u_2. By the end of period 10 the cumulative impact of lower infrastructural investment reduces real nonoil output by 6%. This compensates for the transfers and subsidies so that private consumption ends up at approximately its level in the base run. The efficiency loss due to subsidised food prices is small (as shown by comparing C and D) because food is mainly in the "subsistence bundle" in the LES demand system. Subsidies are therefore similar to direct income transfers.

In the base run manufactures rise from only 9% of exports to 59% as improved quality and marketing are assumed to raise world market share and result in a shift in foreign demand by 15% per year. Run E shows the impact of increasing this to 20% per year. With the high private discount rate the oil boom is greatly preferred but from a "social" viewpoint, improved market penetration confers three quarters of the windfall benefit. Conversely, much of the social value of a large commodity windfall may be eliminated if a buoyant domestic market diverts attention from the expansion of exports and the cultivation of foreign markets.

Figure 1 indicates real modern and traditional wages relative to their values without the windfalls in run B. In run A distribution skews during the boom period; transport, distribution and housing costs rise while food imports limit the multiplier effects from increased spending on the traditional sector. Depreciation of the real exchange rate reverses this trend after the sixth year. When oil revenues fund a uniform food subsidy, the profile of modern sector wages is raised but otherwise resembles that in the base. But traditional sector labor does not have to rely on multiplier effects to increase real income. Limiting food imports further increases real labor incomes during the boom because it protects the most labor-intensive sector. Public expenditure and trade policies therefore have major effects on distribution, both across groups and over time.1/

We now consider domestic oil pricing policy. Figure 2 depicts five time paths for the dual on domestic oil prices. A positive value indicates that the objective function could be increased by raising domestic oil prices (that is, by decreasing the domestic energy subsidy), a negative value indicates the reverse. The efficiency loss caused by cheap energy (see Gelb (1985)) tends to hold the dual above zero. However, energy prices also affect income distribution between public and private sectors so that the dual is influenced by the value of public, relative to private income. This depends on other fiscal policies and on the choice of valuation function.

The most straightforward results are for run C. The efficiency loss due to food subsidies is less than that of cheap petroleum and u_1 values private income more than public income because the longer-run impact of public

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1/ The model is, not suited to further assess distributional shifts because it uses one representative household and makes no allowance for different consumption bundles of recipients at various income levels.

investment is heavily discounted.[1/] There is therefore an argument for raising petroleum prices and transferring revenues to the private sector through less distortionary subsidies or directly (the duals are similar with direct transfers). Allowing for discounting, the duals follow the pattern of world oil prices because the divergence between these and domestic prices is an indication of the oil subsidy distortion.

The other runs are quite different. Consider the social dual valuation in the base, A:u_2, which argues for even lower domestic oil prices in periods 2 and 3. When (i) world oil prices are rising and (ii) government is politically constrained to absorb oil income through public investment, the rate of revenue growth should be slowed by almost any means. Rapid revenue growth locks government in to hastier and progressively less effective investment plans. These impose large future recurrent costs and also promise painful and disruptive cutbacks when world oil prices come down.

In the phase of falling world oil prices the duals indicate extremely strong fiscal pressure to raise domestic oil prices. However, from Figure 1, the timing of this price increase makes it politically even more difficult than usual because the gains of the formal sector over the past four years are being eroded by falling demand and real depreciation.

1/ Over periods of stable world oil prices, private savings are most highly valued by u_2, followed by public income and then by private consumption. This is because the social objective places a premium on highly productive private and public investment. In some periods the marginal value of private consumption may actually be negative because it bids real resources away from investment. This results partly from higher manufactures prices, partly from increased costs of nontraded services which cuts the funds for public investment.

IV. Windfalls when Adjustment is Not Smooth

4a. Sticky Wages and Prices

We now consider the effect of downward wage and price stickiness when foreign borrowing is constrained to the levels of the previous simulations. Run F in Table 3 is identical with the base run A except that real modern sector wage rates are assumed to be rigid downwards. Run G introduces, instead, sticky downward price adjustment; construction, service and manufactures prices can decline by at most 5% per year. If demand is insufficient to absorb full-capacity output, firms operate at less than full capacity. They still base hiring decisions on the product wage so that both labor and capital may be underemployed.1/ Run H introduces both rigidities simultaneously.2/ None of these rigidities bind in run B where world oil prices are constant. Wage rigidity leads to seven years of modern sector unemployment, which peaks at 10.7% in period 5. At this point real nonoil output is 4% below that in the base run. Price stickiness causes a variable pattern of undercapacity which reaches 6% for certain sectors and periods, notably in period 5.

The costs of the rigidities are shown in Tables 2 and 3. Wage rigidity alone eliminates 23% of private windfall value and 32% in social

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1/ Demand pressure does not change the evolution of the full-capacity production function except through lower output, income and investment. There is, for example, no analog to Verdoorns Law, whereby it affects the rate of technical change.

2/ The simulations presented are formally treated as optimising u_1. In pure simulations, runs G and H are underdetermined because the restrictions on price adjustment can be satisfied with more than one pattern of undercapacity across sectors. The results here use optimisation to constrain the pattern of slacks in the model to a favorable configuration.

terms. Price stickiness eliminates 17% of private adjustment cancel out 29% of private and 41% of social gains.[1/]

Wage and price stickiness has an interesting impact on the valuation of public revenues over the oil boom. In the base run A, marginal resources in the hands of government are always positively valued by u_1. But they are negatively valued by u_2 when world oil prices are rising. Public investment plans are already expanding so rapidly that their marginal supply-side contribution is negative when allowances are made for later disruption and recurrent costs. The divergent valuations reflect the immediate demand-side benefits from increased public spending and high discounting of the adverse future consequences by u_1. In runs F, G and H, however, even the private welfare function attributes negative value to marginal public spending at the height of the boom because of its additional later costs in terms of unemployment and undercapacity. These results suggest that conservative fiscal policy will be more politically palatable if the causal relationship from a major boom to subsequent recession is widely appreciated.

4b. Nigenesia and Trinuela: Valuing Some Institutional Differences

The poorest of the oil exporters, Nigeria and Indonesia, have weak class-based political movements and relatively fluid labor markets. Politics in richer producers, Trinidad and Tobago and Venezuela, are competitive and largely class-based with heavily unionised labor markets. Such countries also

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1/ The combined effect is less than the sum of the individual effects because curtailing modern-sector employment keeps prices of nontraded goods and real modern wages high. Preventing a rapid depreciation of the real exchange rate raises the modern-sector consumption wage relative to the product wage. Greater price rigidity can result in the oil windfall having negative private and social value because costs of adjustment are so high.

have better administrative capability to transfer oil income to the private sector, either directly or by subsidies.[1/]

The base run A represents the institutional environment of a poor producer, Nigenesia (oil income spent by the state, flexible labor markets). Run C_1 distributes the oil windfall to households via food subsidies, keeping the level of public activity approximately as in run B and F_1 superimposes sticky modern wages on C_1. F_1 incorporates the wider fiscal options and labor market rigidities of a middle-income producer, Trinuela.

The broader range of spending options is privately beneficial. Valued by u_1 the windfall is enhanced by 58% in C_1 although social valuation falls by 28% because lower public investment slows growth. But Trinuela (or F_1) presents a less rosy picture. At the peak of the boom the food subsidy causes a larger percentage rise in modern wages than in Nigenesia.[2/] Wage cuts are resisted--unemployment persists for 9 years when oil prices decline and peaks, in the fifth period, at 13.1%. With the high private discount rate, this is still better than Nigenesia by 27%, but in social terms 74% of the windfall's base value is eliminated by the subsequent costs of adjustment.

These simulations indicate that more flexible fiscal systems have considerable potential value in permitting rapid disbursement of oil revenues without lowering the quality of public spending. In fact the social value of the windfall can rise by 30% with optimal transfers without reducing its private base run value. But giveaways may backfire when oil prices decline if

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1/ Bienen (1983) discusses the weakness of class based political movements for Nigeria, Glassburner (1984, 1978) for Indonesia. Auty and Gelb (1985) and Bourguignon (1985) note their strength in Trinidad and Tobago and Venezuela respectively.

2/ Indeed, real wage gains over the boom appear to have been larger in Trinidad and Tobago and Venezuela than in Nigeria or Indonesia.

the groups benefiting from subsidies or transfers have the power to resist reductions in their living standards and in so doing lower the degree of factor use.

V. Optimal Public Lending and Borrowing Abroad

How much can appropriate time-phasing of domestic absorption benefit a producing country? This section retains the assumption of perfect foresight which is relaxed in Section VII.

5a. Flexprice Adjustment

To avoid valuing terminal public debt this is constrained to its final-period value in the base run. Creditworthiness criteria related to liquidity rather than long-run solvency are represented by limits on debt service ratios.1/ It is assumed that international capital is rationed; real interest rates are a constant 3% within acceptable debt-service limits.

Figure 3 depicts the exogenous base run government borrowing profile A, and those of several optimised runs. XA2 is the socially optimal borrowing profile and XA1 the privately optimal profile. XB2 is the socially optimal profile for the flat oil price scenario of run B. Table 4 summarises the values of u_1 and u_2 for all runs discussed.

To measure optimal lending abroad out of the windfall the difference between lines XA2 and XB2 over periods 2, 3 and (the shaded area in Figure 3), is compared to the windfall.2/ Seventy one percent of the windfall is

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1/ Debt service is computed on current public sector borrowing as well as on the stock of debt inherited from the previous period, so that an export decline causes an immediate fall in the desired exposure of foreign lenders if a debt service limit is binding.

2/ The windfall is measured by deducting from the terms of trade gain (obtained from run XA2) the increased remittances abroad by foreign oil companies.

saved abroad during periods 2, 3 and 4. Foreign assets are then drawn down gradually over the next five periods. The debt-service ratio peaks at 0.50, only slightly above its maximum level in the base.

Restraint is beneficial. Optimal lending abroad increases the social value of the windfall by 61%. It enhances economic stability, and raises productivity of the public investment program. Government avoids purchasing investment goods at severely inflated prices, and private investment is also less "crowded out". This maintains the command of oil revenues over real investment. Because the optimal saving profile with flat oil prices XB2 is not too different from that in the base run A, there is little gain to optimising borrowing when oil prices are constant.

The stability of the optimal public investment program is mirrored by that of the economy. Real exchange rates appreciate only half as far as in run A and they depreciate more gradually. Real modern wages decelerate after the first two periods but never fall. The optimised economy therefore never runs into problems of adjustment due to wage-price stickiness. There is also less fiscal stress; the relative valuation of public and private incomes is steadier. The dual value on public income declines at the world interest rate, that on private income rises because increasing private savings and tax rates shift expenditures away from socially less-valued private consumption, but private income remains less socially valuable than public income. There is therefore an advantage to reducing the already small transfers to the private sector and in raising domestic petroleum prices in all periods in runs XA2 and XB2. For this reason, the optimal paths are not greatly influenced by the option of allowing transfers of oil income to the private sector.

The picture is quite different with the high-discount u_1. When borrowing is unconstrained by liquidity ratios and the economy adjusts smoothly, optimal public borrowing in XA1 induces violent oscillations in the nonoil economy. Modern sector wages rise by 30% over four years, then crash by 35% over a similar period. At the peak government borrows 22% of GDP; the debt service ratio approaches 2 in period 5. The real exchange rate depreciates by half between periods 3 and 6 before stabilizing at its long-run equilibrium level by period 9. This violent profile of public borrowing is not much different when flat oil prices are assumed; the oil price increase simply delays the onset of heavy borrowing slightly.

Optimisation with a variety of upper debt service bounds indicates that anticipation of a debt service constraint (which bites most sharply when oil prices are declining) has some effect in moderating borrowing when oil prices are rising. But a maximal ratio of 0.6 still allows room for borrowing to reach two thirds of its unconstrained level in period 3 and produces a highly unstable economic trajectory.

5b. Macroeconomic Rigidities

As noted above, socially optimal borrowing produces a stable economic trajectory which never runs into macroeconomic rigidities. Downward wage and price stickiness has important consequences for privately optimal public borrowing strategies. These are shown in Figure 3 by the borrowing profile XF1 where wages in the modern sector are inflexible downwards.

Even heavily discounted, recession is very costly to the private sector. Until oil prices fall, the economy therefore restrains its borrowing to approximately its base run level. This implies a slight fall in the debt-service ratio. Borrowing rises rapidly as oil prices fall to compensate for the tendency of the economy to move into recession. The debt service ratio peaks in period 5 at 0.9; if an upper limit is imposed, optimal borrowing over the initial periods is still more cautious because it will not be possible to borrow heavily to ameliorate the adverse later consequences of the boom. Sticky prices cause similar restraint in the privately optimal public borrowing profile.

VI. Speculative Private Capital Flows

6a. Modelling Capital Flight and its Effects with Flexprice Adjustment

The experience of Venezuela, Mexico, and Indonesia suggests that the problems of adjustment to falling oil prices can be aggravated by volatile private capital outflows when exchange rates are pegged. As domestic demand reduces, rates of return fall in the nontraded sectors lowering the attractiveness of investment. And real exchange rate adjustment is increasingly seen to require nominal devaluation which raises the attractiveness of foreign investments especially if domestic interest rates are restricted.1/

The model does not include money or a nominal price level. Capital flows are endogenised as a function of changes in the real exchange rate. Small capital inflows supplement private savings when the real exchange rate appreciates or falls less than a specified amount (5 percentage points per period). In a stable economic climate foreign savings therefore finance

1/ At the time of debt rescheduling negotiations with the IMF, Mexico's net debt as suggested by current account deficits was only about half its gross debt. Venezuela experienced an outflow of about 7% of GDP in 1983, and a debt crisis despite little net debt. For an analysis of capital flight which emphasizes the importance of overvalued exchange rates and restrictions on domestic interest rates see Cuddington (1985). The present analysis assumes away the possibility of local investment in foreign-denominated assets.

private investment. Large depreciations cause a maximum percentage outflow 22% ? private savings[1/]

Terminal stocks of foreign private assets are mostly undeclared and may never be repatriated. They are assumed to have zero value.

Table 5 summarizes the effects of private capital flows in a number of simulation runs. YA ("Y" indicates a run with endogenous capital flows) valued less (socially and privately) than A. YB, with constant oil prices, produces a higher value according to both criteria, than the corresponding r B. Private capital flows are most valuable in a stable economic environment and possibly adverse when exogenous shocks are experienced and policy is not stabilizing. Capital flows reduce the benefit of the oil windfall by 88% as defined by the private welfare function, and results in the windfall having net social cost. Oil windfalls can be a liability if inappropriate (yet empirically representative) policy causes volatile capital flows.[2/]

1/ This bound is based on Venezuelan data. This can be interpreted as supposing that private capital which has not been induced back into the economy by year 20 never will be, and neglecting the benefit accruing a (usually) limited group of citizens with assets abroad. All private capital flow figures, and resulting asset/debt levels, reported here a in addition to an exogeneous inflow identified in the base-year data a maintained at at a constant level in all periods of all runs; this exogeneous foreign capital source accounts for 12% of base-year privat investment, and roughly 2% in the last period. The effect of changes i terminal foreign assets over and above those due to the exogeneous flo is essentially zero in the base case: with a maximum inflow of 2.5% there is a negligible terminal net asset position.

2/ These conclusions need to be qualified if higher terminal private asset stocks confer a later benefit which is not reflected in the valuation functions. However, even without this post-horizon correction, higher private terminal debt does not imply higher valuation. For example, ru YA results in a small net terminal debt but is valued less than A becau the final net foreign asset stock is an inadequate summary statistic fo the time profile of flows. The value of the time profile depends on th rate of time preference and on the rate of return to domestic investmen and its efficiency. Capital flows with a large early outflow balanced only later by gradually increasing inflows like YA, will be valued less

It could be argued that profit maximising private investors would no disrupt domestic investments too severely by switching savings abroad. In tw additional experiments, YA* and A*, deviations from "normal" private investment growth are allowed without penalty. Capital flows now augment social value slightly, even when world oil prices and the economy are volatile. However, even with an unvalued increase in terminal debt, they reduce the value of the less "patient" private objective function.

6b. Capital Flight and Sticky Adjustment

Capital flight accentuates the contraction in demand, compresses the period of real exchange rate adjustment and increases the costs of wage and price rigidity. Unemployment in run YF is more severe and longer-lived than in run F, the corresponding run without capital flight. Terminal-year output is 2.1% lower than in run YA; without capital flight the terminal output loss from rigid wages was only 0.5% in run F. The value of the windfall is now substantially negative by either welfare function.

The combination of a temporary oil boom, policies which induce capital flight and an inflexible labor market can be disastrous. The economy now consists of two groups. "Speculators" are better able to protect their assets because they have flexibility in disposing of their savings. But they amplify the fluctuations experienced by "workers," at great cost to the economy as a whole.

6c. Optimal Public Lending with Speculative Private Capital Flows

Figure 4 depicts socially optimized government borrowing trajectorie and the resulting real exchange rates with and without private capital flows. Y denotes capital flows, X denotes optimal borrowing; and runs with and without the boom in world oil prices are respectively labelled A and B.

Socially optimal borrowing and lending profiles do not change great with capital flows. They are still strongly countercyclical. Privately optimal borrowing strategies are affected far more- as shown in Figure 5. Th potential losses to the domestic economy from capital flight induce far stronger counter-cyclical policy even with heavy discounting.

Whether one large depreciation is "better" than several small depreciations depends on the determinants of capital flight. When large depreciations cannot be avoided and there is a natural limit to the share of private savings which can be remitted abroad, it is better to effect large parity changes quickly.

The four optimal runs with private capital flows are summarised in Table 6. This allows valuation differences between the base run and constan oil price simulations to be compared with those in the previous optimized ru without private capital flows, in Table 4. With optimal public borrowing abroad, the loss due to volatile capital is 4% with u_1 and 53% with u_2; good policy can limit the adverse effects of volatile capital flows. However, a temporary oil boom which requires eventual real exchange rate depreciation is necessarily less valuable with private investor behaviour as modeled here.

Is "good" policy more or less important when there is a propensity for capital flight? From Table 7, at either discount rate, the "gap" in val between the cases with and without capital flows increases (becomes mo positive) as the problem of economic management becomes more complex--moving from the constant oil price situation to the oil boom and then to the oil boo with rigid wages. In other words, endogenous capital flows increase the premium on optimal policy as the economic environment becomes more complicate due to external shocks and internal rigidities.1/ 2/

1/ 2/ See next page for footnotes.

VII. Imperfect Foresight: the Consequences of Euphoria

The evolution of world oil markets has usually confounded projections. Both oil price shocks were unexpected. In 1974 and 1978 there was widespread skepticism over OPEC's ability to maintain high oil prices. By 1981 predictions of global energy shortage led to projected real oil prices growing at 3% until at least 1990. Some exporters were still more optimistic. Mexico, for example, assumed 6% real growth in oil prices in formulating its national plans. This section considers the consequences of such prediction errors as for economic management.

The socially optimal public lending solution is first found for a "euphoric" oil price projection--after the peak of the boom, world oil prices

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Footnotes from previous page.

1/ The sign of

$$\frac{\partial\ (\text{welfare gain from optimality})}{\partial\ \text{capital flows}}$$ is ambiguous, but that of

$$\frac{\partial^2(\text{welfare gain from optimality})}{\partial\ \text{capital flows}\ \partial\ \text{complexity}}$$ is positive.

2/ Since government borrowing trajectories in YXA2 and YXA1 lead to steadily-rising real wages in the formal sector, they are also optimal with downward wage rigidity unlike the comparable case XA1 in Table 5. Thus, for each of the two valuation functions, the welfare gains in moving from the exogeneous base public borrowing path to the optimal trajectory can be calculated for three situations; (a) with the boom in oil prices, (b) with constant oil prices, and (c) with the oil boom and rigid wages. In five of the six comparisons in Table 7, optimal policy is indeed "worth more" with a free capital market, but this result depends on the particular sub-optimal borrowing trajectory chosen for the exogenous base. Essentially this result means that the base path is closer to being "right" for an environment without capital flows than for one with flows which requires more caution.

are projected to continue to rise at 6% per year.[1/] Public lending and borrowing abroad is then optimised with the base oil price trajectory, but with lending in the first three periods fixed at its values in the euphoric run. Thus, for three periods policy is optimal but conditional on very optimistic projections. As the boom slackens it must be revised in line with a pessimistic correction.

The seriousness of forecasting error depends on the time horizon and borrowing possibilities. Real-world limits on debt service and debt/GDP constrain the ability to smooth out its effects. In the model it is sufficient to impose the same terminal debt constraint because the horizon is not sufficient to permit a very long-term strategy.[2/]

Figure 6 displays optimal public borrowing and real exchange rates for five such imperfect foresight runs. The euphoric projection causes a massive borrowing peak in periods 2 and 3. This augments the oil windfall by

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1/ In addition to optimal public borrowing, the domestic oil price is raised exogenously by 1.5 per period, from the base level of 1 in period 3 to 11.5 by period 10, and a second policy instrument--the level of transfers to households--was also included in the optimization. The optimal transfers is zero in periods 2-5 (transfers in the first period are fixed in accordance with the base-year SAM). For greater comparability with earlier runs transfers are again specified exogenously in the experiments below using the "mistaken" starting point. Instead of the base trajectory, with transfers constant at 0.139, these later runs set transfers to 0.139 in the first and last periods, and to zero in periods 2-9. This trajectory agrees with the first periods of the high-price optimization, and allows the government a little more slack in making up the revenue shortfalls in later years. Only in period 4 and 8 of runs YZA2 and YZF2 below did the duals on household and government income indicate that positive transfer would be desirable; thus, the losses due to mistaken expectations would be slightly larger than those calculated below if the base path for transfers was retained.

2/ In the runs reported, the debt service ratio never rises above 65%. A separate debt service ratio limit is not imposed; its effect is quite predictable.

66%[1] causing the real exchange rate to appreciate by 38%. Runs YZF2 and ZF2 include downward modern wage rigidity, with and without endogenous private capital flows. The heaviest borrowing is in period 4, as the government tries desperately to reduce the macroeconomic costs of adjustment. Mistaken expectations about world oil prices have, however, absorbed borrowing capacity and have also elevated the real wage. Between periods 4 and 8, the formal sector unemployment rate is 15.1%, 17.1%, 16.0%, 11.4%, and 3.1% in run ZF2, and 17.2%, 23.6%, 22.0%, 16.6%, and 7.8% in case YZF2. [2] This indicates the degree of stress on the nonoil economy.

The dramatic swing from borrowing to lending and back in run YZA2 (socially optimal public borrowing with mistaken expectations and private capital flight) results from the fact that a severe depreciation of the real exchange rate is inevitable in these runs and that once large it may be still larger without penalty. Government can partially stabilise real private investment despite private capital flight by severely depreciating then appreciating the real exchange rate, but such violent erratic policies are not optimal with the adjustment costs of runs ZF2 and YZF2.

The projections error has disastrous consequences as shown in Table 8. It eliminates 63% of the social value of the windfall in run ZA2; for the

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1/ Coincidentally, Mexico's increased borrowing over 1980-81 was also 66% of its actual windfall; Gelb (1984).

2/ There is also 4.6% unemployment in period 9 in run YZF2, even though the wage constraint has ceased to bind by that time. This is apparently in order to keep wages up, and through them the price of investment goods, so as to prevent the level of real investment from rising further. As it is, the real growth rate over the previous period is 24%. This is the same rationale (though using a different mechanism) discussed below for run YZA2.

other three [1/] cases the loss ranges from 122% to 325%. The economy may be far worse off receiving a windfall and badly overestimating than correctly anticipating no windfall at all.

All four runs are also valued less than corresponding simulation runs; A, F, YA and YF are respectively preferred to ZA2, ZF2, YZA2, and YZF2 respectively. The base borrowing profile produces (socially) better results than the "optimal" trajectory in all cases with badly incorrect expectations. ZF2, YZA2 and YZF2 are even worse than the corresponding runs with the base borrowing profile and without the windfall.

Is such an error preferred to the full social optimum by u_1 which heavily discounts the after-effects? For YZ2, the error does cause a 27% rise in the windfall valued at the higher discount rate. However, for runs ZF2, YZA2 and YZF2 respectively, the mistake induces losses of 47%, 99%, and 198% of the private benefits. Even though it induces massive borrowing the mistaken trajectory is not preferred by u_1 when the economy cannot adjust smoothly downward and private valuation of all four cases is also lower than that of the corresponding simulations.

VIII. Conclusion.

This study addresses a much debated question--the value to producers of oil windfalls--using a computable general equilibrium model of an exporting country. It emphasises medium-run adjustment and management through terms of trade gains and reversals, not longer-term depletion. Two valuation functions have been used. One (termed "private") has a high discount rate, the other,

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1/ No comparable optimization runs existed for case YZA2*. However, there is a corresponding simulation run YA* (see Table 5).

"social" a low one; the maximands are private consumption streams and a terminal condition on nonoil output. Some results, notably those concerning distribution (which is not given weight in valuation) reflect dualistic features of the model specific to Indonesia and similar economies, but most are more generally valid.

Even if adjustment costs are large, windfalls cannot but be of value if used "optimally". However, their absorption, both over time and across uses, has been constrained by a variety of political and administrative factors which have themselves changed more gradually than the financial resources available to oil producing economies. Further, large changes in world oil markets have been poorly predicted. This paper therefore assesses the value of windfalls under a variety of assumptions on (i) the range of choice available to producer governments, (ii) key macroeconomic closures, and (iii) the predictability of the oil market.

Optimal Absorption Rates. The representative oil exporter did not save windfall gains abroad; neither did it borrow heavily against future oil income. Revenues were mainly transformed into domestic public investments. The base simulation embodies these policy choices in the response to an oil windfall which is perfectly forseen from the start, lasts for six years and peaks at the equivalent of 17% of nonoil GDP. It is also assumed that the nonoil economy adjusts smoothly through flexible wages and prices, and that private capital flows do not react in a volatile manner to changes in world oil markets or to domestic policies.

Downward rigidity of real modern-sector wages and stickiness in the real exchange rate when demand is falling are then introduced. These introduce an asymmetry into the process of adjustment, and result in a tendency for large booms to be followed by recessions. The post-boom recession is shown to eliminate up to 40% of the windfall's value with the above policy choices. If the causal relationship between boom and recession were more widely appreciated, restraint in spending windfall gains might be more politically viable.1/

Assume now that the absorption of windfalls (which are still perfectly forseen) can be optimised over time. At the low discount rate of 3% it is optimal for government to save the equivalent of 71% of the windfall abroad during periods 2, 3 and 4 (each period represents two years) and then to run down its foreign assets as oil exports fall. This strategy raises the windfall's value by 61% relative to the base run because the profile of consumption is steadier, the efficiency of public capital formation is maintained and the real exchange rate appreciates far less. This last effect maintains the purchasing-power of oil over domestic investment goods and so reduces "crowding-out" of real capital formation.

Because the optimal trajectory is steady it does not run up against macroeconomic rigidities unlike the base run. Taking these into account, fiscal restraint roughly doubles the windfall's value. However, even under the most favorable circumstances the contribution to growth of the windfall is modest because of the importance of other factors of production, technical change and the reallocation of labor from subsistence to modern sectors. The expectations raised at the time of the first and second oil price increases appear to have been overoptimistic.2/

1/ It is interesting to note that the high downside cost of poorly sterilised export revenue fluctuations were central to Keynes' arguments for commodity price stabilisation, which were made on macroeconomic grounds (Kanbur (1984)).

2/ For a single-sector analysis which reaches the same conclusion see Gelb (1984).

Discounting at the high rate of 14.5% creates pressure for heavy additional borrowing during the oil boom. This is because multiplier and real exchange rate effects cause about one third of investment expenditures to accrue to private consumers; whether the investment has a favorable longer-run impact on supply is less important because of discounting. Such considerations have undoubtedly been important in explaining the speed with which governments have absorbed windfalls. However, recession after the boom due to macroeconomic rigidities is so costly that, even with heavy discounting, optimised fiscal policy is rather like that in the base scenario, with little lending abroad or borrowing against future income. This confirms the importance of macroeconomic closures in determining appropriate absorption rates.

Use of Windfall Gains. Abstract from the rate of absorption of windfall gains, and consider the question of how they are absorbed. Several aspects of this issue are addressed in Gelb (1985) using a static version of this model; two other aspects are summarised below.

The first is the choice between expanding public investment programs or increasing subsidies and direct transfers to the private sector. Poorer oil exporters have tended to follow the first policy. Richer exporters, with a wider range of fiscal options have included the second. The latter have, however, usually had more powerful organised labor movements and larger modern sectors, so that subsidies and transfers have become institutionalised. This creates serious adjustment problems when world oil markets turn down.

The model's results suggest that the wider range of fiscal options of the richer exporters is valuable. Optimal transfers can raise the windfall's private value by nearly a third without reducing its social value below that of the base run because progressively lower quality and more costly public investment is an inefficient means to disburse the consumption benefits of windfalls to households. But they also indicate that subsidies and transfers can be very costly in the downturn if they become institutionalised. These results suggest that attempts to link any transfer payments explicitly to oil receipts be given serious consideration, despite their obvious administrative difficulties.[1/]

The second question is appropriate pricing of domestic oil over the boom. Because oil is tradeable, economic efficiency argues for maintaining domestic prices at world levels. However, since pricing policy affects the distribution of income between public and private sectors, the relative value of public and private income streams is an important determinant. This relative valuation depends on the discount rate (low discounting favors public income because of the growth impact of public investment) and also on the feasible set of fiscal options and their flexibility over the oil boom.

If government is under political constraints to spend windfall gains rapidly and the margin of fiscal adjustment is limited to public investment, results show that there may be a "third-best" case for delaying increases in domestic oil prices until after the peak of the boom and then raising them rapidly. This is because the marginal social value of public investment can be driven below zero at the peak of the boom once account is taken of subsequent recurrent costs and the dislocation of massive cutbacks. First-best policies would have involved saving a larger part of the windfall abroad, second-best policies would have included less distortionary ways of shifting resources to the private sector such as lower nonoil taxes or higher

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1/ Such arrangements have been implemented in certain oil-rich regions and were considered by policymakers in several developing countries but not implemented.

transfers. Such a pattern of domestic oil pricing is actually not uncommon.[1/] Its timing renders the increase particularly difficult since the nonoil economy is simultaneously experiencing the effects of contracting demand.

These results also suggest that a phase of lower nonoil tax effort may be appropriate when world oil markets are buoyant but that this should be used to develop a comprehensive tax system able to increase revenues when oil income declines. Nonoil tax effort slackened in several exporters, but only Indonesia appears to have used its fiscal breathing space to institute a major tax reform.

Capital Flight. Rapid depreciation of the real exchange rate is usually only possible with nominal devaluation. If exporters peg their exchange rates and restrict the return on domestic financial assets, the experience of several exporters shows that capital flight is likely when world oil markets turn down and exchange rate policy is seen as unsustainable.

Results show that this shortens the period of adjustment to lower revenues and heightens the premium on good--and cautious--economic management. One group (speculators) with greater flexibility is able to throw the burden of adjustment onto less internationally mobile factors (labor). This greatly increases costs of adjustment. When capital flight follows the peak of the boom as simulated in this paper, it is possible for the windfall to be negatively valued especially if speculators' foreign holdings are not given a positive valuation. It is not clear that this provides a first-best

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1/ Ecuador raised domestic oil prices from $0.18 per gallon to $0.60 in mid-1982, Venezuelan oil prices, which had been constant for 30 years, tripled in 1982 and Indonesia raised internal prices sharply after the end of 1981.

argument for capital controls since the other policies above appear to be equally necessary.[1]

Prediction Errors. How important for determining their value is the fact that windfall gains and reversals have been so poorly predicted? Results of the last set of exercises suggest that overoptimistic projection has serious consequences. Government spending is first optimised subject to a projection that real world oil prices will increase at 6% annually after the period of sharp price increase. As in Mexico (where planning embodied the same assumption), government borrows heavily against expected future oil income and augments the impact of the oil windfall on absorption by two-thirds. The real exchange rate appreciates by an additional 13%, real wages soar and foreign debt accumulates.

At the peak of the boom the euphoric projection is corrected but the economy is locked into a real exchange rate-wage-debt configuration from which exit is only possible at high cost in terms of prolonged domestic recession. Under a wide range of assumptions on macroeconomic closures, capital flows and discount rates the economy is better off in the suboptimal base run. Indeed, receiving (and expecting) no windfall at all is often preferable. When capital flight is induced and real wages are downwardly sticky, the error results in the windfall being valued at -325% of its value in the base run.[2]

1/ Similar capital flow effects have been noted for nonoil countries. Corbo, de Melo and Tybout (1984) discuss the case of Chile.

2/ Rather than drawing up budgets on the basis of expected revenues, producers might therefore adopt a projection such as the "30th percentile rule" in their development planning. This and other options for budgeting under uncertainty with an asymmetric penalty function are discussed i the oil exporter context by Kreinheder and Steinberg (1981).

Summing Up. The above results confirm the critical importance of economic management in determining the value of windfalls, especially if macroeconomic adjustment is asymmetric, capital flows are volatile and prediction is poor. They also suggest a number of explanations for the representative base run phasing of public expenditure over oil windfalls. Of course, it could also be argued--with much weight--that public decisionmakers operate by rules of thumb rather than that they attempt to optimise, that policies emerge from fragmented and inconsistent decisionmaking, that simple criteria such as those used in the paper are inappropriate or that the model in the minds of those making decisions is very different from the kind used in this paper.

First, even if its overt social rate of time preference is low, government will come under pressure to spend rapidly if the time preference of individual agents is high because of the stimulative impact on incomes and consumption levels. If direct transfers are ruled out in favor of public investment this is effected largely--and inefficiently--through real exchange rate appreciation.

Second, analyses of the impact of windfalls have typically not addressed the relationship between choices made during the upswing and their consequences in the possible later downwnturn. Therefore the policy debate has not usually included potential costs in terms of recession which appear to be high.

Third, high or rising world oil prices have typically been justified by producers on the grounds of scarcity. This implies still higher future prices and so is less easy to reconcile with cautious fiscal policies. If the serious consequences of major prediction errors are forseen, risk aversion may dampen the urge to borrow against anticipated revenues. The base policy trajectory then emerges as a reasonable compromise. It is not so countercyclical as would be desired at low discount rates given a high probability of the oil market later weakening. However, it satisfies to some degree political pressures to disseminate windfalls rapidly, and over a range of macroeconomic closures and discount rates it is better than full reliance on an optimistic forecast which might prove to be seriously wrong.

Table 1

Base Run for a Twenty Year Horizon

Year	1/2	5/6	9/10	19/
Terms of trade effect/GDPNM[/a]	0.000	0.168	0.093	0.0
Real private consumption index	1.000	1.380	1.657	3.4
Real public consumption index	1.000	1.284	1.717	2.7
Real investment index	1.000	1.670	1.915	4.1
Public/total investment	0.430	0.518	0.376	0.2
Real exchange rate	1.000	1.250	0.994	1.0
Private consumption deflator	1.000	1.138	0.990	0.9
Public consumption deflator	1.000	1.270	0.980	1.0
Investment deflator	1.000	1.228	0.978	1.0
Real wage index:				
Traditional	1.000	0.993	1.199	1.6
Modern	1.000	1.201	1.093	1.5
Modern labour force/total	0.303	0.337	0.372	0.4
Trade patterns (volumes):				
Food imports	-7	-548	-813	-26
Other agricultural exports	465	50	553	25
Oil exports	721	668	791	1
Manufactured imports	-2426	-3599	-2410	-25
exports	282	293	989	44
Service imports	-403	-558	-786	-18
Debt service ratio	.252	.232	.404	.3

/a GDPNM = nonoil GDP

Table 2
Alternative Uses of the Oil Windfall

	A			B	C	D	E
	Base run			Constant world oil prices	Food subsidy	Direct transfers	5% Rise in man. export growth
Period	"Windfall"	Real exchange rate	Real private consumption	Real private consumption	Real private consumption	Real private consumption	Real private consumption
1	0.00	1.00	1.00	1.00	1.00	1.00	1.00
2	0.11	1.17	1.18	1.13	1.27	1.27	1.13
3	0.17	1.25	1.38	1.29	1.53	1.52	1.29
4	0.09	1.09	1.50	1.45	1.63	1.63	1.45
5	0.03	0.99	1.65	1.64	1.73	1.74	1.65
6	0.03	1.00	1.90	1.88	1.98	1.99	1.89
7	0.02	1.00	2.20	2.16	2.24	2.29	2.19
8	0.02	1.00	2.55	2.51	2.60	2.63	2.54
9	0.01	1.00	2.98	2.92	3.06	3.05	2.97
10	0.01	1.00	3.49	3.43	3.46	3.53	3.50
Valuation by:							
"private" objective u_1			12.3525	12.2294	12.5384	12.5477	12.2537
"social" objective u_2			699.0411	698.1487	696.7363	696.9314	698/83;7
Terminal real output			42,011.3	41,353.2	39,447.[illegible]	39,579.0	41.957.2
% deviation from base			--	-1.6	-6.1	-5.8	-0.1

Source: Series of 7/6/83.

Table 3

Windfalls when Adjustment is Not Smooth

Run	F	G	H	C_1	F_1
Period	Base with wage rigidity	Base with sticky prices	Base with sticky wages and prices	Food subsidies over boom	Food subsidies wage rigidi
		Real Private Consumption			
1	1.00	1.00	1.00	1.00	1.00
2	1.18	1.19	1.19	1.23	1.23
3	1.38	1.38	1.38	1.46	1.46
4	1.49	1.49	1.48	1.54	1.52
5	1.61	1.62	1.60	1.64	1.60
6	1.87	1.88	1.86	1.89	1.84
7	2.18	2.18	2.17	2.18	2.15
8	2.53	2.54	2.53	2.53	2.50
9	2.96	2.96	2.96	2.95	2.92
10	3.47	3.48	3.47	3.46	3.43
Value U_1	12.3246	12.3322	12.3173	12.4243	12.3867
Value U_2	698.7597	698.7890	698.6734	698.7937	698.3822
Terminal non-oil real output	41,803.0	41,815.0	41,738.0	41,680.7	41,376.6
% deviation from base	-0.5	-0.5	-0.7	-0.8	-1.6

Table 4

Optimal Public Savings Abroad

Run[/a]	Summary Valuation: Private	Summary Valuation: Social
A	12.3525	699.0411
B	12.2294	698.1486
XA1	12.4431	698.3066
XB1	12.3657	696.1014
XA2	12.3161	699.6270
XB2	12.2290	698.1875
Windfall:		
(1) A-B	.1231	.8925
(2) XA1-XB1	.0774	
(3) XA2-XB2		1.4395
(2)/(1)	0.63	
(3)/(1)		1.61

/a Runs A and B assume the base borrowing profile over windfall and constant world oil price trajectories, respectively. XA1 and XB1 optimise public borrowing with "private" valuation function U_1 and XA2 and XB2 with "social" valuation function U_2 over the same respective oil price trajectories.

Table 5

Effects of Private Capital Flows

Run Name	A	YA			B	YB		
	Base run	Base with private capital flows			World Oil Prices constant	Run B, with private capital flows		
Period	Real private consumption	Real private consumption	Real exchange rate	Private capital inflows	Real private consumption	Real private consumption	Real exchange rate	Private capital inflows
1	1.00	1.00	1.00	.000	1.00	1.00	1.00	.000
2	1.18	1.18	1.17	.051	1.13	1.13	1.07	.047
3	1.38	1.38	1.25	.067	1.29	1.29	1.12	.059
4	1.50	1.48	1.04	-.613	1.45	1.45	1.08	.038
5	1.65	1.62	1.02	.078	1.64	1.65	1.06	.079
6	1.90	1.77	1.04	.095	1.88	1.89	1.04	.097
7	2.20	2.07	1.02	.104	2.16	2.18	1.03	.118
8	2.55	2.41	1.00	.138	2.51	2.53	1.01	.147
9	2.98	2.84	1.00	.174	2.92	2.96	1.01	.183
10	3.49	3.35	1.0	.218	3.43	3.47	1.00	.228
Value U_1	12.3525	12.2654			12.2294	12.2503		
Value U_2	699.0411	697.1211			698.1487	698.7248		
Terminal Real Output	42,011.3	40,409.4			41,353.2	41,867.6		
Deviation from Base	---	-3.8%			-1.6%	-0.3%		

Table 5 (continued)

Run name	A*	YA*				YF	
	A without private investment efficiency losses	A* with private capital flows				Rigid real wages and private capital flows	
Period	Real private consumption	Real private consumption	Real exchange rate	Private capital inflows	Real private consumption	Real exchange rate	Private capital inflows
1	1.00	1.00	1.00	.000	1.00	1.00	.000
2	1.18	1.18	1.17	.051	1.18	1.17	.051
3	1.38	1.38	1.25	.067	1.38	1.25	.067
4	1.51	1.49	1.04	-.614	1.46	1.09	-.617
5	1.66	1.65	1.02	.075	1.57	1.07	.076
6	1.91	1.89	1.02	.099	1.72	1.09	.094
7	2.21	2.19	1.01	.121	2.00	1.01	-.166
8	2.57	2.56	1.00	.149	2.37	1.00	.135
9	3.00	3.00	1.00	.145	2.76	.99	.170
10	3.53	3.53	1.00	.231	3.27	.99	.212
Value u_1	12.3648	12.3539			12.2039		
Value u_2	699.4770	699.5256			695.9581		
Terminal Real Output	42,416.7	42,499.6			39,491.2		
Deviation from Base	+1.0%	+1.2%			-6.0%		

Table 6

Optimal Government Borrowing with Speculative Capital Flows

	Base World Oil Price Profile		Constant World Oil Prices	
Real private consumption period	Privately optimal YXA1	Socially optimal YXA2	Privately optimal YXB1	Socially optimal YXB2
1	1.00	1.00	1.00	1.00
2	1.18	1.15	1.17	1.13
3	1.36	1.33	1.33	1.28
4	1.53	1.49	1.50	1.45
5	1.72	1.68	1.70	1.65
6	1.96	1.93	1.93	1.89
7	2.23	2.23	2.18	2.18
8	2.55	2.60	2.46	2.53
9	2.93	3.04	2.88	2.97
10	3.55	3.53	3.47	3.47
Value u_1	12.3810	---	12.3064	---
Value u_2	---	700.1479	---	698.7709
Terminal year real output	41,888.4	43,142.6	40,534.5	41,921.4
Deviation from base	-0.3%	+2.7%	-3.5%	-0.2%

Table 7

The Welfare Gains of Optimal Government Borrowing with and without Speculative Capital Flows [a]

	Privately optimal (Valuation function u_1)		Socially optimal (Valuation function u_2)	
	With capital flows	Without capital flows	With capital flows	Without capital flows
Base world oil prices profile	YXA1-YA: .1156	XA1-A: .0906	YXA2-YA: 3.0268	XA2-A: .5859
Constant world oil prices	YXB1-YB: .0561	XB1-B: .1363	YXB2-4B: .0461	XB2-B: .0388
Base oil prices profile with sticky wages	YXA1-YF: .1771	XF1-F: .0779	YXA2-4F: 4.1898	XA2-F: .8673

/a The Table shows differences between valuations of paired runs. A denotes the base world oil price profile, B constant oil prices, F sticky wages, X optimised borrowing and Y open capital markets.
1 and 2 denote the criterion used in the optimisation.

Table 8

Socially Optimal Government Borrowing Under Incorrect Expectations

Run description		ZA2 Base world oil prices, incorrect expectations	ZF2 Same as ZA2 with rigid wages	YZA2 ZA2 with private capital flows	YZA2* YZA2 without private investment penalty	YZF2 YZA2 with rigid-wages
Real private consumption	Period					
	1	1.00	1.00	1.00	1.00	1.00
	2	1.16	1.16	1.16	1.16	1.16
	3	1.41	1.41	1.41	1.41	1.41
	4	1.50	1.47	1.40	1.45	1.45
	5	1.65	1.60	1.60	1.64	1.51
	6	1.88	1.81	1.79	1.88	1.61
	7	2.17	2.08	2.08	2.18	1.93
	8	2.52	2.45	2.43	2.53	2.30
	9	2.95	2.89	2.87	2.98	2.72
	10	3.50	3.45	3.37	3.53	3.28
Social value (u_2)		698.7230	697.8728	697.5134	699.2967	695.6718
Relevant comparison runs with perfect foresight		XA2, XB2	XA2, XB2	YZA2, YXB2		YXA2, YXB2
Percentage of windfall benefits lost due to expectations error		62.8%	121.9%	191.3%		325.1%
Terminal-year real output		41,728.4	41,076.9	40,804.5	42,319.0	39,350.8
Deviation from base		- 0.7%	- 2.2%	- 2.9%	+ 0.7%	- 6.3%
Memorandum item: percentage of windfall benefits lost at Private Discount rate against same comparison runs		- 27.1%	46.8%	99.0%		197.6%

Figure 1

Real Wage Trends over the Oil Cycle

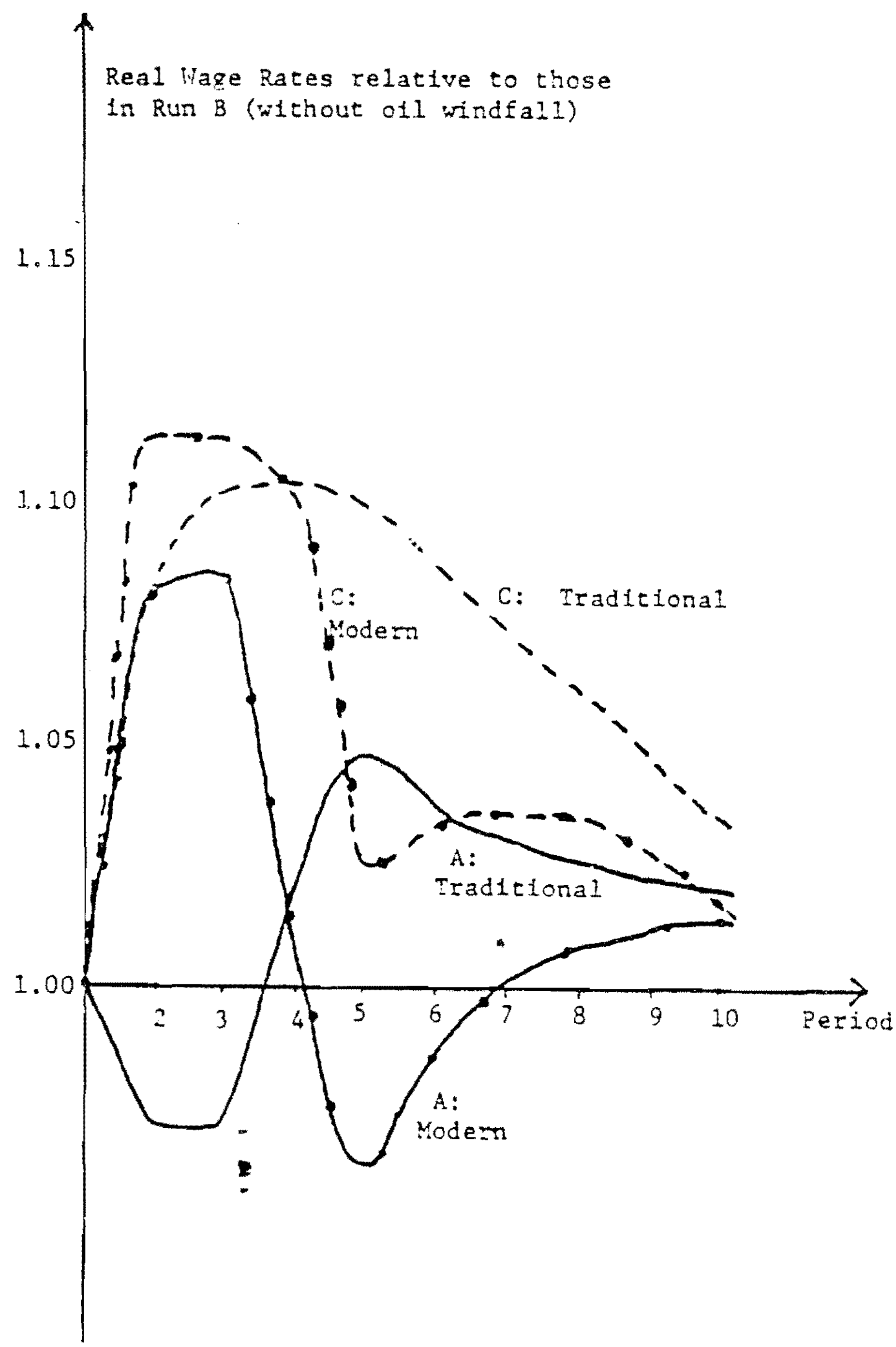


Figure 2

Normalised Duals of Domestic Oil Price

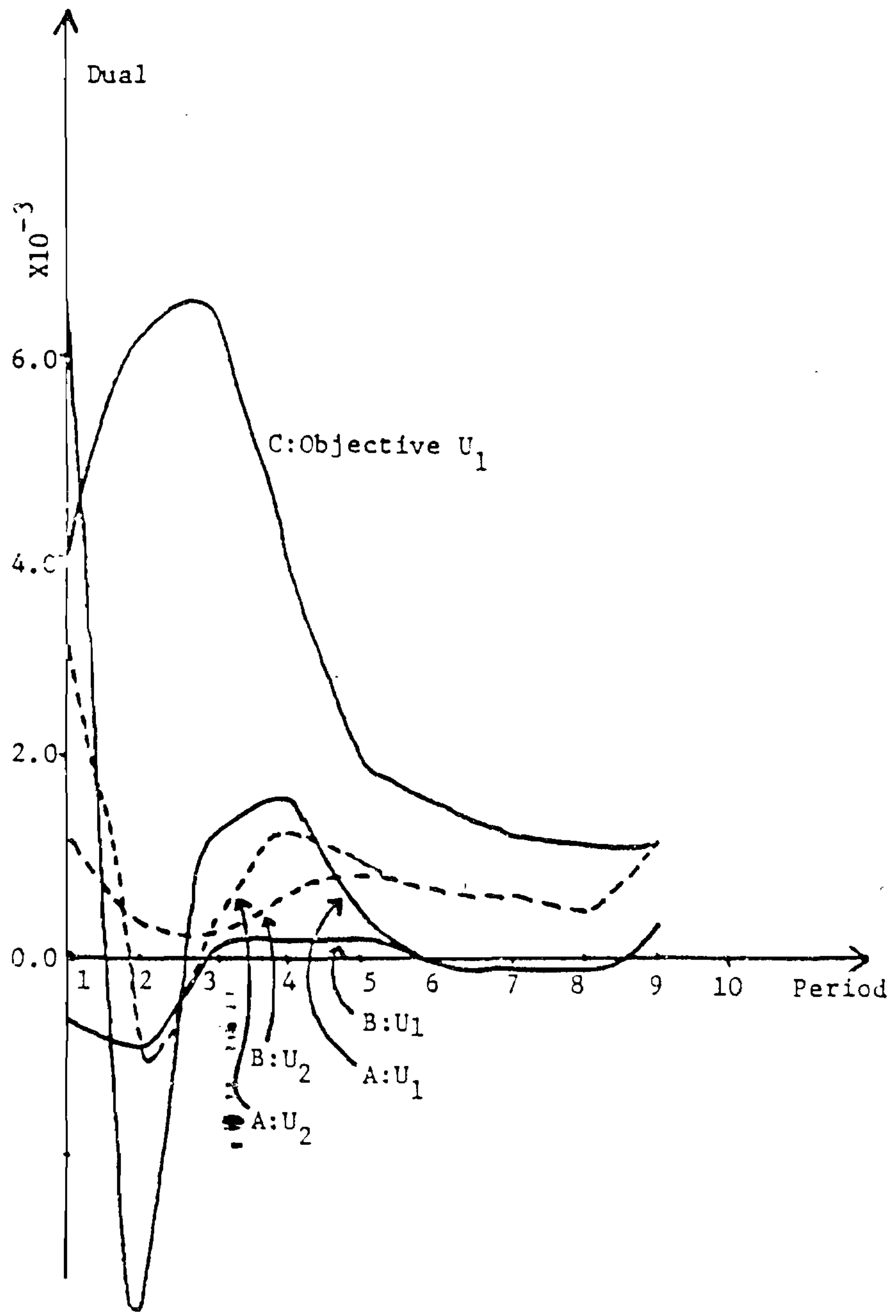


Figure 3

Optimal Public Borrowing

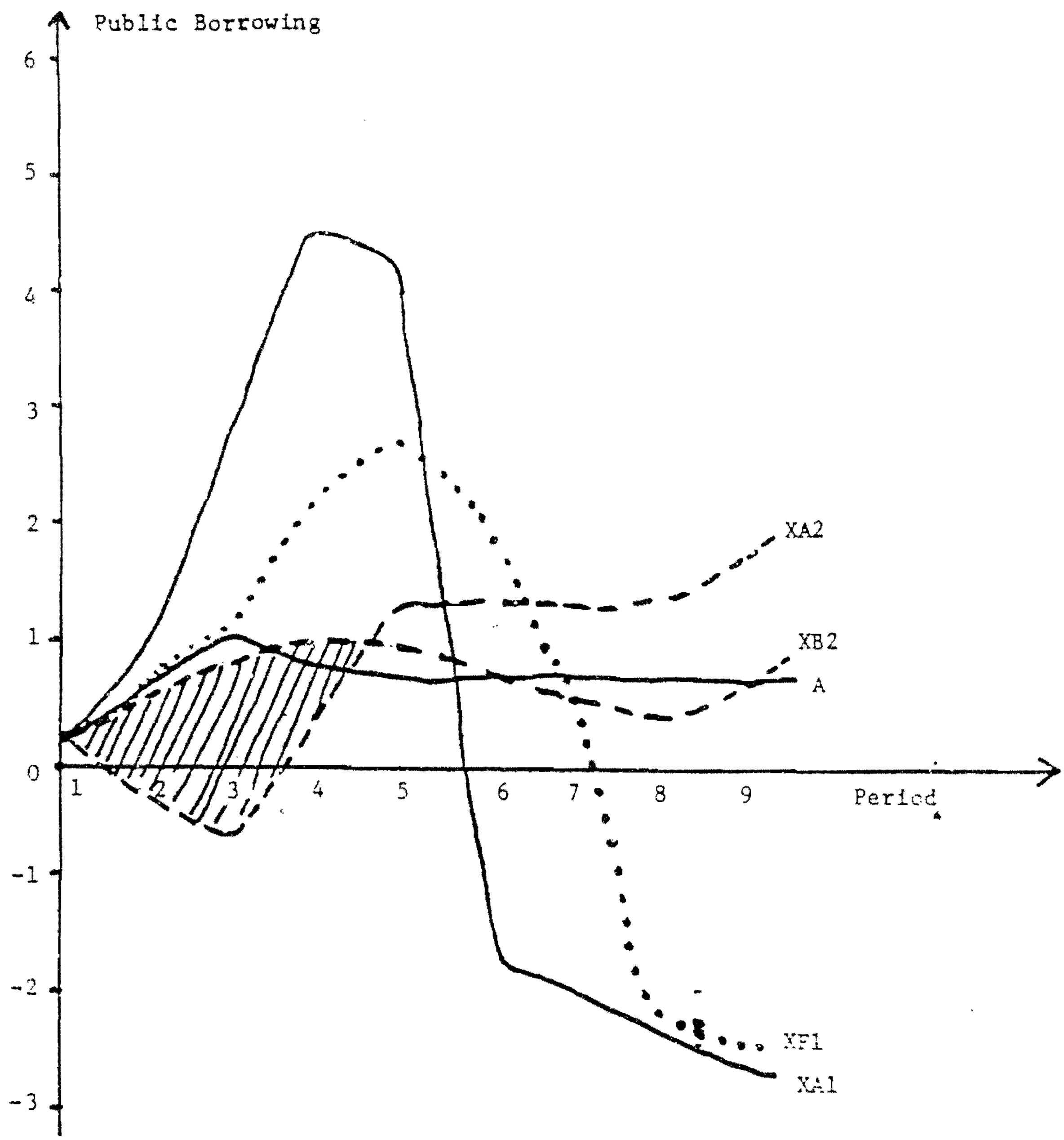
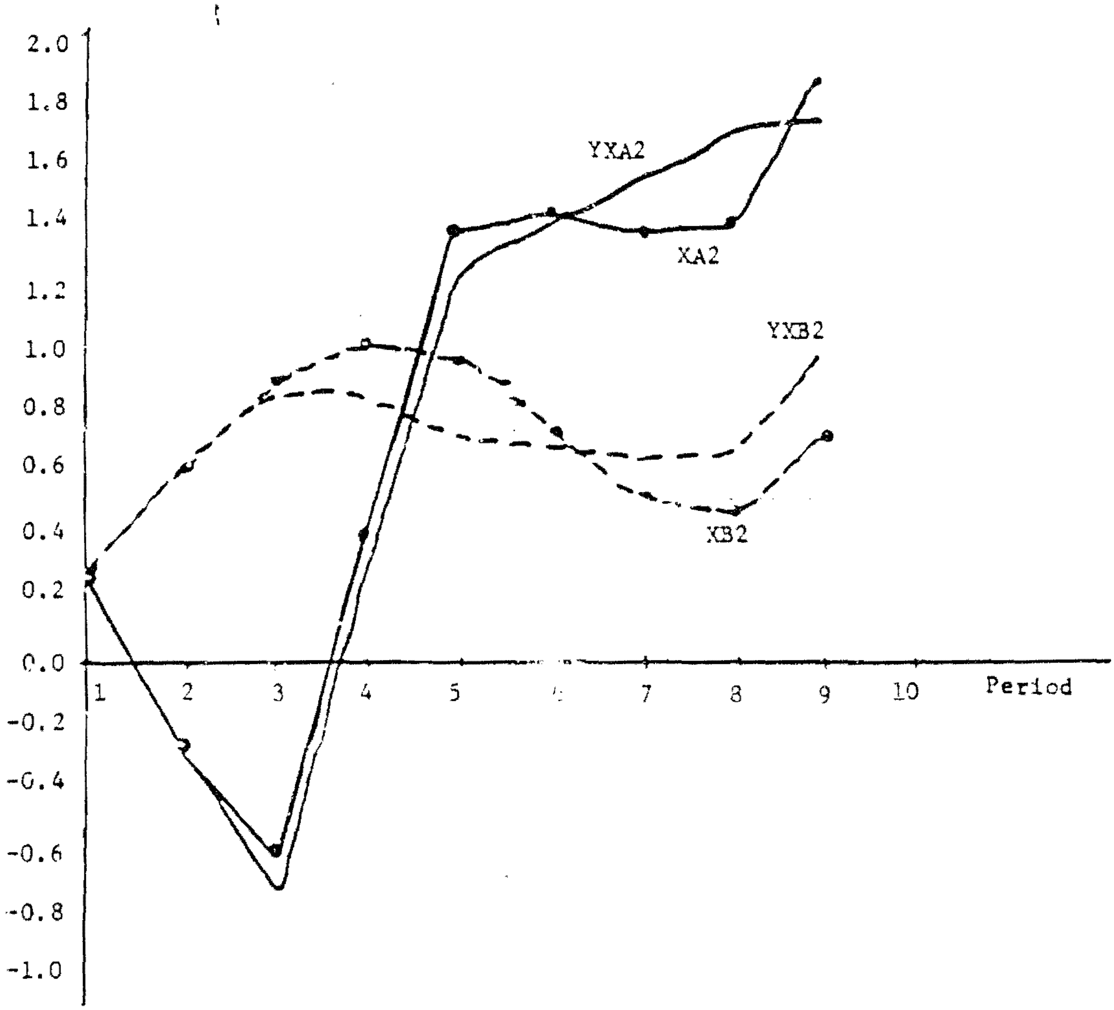


Figure 4

Socially Optimal Public Borrowing



and Resulting Real Exchange Rates

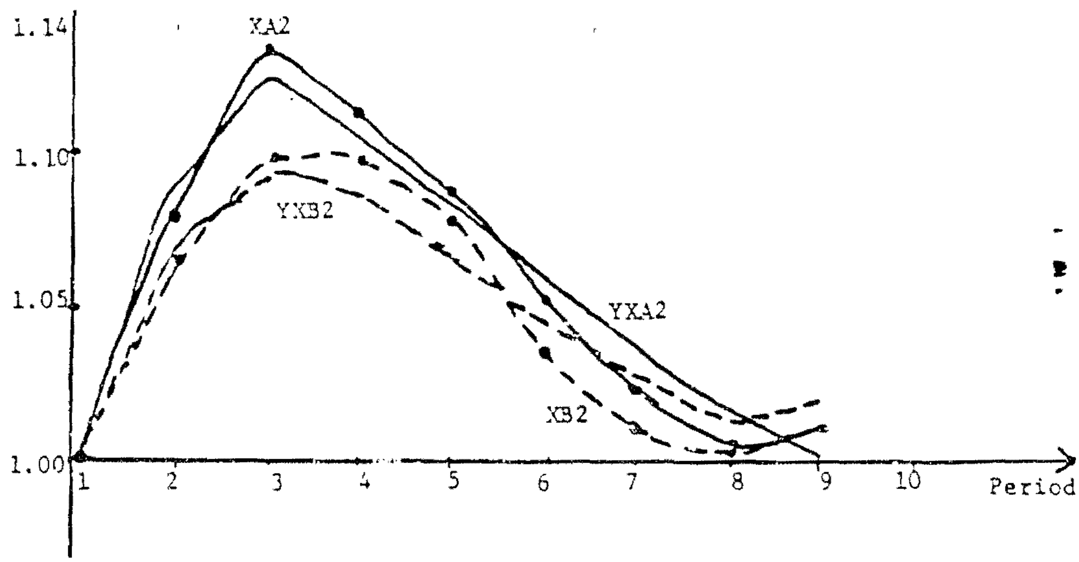
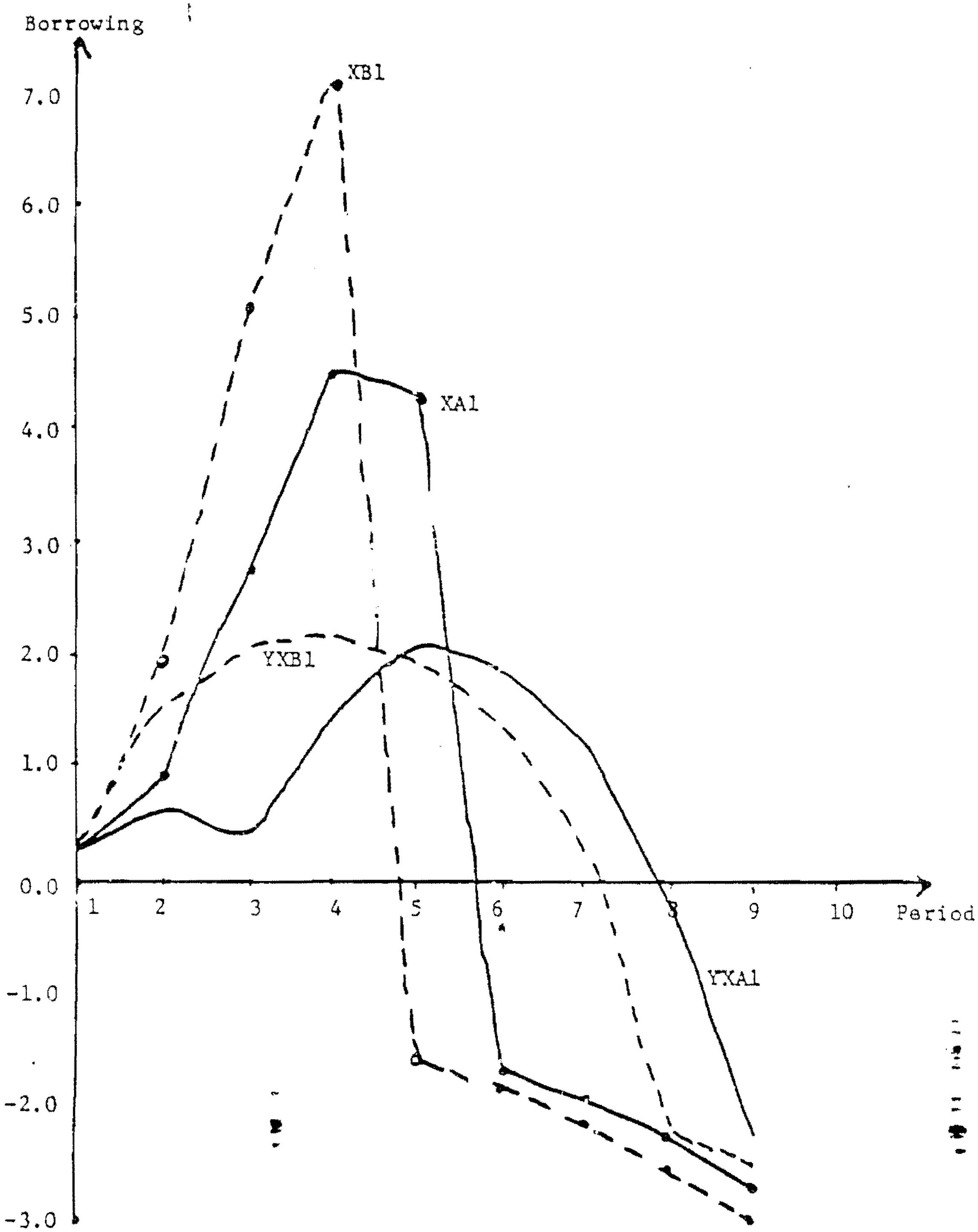


Figure 5

Privately Optimal Public Borrowing



CONTINUED

Figure 5 (continued)

and Resulting Real Exchange Rates

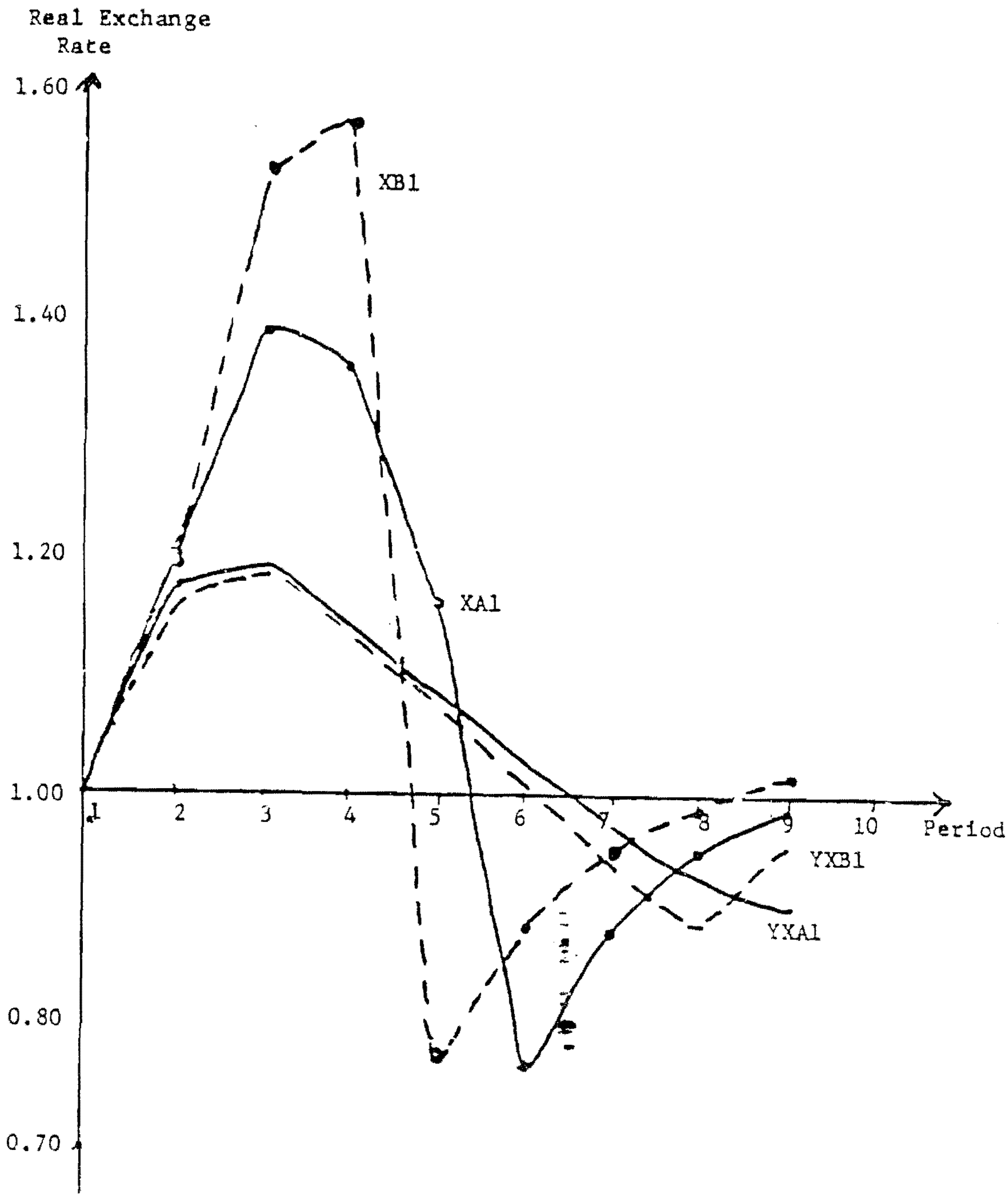
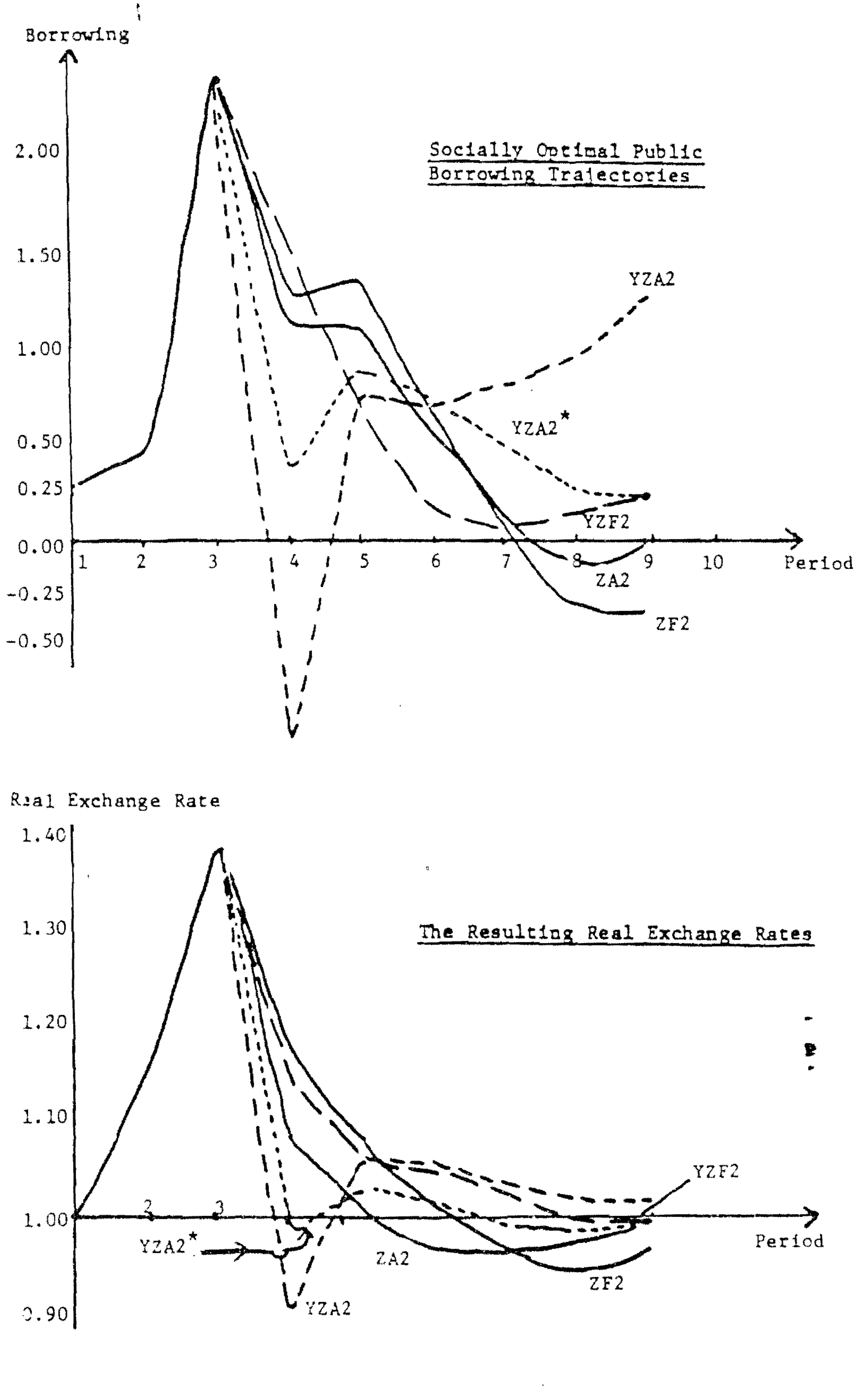


Figure 6

Euphoric Expectations



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Annex I
SIMULATION AND OPTIMIZATION

An objective function is termed "compatible" with a base simulation if the latter is close to optimal, under a given set of constraints, when judged by the function. Objective functions may also be "imposed." This Annex describes the objective functions used and their relationship with the base simulation.

Cross-country studies such as Chenery and Syrquin (1975) provide typical savings rates for countries in transition to middle-income status; modelled Indonesia is assumed to experience such a transition. Preference underlying the private savings decision may not be identical with social preference; an arbitrary "social" welfare function, identical to the "private" function except for the discount rate, provides an additional alternative objective. It is not feasible to calibrate this second function since there is no cross-country evidence that government policy is strongly and regularly related to the level of development, let alone optimal. A social discount rate of 3% per year was chosen exogenously, to represent planners' time preference.

Calibration of the "private" function also involves absorptive capacity constraints on the rate of investment. As shown in Figure A1, without them and with low discounting the optimal savings rate rises to an asymptote far more rapidly than on the base path. Once reasonable absorptive constraints were established, the least-squares distance between the simulation and optimization trajectories was minimized, resulting in a value for the private discount rate of 14.5% per year.[1/]

Objective Function

The maximand is:

$$\sum_{t=1}^{10} (1+r)^{-2(t-1)} \ln\left[\frac{CH_t}{PCPI_t \cdot 1.046^{t-1}}\right] + \frac{(1+r)^{-18}}{(1+r)^2-1} \ln[\phi(Y_{10}) \cdot 1.1151^{(1+r)^2/((1+r)^2-1)}]$$

where:

$\phi(Y_{10}) = .57247\, Y_{10} - .0034215\, Y_{10}^2$ is an estimate of per-capita real consumption possible with final period real non-mining GDP, Y_{10}

r = discount rate less population growth rate

$\frac{CH_t}{PCPI_t}$ = aggregate real consumption, period t

1.046 = per-period population growth factor

1.1151 = assumed post-horizon growth per period in real per-capita consumption (5.6% per year).

The starting point for this function is the discounted sum ot individual utility, a function of per-capita real consumption, C:

$$\sum_{t-1}^{\infty} POP_t (1+\hat{r})^{-2(t-1)} U(C_t).$$

1/ This figure is high compared to the zero to five percent range commonly supposed for a social welfare function, but the private rate has to compensate for the absence of risk to modelled private investors. In view of the 3-5 year payback period commonly required for corporate investments it is not unreasonable.

$\hat{r}$ is the discount rate (3.0% or 14.5%).

$$\sum_{t=1}^{\infty} POP_t(1+\hat{r})^{-2(t-1)} U(C_t) = POP_1 \sum_{t=1}^{\infty} (1+r)^{-2(t-1)} U(C_t)$$

where $1+r = \dfrac{1+\hat{r}}{1.046}$. Assume that U is the natural logarithm.

$$U(C_t) \equiv \ln(C_t) = \ln\left[\frac{CH_t}{PCPI_t \cdot POP_t}\right] = \ln\left[\frac{CH_t}{PCPI_t \cdot 1.046^{t-1}}\right] - \ln POP_1$$

and the last term may be disregarded. The objective function is now:

$$\sum_{t=1}^{\infty} (1+r)^{-2(t-1)} \ln\left[\frac{CH_t}{PCPI_t \cdot 1.046^{t-1}}\right].$$

To solve the terminal condition, in the "post-horizon" steady nonoil output growth at 8% per year and a constant consumption/output ratio are assumed. Consumption/head grows at 11.51% per two years. Let C_{11} be per-capita real consumption in period 11; the objective can be written:

$$\sum_{t=1}^{\infty} (1+r)^{-2(t-1)} \ln(C_t) = \sum_{t=1}^{10} (1+r)^{-2(t-1)} \ln(C_t) + \sum_{t=11}^{\infty} (1+r)^{-2(t-1)} \ln(C_{11}.1.1151^{t-1})$$

Considering the second term,

$$\sum_{t=11}^{\infty} (1+r)^{-2(t-1)} \ln(C_{11}.1.1151^{t-11}) =$$

$$= (1+r)^{-20}[\ln C_{11} \sum_{t=0}^{\infty} (1+r)^{-2t} + \ln 1.1151 \sum_{t=0}^{\infty} t(1+r)^{-2t}]$$

$$= (1+r)^{-20}[\ln C_{11} \frac{(1+r)^2}{(1+r)^2-1} + \frac{\ln 1.1151}{(1+r)^2} \frac{d}{d(1+r)^{-2}} \sum_{t=0}^{\infty} (1+r)^{-2t}]$$

$$= (1+r)^{-20}(\ln C_{11} \frac{(1+r)^2}{(1+r)^2-1} + \frac{\ln 1.1151}{(1+r)^2} \cdot \frac{1}{[1-(1+r)^{-2}]^2})$$

$$= \frac{(1+r)^{-18}}{(1+r)^2-1} \ln(C_{11} \cdot 1.1151^{1/(1+r)^2-1}) .$$

From the national accounts identity:

$$\frac{C}{Y} = 1 - \frac{G}{Y} - \frac{I}{Y} \quad \text{1/}$$

On the steady growth path, $I = \alpha K$, where α is the sum of depreciation and growth. From simulation runs with different savings trajectories, the

---

1/ Actually, this is a closed-economy identity. Given the positive trade balance and petroleum sector output (not included in the definition of Y_{10}), the 10th-period base simulation equation is more precisely $C + I + G = 1.0678Y$. Since these other factors could not be expected to keep pace with the 8% annual growth of the non-mining economy, and in fact will tend to zero over time, the actual C/Y and G/Y ratios were scaled down by a factor of 1/1.0678 in calibrating $\phi(Y_{10})$. In other words, the terminal valuation ignores any temporary increments to consumption from petroleum or net foreign savings in period 10.

terminal-year aggregate economy can be roughly approximated by a simple Cobb-Douglas production function with equal capital and labor value shares. K/Y is then proportional to Y/L and $C/Y = 1 - G/Y - \lambda Y$. Using the C/Y and G/Y ratios from the final period of the base simulation run, λ can be derived;1/ If the government share holds in the post-horizon period, $C/Y = .8581 - .0051286Y_{10}$; higher C/Y within the horizon implies a higher post-horizon consumption rate, lower savings, lower capital intensity and smaller terminal-year output. To obtain per-capita consumption in "period 11" the consumption ratio is multiplied by Y_{10}, divided by the population factor 1.046^9 (yielding $\phi(Y_{10})$ in the full objective function), and multiplied by the constant per-capita consumption growth rate assumed to apply between periods 10 and 11. This raises the exponent on the 1.1151 term from $\frac{1}{(1+r)^2-1}$ in the above derivation to $\frac{(1+r)^2}{(1+r)^2-1}$ as in the full objective function.

This completes the derivation of the objective function.

1/ The Cobb-Douglas scaling factor includes the effects of technological progress and government infrastructure investment, as well as compositional shifts hidden in the 1-sector aggregation. Because the first of these, like the labor supply, is constant across runs, while the others do not vary greatly, it is a reasonable approximation to use the same λ to evaluate all 10-period variables, and thus to attribute major changes in real GDP to changes in the capital stock and capital/output ratio.

Figure A1

Base and Optimal Private Savings