'To refer to a vast, valuable energy resource as the source of a “disease” sounds rather ungrateful.' The Economist on the Netherlands.

It is becoming increasingly clear that high but temporary oil revenues may be somewhat of a mixed blessing, the quip of The Economist notwithstanding. Many third world oil producers are encountering serious problems in building up a diversified export base, while West European oil and gas producers (Netherlands, United Kingdom) are suffering a decline in their traded goods (manufacturing) sector induced by real wage pressures. The mechanism behind all this is clear enough: part of the oil revenues is spent on non-traded goods which leads to a real appreciation (i.e., a rise in the relative price of non-traded goods in terms of traded goods). This in turn draws resources out of the non-oil traded sector into the non-traded goods producing sector (Corden and Neary (1982); van Wijnbergen (1980)). One could argue of course that this is an efficient response to the increase in income from oil production, the United Kingdom (Mexico, Egypt, ...) simply should move into oil derived industries and non-traded goods and forget about their manufacturing sector until oil reserves are exhausted. Many developing countries are hesitant to take this advice: after all the post-World War II success stories in economic development involve without exception countries that promoted their traded goods sector aggressively. Moreover, it is a well-established ‘stylised fact’ that technological progress is faster in the traded non-sheltered sectors of an economy than in the non-traded sector (Balassa (1964) is an early reference). If one further adopts the hypothesis that technological progress, rather than taking place exogenously with the passage of time, is a function of accumulated experience, the concern of countries like Egypt, Mexico or Indonesia is much easier to understand. Since Solow (1957) and Denison (1962) we know that capital accumulation explains only a small part of economic growth. If most of economic growth is caused by Learning by Doing induced technological progress which moreover is largely confined to the traded goods sector, a temporary decline in that sector may permanently lower income per head compared with what could otherwise have been attained (Hahn and Matthews (1965), p. 70). This is the issue we will address in this paper.

Learning by Doing induced technological progress is somewhat analogous to the phenomenon of economies of scale, although the irreversibility of accumu-
lating experience makes for a crucial difference. As with economies of scale, however, the main issue is whether it is a firm-specific or industry-specific phenomenon. If a firm can appropriate all the return on experience, there is no reason to expect a divergence between private and social marginal net product and no government intervention is called for. There is, surprisingly enough, no empirical evidence to resolve this problem, but a survey of the literature leads to the belief that a significant part is in fact industry-specific. The classic case refers to diffusion of new processes (Mansfield, 1968): successful application of new processes by one firm provides information to non-adopters who will accordingly be more likely to adopt the new technique the more other firms have already done so. There is no way the first firm can extract payment for this information, so there is a case for government intervention. Another example is the case where Learning by Doing takes place as on-the-job training of industry specific skills, with no quit costs to the worker. In that case the worker would be forced to finance the training costs himself by taking a lower starting wage: the firm cannot appropriate the returns on training if the worker can quit costlessly, so the firm will refuse to pay for it (Becker 1962)). However, human capital is to a large extent a non-tradeable asset; a market in human capital (future wage claims) would present obvious moral hazard problems in modern non-slave societies. This creates at least two problems with the Becker story about optimality of the market solution. One is that if workers buy the optimal amount of training by foregoing part of their marginal product early in life they may end up saving more than they want: they cannot finance current consumption by selling claims on their higher future wages. The second is that even if they could consume enough they might end up with too high a share of their wealth in human capital as opposed to claims on physical capital if uncertainty about future factor shares calls for diversification over physical and human capital (Merton, 1981). So even in this case one might end up with under-investment in experience without government intervention. All this warrants in my view an exploration of the implications of industry-specific, Learning by Doing induced technological progress.

In Section I we will present a simple two sector, two period model, where Learning by Doing (LD) is modelled via a positive link between second and first period Traded (T) goods output. The optimal intervention is a production subsidy, the size of which depends on a trade off between the current welfare costs and the future welfare benefits of such a subsidy. The model is analysed using the dual approach, pioneered in trade theory by Dixit and Norman (1980), because this method of analysis provides explicit expressions for welfare changes in a very straightforward manner. We will first analyse the relation between the optimal subsidy to the T-sector and temporary oil revenues in the absence of foreign asset accumulation or foreign borrowing (an exogenous current account): expenditure is not smoothed across the drop in oil revenues between period 1 and 2. This assumption will be relaxed in Section II. The results unambiguously confirm that high temporary oil revenues should lead to a higher subsidy to the T-sector during the period of high oil revenues.

1 This is of course the rationale behind agricultural extension projects.
In Section II we introduce foreign capital markets and allow countries to smooth expenditure over time via foreign asset accumulation. As this leads to a shift of expenditure towards the (post-oil) future, and so to more demand for NT-goods in the post oil period, the case for an increase in subsidies to the T-sector is weakened. In fact no unambiguous answer is possible under the extreme assumption of a perfect foreign capital market with a rate of interest not influenced by our country’s actions (the small country assumption). Section III concludes.

Since the pioneering work by Arrow (1962) it is recognised that industry specific (as opposed to firm-specific) Learning by Doing effects call for government intervention; more specifically for production subsidies. In this section we will analyse the relation between the optimal subsidy to the sector where the LD takes place (by assumption the traded good sector) and temporary changes in oil revenues. We will do this within the context of a simple two-period extension of the Salter–Swan model of the open economy. In Section I the current account is assumed exogenous (and for simplicity equal to zero); an endogenous current account and optimal borrowing are introduced in Section II.

Consumer preferences are represented by a homothetically weakly separable utility function $U[Z(ZT, ZN), z(zT, zN)]$ where the subutility functions $Z, z$ are also assumed to be homothetic and the same in each period. Upper case letters refer to period 1 variables, and lower case to period 2 variables. $ZT, zT$ indicate consumption of traded goods in period one and two respectively and $ZN, zN$ are the corresponding concepts for Non-Traded goods. We will use the corresponding expenditure function $E[\Pi(P, Q), \pi(p, q, U)]$, giving the minimum expenditure needed to achieve utility level $U$ given the price structure. $P$ and $Q$ are the prices of $T$ and NT goods today and $p, q$ the prices, in discounted value terms, of these goods in period 2. $\Pi$ is the exact price index corresponding to the subutility index $Z$ (similarly for $\pi$ and $z$) and is a unit expenditure function: $\Pi_P = ZT/\Pi$ etc. We can define a ‘within period’ expenditure function $E$ ($e$ for period two) as

$$E = \Pi(P, Q)Z, \quad e = \pi(p, q)z$$

where the discounted value of total expenditure equals

$$\tilde{E} = E + e.$$

The expenditure decisions can be thought of as taking place in two steps: first, $E$ and $e$ are minimised for any given value of $Z$ and $z$. Then the cost-minimising allocation of intertemporal expenditure takes place.

In the absence of a capital market, however, step 2 will be impossible and $Z, z$ will in essence be determined by the within period budget constraint (for an extensive discussion of all this see Razin and Svensson (1983)).

The assumption of an exogenous current account gives us our first equation,
income from oil ($F$) and from production of Traded and Non-Traded goods in period $i$ ($R$) should equal expenditure in period $i$, $E$:

$$E(P, Q; Z) = R(P, Q) + F,$$

(1)

$R$ is a revenue function indicating the maximum revenue one can obtain from the production of traded and non-traded goods in period $i$ given prices $P$ and $Q$ and the factors of production available to the economy.\(^1\) For an application of these concepts to trade theory see the lucid exposition by Dixit and Norman (1980). A similar equation must hold for the second period, with one added complication: LD in the T-sector implies that more production in the T-sector during period $i$ will increase output in the T-sector in period 2 given that everything else remains the same. The way to incorporate that in the analysis is to introduce a shift factor in the second period revenue function that is proportional to the output of traded goods in the first period $X_T$ (which is, by the duality properties of the revenue function, $dR/dP (= R_P)$):

$$T = r(p, q; R_P)$$

with $r_R > 0$, $r_pR > 0$, $r_qR < 0$,

(2)

where $r_R = \partial r/\partial R_p$ etc. The signs of the cross effects indicate that the outward shift indeed occurs in the T-sector. For analytical convenience we will assume that the shift is linear: $r_{RR} = 0$.\(^2\) Oil revenues are temporary, which is incorporated by setting them equal to zero in period 2. The income equals expenditure relation for period 2 then becomes:

$$e(p, q; z) = r(p, q; R_P),$$

(3)

where $p$ and $q$ are the prices of traded ($p$) and non-traded ($q$) goods in period 2 discounted back to period 1 at the world rate of interest $r^*$. By choice of normalisation, the current price of traded goods in each period is set equal to one so that

$$P = 1, \quad p = \frac{1}{1 + r^*}.$$  

(4)

The profit maximising level of non-traded goods output in each period is given by the derivative of the respective revenue function with respect to the real exchange rate, which, given our normalisation rule, equals $Q$ in period 1 and $q$ in period 2,

$$X_N = R_Q, \quad x_N = r_q.$$  

(5)

Similarly, demand for NT goods can be derived from the expenditure functions:

$$C_N = E_Q, \quad c_N = e_q.$$  

(6)

Market clearing in both periods requires demand to equal supply in the NT market:

$$R_Q = E_Q, \quad r_q = e_q.$$  

(7)

\(^1\) Total factor supply is considered exogenous and therefore not introduced as an argument of the revenue function $R$.

\(^2\) This assumption was relaxed in an earlier version. Doing so strengthened the results without however adding qualitative insights so I left it out.
By assumption the private sector does not internalise the 'Learning by Doing' externality, so its output of T-goods in period one will equal

$$X_T = R_P.$$  
\(8\)

Socially optimal production (in the absence of capital market distortions, see below) clearly equals

$$\bar{X}_T = R_T + r_R R_{PP}.$$  
\(9\)

\(R_{PP} > 0\) because the revenue function is convex, so that the socially optimal output of traded goods in period 1 always exceeds private output without government intervention. The reason is that firms will not internalise the positive future benefits associated with higher current production of traded goods. The optimal response of course is a production subsidy to the traded goods sector that would induce it to produce at the socially optimal level. Of course this subsidy needs to be financed one way or another; we will make the time honoured (but not very realistic) assumption that the government finances the subsidy via non distortionary taxes.\(^1\) This leads to a minor change in the first period income equals expenditure relation \((1)\) which now becomes:

$$E(P, Q; Z) = R(P + s, Q) + F - SR_P,$$  
\(10\)

where \(S\) is the per unit subsidy.

To determine the socially optimal level of the subsidy one needs to maximise a social welfare function subject to the constraints set up so far. A natural choice for that welfare function is the function \(U(Z, z)\) underlying the expenditure function \(E\). Differentiation of \(U\) with respect to \(S\) yields:

$$\frac{\partial U}{\partial Z} \frac{\partial Z}{\partial S} + \frac{\partial U}{\partial z} \frac{\partial z}{\partial S} = -U_Z E_z^{-1} + U_z e_z^{-1} r_R = 0$$  
\(11\)

or

$$S^* = \lambda r_R; \quad \lambda = \frac{\Pi \frac{\partial U}{\partial z}}{\Pi \frac{\partial U}{\partial Z}},$$

\(\lambda\) is the ratio of the marginal utility of expenditure tomorrow \((z)\) (discounted back to today) to the marginal utility of expenditure today \((Z)\). \(r_R\) is the discounted value of the additional revenues tomorrow generated by an additional unit of T-goods produced today.

The formula has a nice intuitive interpretation: if private producers receive the benefits generated on the margin by this LD externality, corrected for any wedge between the marginal utility of income today and tomorrow induced by capital-market imperfections, they will produce the socially optimal level of traded goods in period one. If there are no capital-market imperfections, \(\lambda = 1\) and the formula simplifies to \(S^* = r_R\) (Section II). The presence of \(\lambda\) in \((11)\) indicates there is an intertemporal tradeoff involved in determining \(S^*\): an increase in \(S\) will lead to a decline in welfare today because of the increased static price distortion it causes in period 1, but to an increase in welfare tomorrow because of the dynamic benefits associated with the larger future outward shift of the production function in the T-sector. If on the margin expenditure generates

\(^1\) Note, however, that the government could tax oil revenues.
more utility today than tomorrow because capital market imperfections prevent intertemporal arbitrage (λ < 1), a smaller subsidy is called for than would otherwise be the case.

What happens when oil revenues in period 1 go up \((dF > 0)\)? The impact effect on welfare in period 1 is of course positive, as can be seen by differentiating (10):

\[
\frac{\partial Z}{\partial F} = E_Z^{-1} = \Pi^{-1} > 0.
\]

There is no direct impact effect of current oil revenues on second period welfare under our assumption of an exogenous current account. The only intertemporal channel there is runs from the first period real exchange rate \(Q\) via the share of resources devoted to T-goods production in period 1 to LD effects on the T-sector in period 2. So to find out what happens to second period welfare and exchange rate given \(S\), we first have to analyse what happens to today's real exchange rate. This can be done by looking at the NT-goods market clearing equation for period 1 in conjunction with (10) to substitute out first period-welfare \(Z\):

\[
(R_{QQ} - E_{QQ} + C_N^Q R_{PQQ} S) dQ = -(R_{QP} + SR_{FP} C_N^P) dS + C_N^Q dF,
\]

where \(C_N^Q\) is the marginal propensity to spend on NT-goods in period 1

\[
(C_N^Q = E_{QQ} E_Z^{-1}).
\]

If oil revenues go up, expenditure will rise and part of that increase will fall on non-traded goods. To restore equilibrium in the NT-goods market a real appreciation is called for. In Fig. 1 (NE quadrant) this is shown as an upward shift of the locus describing NT market equilibrium in period 1. Higher subsidies in period 1 will draw resources into the T-sector during period 1, thus reducing the supply of NT-goods; once again a real appreciation is called for to restore

![Fig. 1. First round effects of an increase in oil revenues in period 1.](image-url)
equilibrium in the period 1 NT-goods market. This implies an upward sloping $NT^1$ schedule (see Fig. 1).

If today's real exchange rate goes up ($Q$ increases), more resources will be drawn into the NT-sector away from the T-sector, thus reducing LD effects and the future supply of T-goods. The resulting excess demand for T-goods in period 2 has as its mirror image an excess supply of NT-goods via Walras' law, so a real depreciation in period 2 will be necessary. This is what differentiation of the period 2 NT-goods market equilibrium condition, equation (7) for period two, tells us and is shown by the downward sloping curve $NT^2$ in the NW quadrant of Fig. 1. A higher subsidy to the T-sector in period 1 would lead to a transfer of resources back into the T-sector; this would of course have the opposite effect on tomorrow's real exchange rate: the $NT^2$ curve shifts up when first period subsidies are increased.

From (11) it is clear that there is a negative relation between tomorrow's real exchange rate $q$ and the size of the optimal subsidy $S^*$. Two channels work in that direction, one via $r_F$ and the other via $\lambda$. The first one is straightforward. A higher real exchange rate tomorrow leads to a lower value of future benefits of the subsidy ($r_{Fq} < 0$), so the optimum first period subsidy goes down. The second channel is more subtle. A higher real exchange rate tomorrow given everything else means there is an appreciation between today and tomorrow. This means that, for a given foreign capital market rate, the cost of borrowing is going down in terms of consumption foregone to repay any given loan: we borrow in terms of traded goods which are becoming cheaper over time (see Martin and Selowsky (1983) or Dornbusch (1983) for an elaboration of this issue). This in turn means we would like to shift expenditure from the future to today (it is less valuable tomorrow), or equivalently, $\lambda$ falls. We will encounter this effect (Cost of Borrowing effect) of a change in relative prices over time again in the next section. Formally this can be seen by differentiating the expression for $\lambda$ in (11):

$$\frac{\partial \lambda}{\partial q} = -\frac{\lambda \partial \pi}{\pi \partial q} = -\frac{\lambda z_N}{\pi} < 0.$$  

Since $S = \lambda r_F$, this decline in $\lambda$ leads to a second downward influence on $S$ in addition to the one via $r_F$. Accordingly the optimal subsidy $S^*$ goes down unambiguously when $q$, the second period real exchange rate, goes up. So the $OS$ schedule in the SW quadrant in Fig. 1 also slopes down.

Consider now the effects of a temporary increase in oil revenues, $dF > 0$. As argued above, higher oil revenues today will at least partially be spent on NT-goods today so a real appreciation will be the first result (upward shift of $NT^1$ in Fig. 1). This in turn will lead to a shift of resources out of the T-sector today and a concomitant decline in period 1 T-goods production and the associated downward shift in the period 2 production function of T-goods. The resulting second period excess demand for T-goods will lead to a real depreciation in period 2 (Fig. 3, SW quadrant), indicating that more resources are needed in the

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1 A higher subsidy will also lower current real income and so depress demand for $NT$ goods in period 1 (the term $SRPP C_F^T$ in (12)). I will assume that this will not offset the direct supply effect.
T-sector. Accordingly, the OS schedule tells us that a higher subsidy is called for: the post-oil increase optimal subsidy $S^*$ exceeds the pre-oil increase one $S_0$, as shown in the SE quadrant in Fig. 1.

Moreover the increase in oil revenues also affects $\lambda$ (and therefore $S$) directly given the relative price structure: more oil today given the budget constraint in the absence of intertemporal arbitrage via capital markets will raise current expenditure $Z$ but not future expenditure $z$, increasing the wedge between the marginal utility of expenditure tomorrow and today: $\lambda$ goes up and so does $S^*$ given relative prices (the OS schedule shifts out):

\[
\frac{\partial S}{\partial F|q=q_0} = \frac{\partial \lambda}{\partial F} = -\frac{r_F \lambda}{\partial U/\partial Z^2} > 0
\]

since concavity of $U$ implies $U_{zz} < 0$.

This outward shift of the OS-schedule leads to a further increase in the optimal subsidy ($S_0 - S_1^*$ in Fig. 1), essentially because the temporary increase in oil revenues increases the distortionary costs associated with the capital market imperfection.

There is a further shift in the OS schedule because the increase in $Q$ also increases $\lambda$ for a reason very similar to the one underlying the negative sign of $\partial \lambda/\partial q$; we therefore do not spell this out any further, but it has been incorporated in the algebraic analysis contained in Appendix A. All these effects via $\lambda$ of course disappear when the capital market distortion is removed (Section II).

Of course, there will be second round effects if the actual subsidy $S$ is indeed changed to equal the new optimal level $S^*$. In terms of our diagram, the NT schedule shifts whenever the actual subsidy $S$ changes. As one might expect, these second-round effects do not qualitatively change the results. A higher subsidy now leads to more output in the T-sector tomorrow; the resulting excess supply of T-goods (excess demand for NT-goods via Walras’ law) pushes the second period real exchange rate up: the NT schedule shifts towards from NT to $NT^*$ in Fig. 2.

![Fig. 2. 'Second round' effects of the change in the optimal subsidy.](image-url)
The increased subsidy will draw part of the resources diverted to the NT-sector after the oil revenues increase back into the T-sector, thus leading to a further appreciation of the current real exchange rate $Q$. This is not enough, however, to offset the outward shift of the NT curve, the optimal subsidy increase with repercussion effects is smaller than the increase without these second round effects. It is still bigger than zero of course: higher oil revenues today call for a higher subsidy to the T-sector to at least partially offset the decline in LD externalities that would result from the decline of the first period Traded-goods sector associated with a non-interventionist policy in the presence of temporarily higher oil revenues.

Without changes in the subsidy, second period welfare will decline because of the slowdown in Learning by Doing related technological progress as the non-oil traded goods sector declines. With the subsidy set at the new optimal level, however, this decline will be less pronounced and may actually be reversed so that second period welfare will increase in comparison to the no-change-in-subsidy case. In that sense the subsidy acts as a way to move resources towards the future. There are of course other ways of doing that, part of the oil revenues could be used to accumulate assets to generate income in the future when oil has run out. If these take the form of claims on the rest of the world (accumulated via a CA surplus), the situation becomes less clearcut; accumulating Net Foreign Assets does not generate a flow demand for NT-goods, so it does not add to the pressure on the first period NT-goods market. It will, however, allow higher expenditure in the second period, part of which will fall on NT-goods, and generate an alternative source (alternative to domestic production) of traded goods. This will weaken the case for higher subsidies. These are the issues addressed in the next section.

II: OPTIMAL BORROWING ALLOWED

The modifications needed for the model of Section I to allow consideration of optimal borrowing are fairly straightforward. Instead of period by period expenditure equals income constraints we now only impose an intertemporal budget constraint, the foreign capital market permits different patterns of expenditure and income, as long as the totals over time (properly discounted) remain equal. So equations (1) and (10) are replaced by

\[ E = E(P, Q, p, q, U) = R(P + S, Q) + r(p, q; R_P) + F - SR_P. \]

The NT-goods market clearing conditions carry over with a minor adjustment due to the new expenditure function:

\[ E_Q = R_Q, \quad E_q = r_q, \]

while the optimal subsidy is now defined by

\[ S^* = r_R. \]

\( \lambda \) is now always equal to one, since there are no capital-market distortions anymore.

\[ ^1 \text{ Keep in mind that } p, q \text{ are the prices of second period goods discounted back to today at the foreign interest rate. So we really want } R \text{ and not } R/(1 + r^*). \]
Consider now the effect of an increase in oil revenues. Substituting out total welfare $U$ using the intertemporal budget constraint (14) gives us three equations ((15) and (16)) in the unknowns $Q, q$ and $S$. The full blown analytical solution is presented in Appendix B, but is rather tedious. A simplified procedure clarifies all the elements of the solution and allows a diagrammatical analysis. This procedure is the same as the first step approach underlying Fig. 1 in Section I: first consider what higher oil revenues do to current and future values of the real exchange rates, given the actual level of the subsidy, using the non-traded goods market clearing equations (15). Then explore what those levels of the exchange rate today and tomorrow mean for the level of the optimal subsidy $S^*$ via equation (16). The full blown analysis in Appendix B assumes throughout that changes in the optimal subsidy are actually implemented, which of course influences non-traded goods market equilibrium in both periods, and via that again the level of the optimal subsidy. Such second round effects do not change the solution qualitatively, as can be seen in Appendix B.

Figs. 3 and 4 will be of help in the analysis. Consider first Non-Traded goods market equilibrium in period $i$ given $S^{NT^1}$ in Fig. 3:

$$
\frac{dq}{dQ}|_{S^{NT^1}} = R_{QQ} - E_{qq}.
$$

The NT-goods market equilibrium condition in period one yields a positive relation between today's and tomorrow's real exchange rate ($Q$ and $q$) via the link between relative price changes over time and the cost of borrowing: a higher real exchange rate tomorrow ($q^t$) given the real exchange rate today implies a real appreciation over time and therefore a decline in the cost of borrowing given the foreign interest rate. Accordingly, it pays to borrow more against future income, to shift expenditure from tomorrow to today via a larger first period CA deficit. Part of the higher expenditure today will fall on NT goods, thus pushing up today's real exchange rate $Q$ leading to the positive relation shown in Fig. 3 (the locus $NT^1$).

Higher oil revenues will partially be spent today ($C^N > 0$), so the $NT^1$ curve shifts outward (a real appreciation today) for the usual Dutch Disease type reasons after an increase in oil revenues:

$$
\frac{dQ}{dF}|_{S^{NT^1}} = \frac{C^N}{R_{QQ} - E_{QQ}} > 0.
$$

See Fig. 3, the NE quadrant.

The NW quadrant in Fig. 5 shows the negative relation between the optimal subsidy $S^*$ and the second period exchange rate $q$ that we already discussed in Section I.

Finally, the second period NT-goods market equilibrium schedule $NT^2$:

$$
\frac{dq}{dQ}|_{S^{NT^2}} = -\frac{r_{qR}R_{PQ} - E_{qq}}{r_{QQ} - E_{qq}}
= -(r_{qq} - \bar{E}_{qq})^{-1}\left(\frac{\partial v_N}{\partial Q} - \frac{\partial c_N}{\partial Q}\right) \geq 0.
$$
The slope may be either positive or negative. A higher real exchange rate today leads to less Learning by Doing in the T-sector, therefore to a lower productivity of labour in the T-sector during period 2 and so more release of workers into the N-sector. The resulting increase of output in the NT-goods sector will put downward pressure on the exchange rate in period 2. On the other hand a higher real exchange rate today given \( q \) implies more of a gradual depreciation over time and therefore a higher cost of borrowing. This would lead to more expenditure tomorrow and less today, putting upward pressure on tomorrow's real exchange rate \( q \). Fig. 3 is based on the assumption that the first argument ('Learning by Doing effect') dominates the second ('Cost of Borrowing effect'): \( NT^2 \) slopes downward. Fig. 4 is based on the opposite assumption.

Higher oil revenues will partially be spent tomorrow and therefore lead to a higher real exchange rate tomorrow; \( NT^2 \) shifts up if \( \epsilon^N_E > c \):

\[
\left. \frac{dq}{dF} \right|_{dF = 0, \Delta = 0} = \frac{\epsilon^N_E}{q_{qq} - F_{qq}} > 0.
\]

Consider now the effect of higher oil revenues on the optimal subsidy (NW quadrant in Figs. 3 and 4).

The increase in expenditure today (\( C^N_E > 0 \)) leads to excess demand for NT-goods in the first period, calling for a higher real exchange rate today: \( NT^2 \) shifts out. This will lead to less resources in the T-sector today, therefore less beneficial LD effects tomorrow (a move down the \( NT^2 \) curve) and, if tomorrow's curve does not shift (which of course it will as we shall see), a lower real exchange rate tomorrow because of the decline in T-goods output in period 2; see point \( C \) in Fig. 3. This leads to an increase in the optimal subsidy from \( S^*_E \) to \( S^*_F \) of \( \Delta \) (see NW quadrant of Fig. 3). Call this the LD effect on \( S^* \). However, more expenditure today would lead to a gradual depreciation over time (a bigger appreciation today than tomorrow) which increases the cost of taking out foreign

\[1\] Or, equivalently, a smaller CA deficit in period 1 and a smaller surplus in period 2.
loans denominated in traded goods. Accordingly, expenditure will be shifted from today towards tomorrow (again, the CB effect) which will weaken the case for an increase in the optimal subsidy.

Also some of the additional income is going to be spent in period 2. Higher expenditure tomorrow however will lead to a higher real exchange rate tomorrow and accordingly to a smaller subsidy to the T-sector in period 1; see point B in Fig. 3 and $S^*_E$ in the NW quadrant: $S^*_E - S^*_E = \Delta x < 0$. Call this the 'Direct Expenditure (DE) effect'.

As long as both $C^N_E$ and $c^N_E$ are positive, the net effect will be ambiguous. In Appendix B it is shown that:

$$\frac{dS^*}{dF} = \bar{\Delta}^{-1} \left[ \begin{array}{l} r^R_Q + r^R_Q R^P_Q C^N_E \\ - E^Q_Q C^N_E \\ - (R^Q_Q - E^Q_Q) c^N_E \end{array} \right]$$

$\bar{\Delta}$ is the Jacobian of the system and is negative in stable configurations. The net effect is ambiguous and among other things depends on the rate of time preference and the foreign interest rate.

The net effect can be unambiguously signed of course if $NT^2$ slopes upward: this implies that the CB effect outweighs the LD effect, making the net effect unambiguously negative (Fig. 4).

The dominance of the CB effect is not a very plausible assumption, however; there does not seem to be much evidence supporting such a high interest sensitivity of savings. We are accordingly left with the basic ambiguity of equation (21).

Finally, declining marginal returns to experience ($r^R_R < 0$) would increase the gains to be obtained from a unit increase in the subsidy after a Dutch Disease caused decline in period T-sector output, since, loosely speaking, that decline would move the economy back up its marginal return to experience curve.

In this case both $NT^1$ and $NT^2$ slope upwards. Stability requires that $NT^1$ be steeper than $NT^2$. 

\[ \text{Fig. 4. Change in the optimal subsidy with endogenous current account and dominant CB effect.} \]
Accordingly, taking this nonlinearity into account will strengthen the argument for a higher subsidy during periods of high oil revenues.

III. Conclusions

Oil producers across the development spectrum are or will be facing ‘Dutch Disease’ type crowding out of their non-oil traded goods sector. Those among them that are at an early stage of industrial development have voiced complaints that such a period of retrenchment of non-oil traded goods production will delay the Learning by Doing experience that would improve their comparative advantage (or lessen a comparative ‘disadvantage’) in the production of manufactured goods. Such industry-specific Learning by Doing effects will of course always present a case for production subsidies to the sector concerned. The question raised in this paper is whether high but temporary oil revenues and the concomitant negative effects on the non-oil traded goods sector should lead to an increase in these subsidies during the period of higher oil revenues.

The answer is unambiguously yes for those countries that have chosen not to use periods of high oil revenues to accumulate foreign assets but to use newly discovered (or revalued) oil wealth for consumption. If the current account is not used to smooth expenditure, subsidies to the non-oil traded goods sector should be increased if that sector shows the potential of significant Learning by Doing induced increases in productivity. In this sense the question asked in the title – is the Dutch Disease a disease after all? – should be answered in the affirmative because more corrective medicine is needed.

If, however, the link between temporarily high oil revenues and total expenditure can be broken by accumulating foreign assets no straight answer can be given. Dutch Disease phenomena will still be present but it may not be necessary to switch back to non-oil traded goods production in the post-oil period as income from foreign assets accumulated when oil revenues were flowing in will allow continued concentration of resources in the non-traded goods sector. Accordingly, the case for subsidies to the traded goods sector during the period of oil revenues is weakened, and it is actually possible under this scenario that subsidies should be decreased (although they will always remain positive). However, foreign asset accumulation is not the route chosen by most oil producers to smooth consumption expenditure, while those that did (Saudi Arabia, etc.) may have done so involuntarily, with absorptive capacity constraints constraining their current expenditure (a ‘clogged harbour’ theory of the current account). So, from an empirical point of view, the conclusions derived in Section I, with foreign asset accumulation excluded, may have more practical relevance than the answers provided by the analysis of Section II where foreign borrowing is allowed under the extreme assumption of perfect, riskless foreign capital markets too big to be influenced by the policy choices made by the oil producer under study.

Development Research Department, World Bank

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APPENDIX A: NO EXTERNAL BORROWING

After substituting out $Z$ and $z$ via the budget constraints the system can be represented by $NT^1$, $NT^2$ and $OS$:

\[
\begin{bmatrix}
R_{QQ} - E_{QQ} + C^N_{E}SR_{PQ} & 0 & R_{QP} + C^N_{E}R_{PP}S \\
(r_{qR} - c^N_{E}r_R) R_{PQ} & r_{qq} - \epsilon_{qq} & (r_{qR} - c^N_{E}r_R) R_{PP} \\
\frac{\lambda Z_N}{\Pi Z} & \lambda \left(r_{Rq} - \frac{Z_N}{nz}\right) & -1
\end{bmatrix}
\begin{bmatrix}
dQ \\
dq \\
dS
\end{bmatrix}
= \begin{bmatrix}
C^N_{E}dF \\
0 \\
SU_{ZZ}dF \\
\frac{\Pi Z}{U_Z}
\end{bmatrix}
\] (A1)

If we base a stability analysis on the plausible adjustments $Q = \gamma_1(E_Q - R_Q)$, $Q = \gamma_2(e_q - r_q)$ and $S = \gamma_3(S^* - S)$, a necessary condition for stability is that the determinant of the matrix in (A1) is smaller than zero; we will confine our analysis to those cases where this condition is indeed satisfied. Call that determinant $\Delta$.

Cramer's rule tells us that

\[
\frac{dS}{dF} = \frac{\Delta_3}{\Delta},
\]

where

\[
\Delta_3 = (R_{QQ} - E_{QQ} + C^N_{E}SR_{PQ})(r_{qq} - \epsilon_{qq}) \frac{SU_{ZZ}}{\Pi Z^2} + (r_{qR} - c^N_{E}r_R) R_{Pq} \lambda \left(r_{Rq} - \frac{Z_N}{nz}\right) C^N_{E} - C^N_{E}(r_{qq} - \epsilon_{qq}) \frac{\lambda Z_N}{\Pi Z}.
\]

Clearly $\Delta_3 < 0$, so stability requirements ($\Delta < 0$) and (A2) unambiguously confirm that $dS/dF$ is positive in the non-borrowing case.

The other comparative statics results ($dQ/dF > 0$, $dq/dF < 0$) are straightforward and are left to the interested reader.

APPENDIX B: THE SOLUTION WITH EXTERNAL BORROWING

The equations of Appendix A are substantially simplified once foreign borrowing is allowed. First $\lambda$ always equals one with perfect capital markets, so the formula for the optimal subsidy simplifies to $S^* = r_R$. Second several complicating income effects disappear now that current losses and future gains can be offset against each other.

The new model now becomes:

\[
\begin{bmatrix}
R_{QQ} - E_{QQ} & -E_{qq} & R_{QP} \\
r_{qR}R_{PQ} - E_{qq} & r_{qq} - E_{qq} & r_{qR}R_{PP} \\
0 & r_{Rq} & -1
\end{bmatrix}
\begin{bmatrix}
dQ \\
dq \\
dS
\end{bmatrix}
= \begin{bmatrix}
C^N_{E}dF \\
c^N_{E}dF \\
0
\end{bmatrix}.
\] (A3)

Stability once again requires the determinant of the matrix in (A3) (call it $\bar{\Delta}$) to be negative. Cramer's rule gives us the expression for $dS/dF$, equation (21) in the text.
References


